



GO WITH THE FLOW!

LESSON PACKET

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LESSON ONE

1 | WHAT IS RUNOFF?



National Learning Standards:

ELEMENTARY SCHOOL

- NGSS.5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
- CCSS.ELA-LITERACY.RI.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.

MIDDLE SCHOOL

- NGSS.MS-ESS2-2 Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.
- NGSS.MS-ESS2-4 Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
- CCSS.ELA-LITERACY.W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

HIGH SCHOOL

- NGSS.HS-ESS3-4 ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
- NGSS.HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.
- CCSS.ELA-LITERACY.SL.9-10.4 Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.

LEARNING OBJECTIVES:

1. Students will define and investigate runoff.
2. Students will gain knowledge of pollution and other materials found in runoff and how we all contribute to it.

KEY TERMS:

Runoff
Pollution

Permeability
Infiltration

Water cycle
Precipitation

Vegetation
Impervious

LESSON ONE

1 | WHAT IS RUNOFF?

Background Information:

Runoff is a natural part of the water cycle. It is the water that flows over the land as surface water instead of being absorbed as groundwater or evaporating. Runoff is part of precipitation, snow melt, or irrigation water that appears in rivers, streams, drains, or sewers. It then flows to major bodies of water, picking up pollutants such as trash, oil, and fertilizers as it moves. You can learn more runoff basics here:

<https://youtu.be/aWsnTtT0Uws>

Materials:

- Poster board
- Construction paper
- Crayons, markers, colored pencils
- Computer with Internet access

WHAT IS RUNOFF?

1 | INTRODUCTION (ANTICIPATORY SET):



1. Introduce the concept of runoff to the class and connect it to the Purple Plow Challenge.
 - a. “Who remembers what our challenge question is? What do you know about the water cycle and runoff?”
 - b. “Today, we will explore some basic terms and facts about runoff.”
2. Dive deeper into terms and basics through a short explanation and discussion.
 - a. “Runoff is a natural part of our water cycle. Some of the water from precipitation, snow melt or irrigation will be soaked into the ground as ground water. But what about the water that isn’t soaked into the ground? Where does it go? Today we are going to discuss runoff on impervious surfaces and the things we can find in our runoff.”
 - b. “Impervious surfaces such as roofs, roads, sidewalk, parking lots, and industrial areas like airports and distribution centers are covered with impervious material such as asphalt. The runoff from these areas can’t be soaked into the ground. The water picks up pollutants from that surface and carries it to nearby sewers, rivers, and streams. This is causing our water ways to become more and more polluted. Even pervious surfaces like grasses and farmland will have runoff when the amount of rainfall is happening faster than the ground can take it in. Fertilizers and other chemicals are then picked up in the runoff and carried to local streams and rivers.”
3. Write the following phrases on the board:
 - a. What is runoff?
 - A. Runoff is a natural part of the water cycle.
 - B. It is the water that from precipitation, snow melt, and irrigation that doesn’t soak into the ground.
 - C. Pollutants from impervious surfaces such as roofs, driveways, and sidewalks are in the runoff.
 - b. Where does it come from and where is it going?
 - A. Runoff comes from precipitation, snow melt, and irrigation.
 - B. Runoff collects the pollutants it flows over such as fertilizers, trash, oil, and other chemicals as it flows to nearby sewers, streams, rivers, lakes, and oceans.
 - c. What’s happening once it gets there?
 - A. The polluted runoff mixes in with our ocean waters and affects the quality of the water and the habitat of the animals living in the water.

WHAT IS RUNOFF?

1 | INPUT AND MODELING:



Divide students into groups of three to four.

Distribute materials to make a poster.

Assign each group to draw the “runoff cycle” in an urban or rural setting.

Tell students that their posters should share important information in a creative and eye-catching manner.

1 | INDEPENDENT PRACTICE:



Allow students time to research, explore, plan, and create their posters.

1 | WRAP-UP (REVIEW, ASSESS, CHALLENGE):



Allow students to share their posters and discuss runoff in both urban and rural settings.

Display the posters for others to see after groups have shared with the class.

LESSON TWO

2 | WHERE IS MY RUNOFF RUNNING TO?



National Learning Standards:

ELEMENTARY SCHOOL

- NGSS.5-ESS2-1 Develop a model using an example to describe a scientific principle ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
- NGSS.5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
- CCSS.ELA-LITERACY.W.5.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

MIDDLE SCHOOL

- NGSS.MS-ESS2.C.1 Develop and use a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
- CCSS.ELA-LITERACY.RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.
- CCSS.ELA-LITERACY.WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

HIGH SCHOOL

- NGSS.HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
- NGSS.HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.
- CCSS.ELA-LITERACY.SL.9-10.4 Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.

LEARNING OBJECTIVES:

1. Students will define a watershed and/or drainage basin.
2. Students will explain a watershed and/or drainage basin's connection to the ocean.
3. Students will create a map of a major watershed and/or drainage basin.

KEY TERMS:

Drainage basin Watershed Tributary Estuary Water cycle Runoff

LESSON TWO

2 | WHERE IS MY RUNOFF RUNNING TO?

Background Information:

When precipitation collects and drains to a common outlet, we call this a drainage basin or watershed. Every lake, stream, river, etc. has a watershed. These ecosystems are important “because the streamflow and the water quality of a river are affected by things, human-induced or not, happening in the land area “above” the river-outflow point.”²

Materials:

- Computers with access to Internet
- PowerPoint, Google Slides, etc.
- Large construction paper or poster board
- Markers, crayons, colored pencils, etc.

WHERE'S MY RUNOFF RUNNING TO?

2 | INTRODUCTION (ANTICIPATORY SET):



1. Project a map of your location on an interactive whiteboard or point to your location on a map. Explain that the water where you live is connected to the ocean.
2. Introduce the term “watershed.” Ask students what they think the word means. Then explain that a watershed is an area of land that drains all streams and rivers to a common outlet.
3. Explain that due to the water cycle, all water is connected to the oceans. For example, “When precipitation falls over the land surface, it follows various routes in its subsequent paths. Some of it evaporates, returning to the atmosphere; some seeps into the ground as soil moisture or groundwater; and some runs off into rivers and streams. Almost all of the water eventually flows into the oceans, where the cycle continues.”¹

2 | INPUT AND MODELING:



1. Put students into groups of two or three.
2. Explain that each group will choose a location on Earth and create a map that shows that location’s watershed.
3. Share the following links with the class and explain that each team should create a two to three slide presentation that defines the concept of a watershed/drainage basin to accompany their map.

<https://education.nationalgeographic.org/resource/watershed/>

https://www.usgs.gov/special-topic/water-science-school/science/watersheds-and-drainage-basins?qt-science_center_objects=0#qt-science_center_objects

<https://oceanservice.noaa.gov/facts/watershed.html>

WHERE'S MY RUNOFF RUNNING TO?

2 | INDEPENDENT PRACTICE:



Allow for students to discuss, research, and take notes as well as create their map and summary presentations

2 | WRAP-UP (REVIEW, ASSESS, CHALLENGE):



Each team shares their short presentation and their chosen watershed.

WHERE'S MY RUNOFF RUNNING TO?

2 | RESOURCES



¹ <https://earthobservatory.nasa.gov/features/Water/page2.php>

² https://www.usgs.gov/special-topic/water-science-school/science/watersheds-and-drainage-basins?qt-science_center_objects=0#qt-science_center_objects

LESSON THREE

3 | HOW RUNOFF AFFECTS WATER QUALITY & RISE OF HYPOXIC ZONES



National Learning Standards:

ELEMENTARY SCHOOL

- NGSS.5-ESS3-1.C Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
- CCSS.ELA-LITERACY.W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

MIDDLE SCHOOL

- NGSS.MS-ESS3-3 ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- NGSS.MS-ESS3-4 ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
- CCSS.ELA-LITERACY.W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

HIGH SCHOOL

- NGSS.HS-ESS3-4 ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
- NGSS.HS-ESS3-6 ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.
- CCSS.ELA-LITERACY.SL.9-10.4 Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.

LEARNING OBJECTIVES:

1. Students will discover and identify hypoxic zones worldwide.
2. Students will research water quality as it relates to underwater life quality.
3. Students will begin to synthesis all the contributions to polluted runoff and what has already been done to protect our water.

KEY TERMS:

Hypoxic zones	Dead zones	Eutrophication	Water quality
Nitrogen	Phosphorus	Algae blooms	

LESSON THREE

3 | HOW RUNOFF AFFECTS WATER QUALITY & RISE OF HYPOXIC ZONES

Background Information:

Hypoxia is a term used to describe the depletion of oxygen. It is an environmental phenomenon in which oxygen levels decrease to a point in which the aquatic environment can no longer support aquatic organisms. Hypoxic zones are occurring all over the world in our lakes and oceans. Human activity is the largest reason we are dealing with this issue.

Materials:

- Computers with access to Internet
- Materials for note taking

HOW RUNOFF AFFECTS WATER QUALITY & RISE OF HYPOXIC ZONES

3 | INTRODUCTION (ANTICIPATORY SET):



Remember that in our previous lesson, we discovered that all water is connected to the oceans through the water cycle, and that water reaches various locations through rivers and tributaries, sharing a common outlet called a watershed or drainage basin. Today, we will explore how runoff is affecting water quality all over the world and the rise of hypoxic zones.” Write the following categories on the board and ask students to identify practices that contribute to polluted runoff:

Home practices: (lawn fertilizer, oil, grease, pet waste, etc.), Agricultural practices: (fertilizers, pesticides, manure, etc.) , Industry practices: (heavy metals from roofs and other materials, thermal pollution from dark impervious surfaces, etc.)

As these materials make their way to our lakes and oceans, they are causing a rise in nitrogen and phosphorus. The rise in these nutrients increase production of things like seaweed and algae blooms. As the algae blooms grow, it results in less sunlight penetrating the water and a lack of oxygen for the animals that live there.

Today, you will work in groups to research the world’s largest dead zones in each continent and what is happening to the animals that live there. Discuss with your group the potential causes of the polluted runoff and if anything has been done to improve the water quality there.

3 | INPUT AND MODELING:



1. Put students into seven groups.
2. Assign a continent to each group.
3. Each group will research hypoxic zones for that continent, noting the largest hypoxic zone for the area and prepare to present their findings to the class. You might choose to share the following links to get students started:

<https://oceanservice.noaa.gov/facts/deadzone.html>

<https://www.scientificamerican.com/article/ocean-dead-zones/>

<https://www.nationalgeographic.com/environment/oceans/dead-zones/>

https://www.vims.edu/research/topics/dead_zones/index.php

HOW RUNOFF AFFECTS WATER QUALITY & RISE OF HYPOXIC ZONES

3 | INDEPENDENT PRACTICE:



Allow for students to discuss, research, and take note of the largest hypoxic zones in the world and reasons why.

3 | WRAP-UP (REVIEW, ASSESS, CHALLENGE):



Discuss and begin drawing conclusions through comparisons of hypoxic zones as to why they are so large in certain parts of the world. Begin discussions on what has already been done in those areas to protect the quality of the water.

HOW RUNOFF AFFECTS WATER QUALITY & RISE OF HYPOXIC ZONES

3 | RESOURCES



https://www3.epa.gov/npdes/pubs/nps_urban-facts_final.pdf

<https://copperriver.org/programs/dont-run-off-salmon/how-does-stormwater-run-off-affect-rural-communities/>

LESSON FOUR

4 | SOLUTIONS ALREADY IN PLACE



National Learning Standards:

ELEMENTARY SCHOOL

- NGSS.5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
- CCSS.ELA-LITERACY.RI.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.

MIDDLE SCHOOL

- NGSS.MS-ESS3-3 Apply scientific principles to design an object, tool, process or system.
- NGSS.MS-ESS3-4 Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
- CCSS.ELA-LITERACY.W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

HIGH SCHOOL

- NGSS.HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
- NGSS.HS-ESS3-6 ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.
- CCSS.ELA-LITERACY.SL.9-10.4 Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.

LEARNING OBJECTIVES:

1. Students will learn about solutions for runoff issues.
2. Students will be able to explain how humans use ideas from science and engineering to protect, control, and make use of natural resources.
3. Students will research the impact humans have on an environment.

KEY TERMS:

Permeability Impervious Vegetation Runoff Erosion

LESSON FOUR

4 | SOLUTIONS ALREADY IN PLACE

Background Information:

We know that runoff is naturally occurring, but we can have more control over what is in the runoff. Protecting clean drinking water, lakes, and oceans from an overabundance of nutrients like phosphorus and nitrogen is a problem we should all be thinking about solving. There are steps we all can be taking. This lesson explores what has already been done to protect the quality of our water and what can still be done.

Materials:

- Activity Sheet
- Computers with Internet access
- Note taking materials

SOLUTIONS ALREADY IN PLACE

4 | INTRODUCTION (ANTICIPATORY SET):



1. "Today, we will begin to research the solutions that are already in place for issues like hypoxic zones because of polluted runoff." Write the following on the board in three columns:
 - a. What do we know is being done already to help control runoff issues?
 - b. What questions do we need answered?
 - c. What are some solutions currently being used to address the problem?
 2. Ask students to answer the question, "What do we know is being done to help control runoff issues?" Record student answers.
 3. Ask the students to generate questions they need or want answered about addressing runoff issues and record their responses in the second column under the question, "What questions do we need answered?"
-

4 | INPUT & MODELING:



1. Break students into small groups.
2. Explain to the students that they will use their time to explore the solutions scientists and engineers are already using to address runoff issues. Use the following links to get them started:
 - <https://education.nationalgeographic.org/resource/runoff/>
 - <https://www.epa.gov/nutrientpollution/sources-and-solutions-stormwater>
 - <https://www.cbf.org/issues/polluted-runoff/solutions/>
 - <https://www.rivernetwork.org/our-work/clean-water/best-practices/managing-urban-runoff/>
3. Students should be prepared to present their solutions to the class.

SOLUTIONS ALREADY IN PLACE

4 | INDEPENDENT PRACTICE



Students begin to research, analyze, and record ideas to share with the class.

4 | WRAP-UP (REVIEW, ASSESS, CHALLENGE):



1. Students present the solutions they learned about for the prevention or reduction of polluted runoff and discuss these solutions with the class.
2. Record student responses in the last column under the question, "What are some solutions currently being used to address the problem?" Connect students' responses to the current Purple Plow Challenge, and use these responses as a way to start brainstorming new and innovative solutions which the students might pursue in completing the design challenge.

SOLUTIONS ALREADY IN PLACE

4 | RESOURCES



<https://education.nationalgeographic.org/resource/runoff/>

<https://www.epa.gov/nutrientpollution/sources-and-solutions-stormwater>

<https://www.cbf.org/issues/polluted-runoff/solutions/>

<https://www.rivernetwork.org/our-work/clean-water/best-practices/managing-urban-runoff/>

LESSON FIVE

5 | WHY WE SHOULD CARE: A PSA



National Learning Standards:

ELEMENTARY SCHOOL

- NGSS.4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
- CCSS.ELA-LITERACY.W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

MIDDLE SCHOOL

- NGSS.MS-ESS3-3 ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*
- NGSS.MS-ESS3-4 ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
- CCSS.ELA-LITERACY.W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

HIGH SCHOOL

- NGSS.HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
- NGSS.HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.
- CCSS.ELA-LITERACY.SL.9-10.4 Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.

LEARNING OBJECTIVES:

1. Students will create a public service announcement informing the public of issues that are affecting runoff and our world's waterways.
2. Students will research, plan, and discuss solutions to hypoxic zones.
3. Students will demonstrate knowledge gained through a creation of a public service announcement which includes solutions for all contributors to runoff and hypoxic zones.

KEY TERMS:

Dead zones	Hypoxic zones	Eutrophication	Runoff
Pollution	Waste		

LESSON FIVE

5 | WHY WE SHOULD CARE: A PSA

Materials:

- Poster board
- Crayons, markers, colored pencils, etc.
- Construction paper
- Video recording devices

WHY WE SHOULD CARE: A PSA

5 | INTRODUCTION (ANTICIPATORY SET):



We have been researching the environmental effects runoff has had on our lakes and oceans. Today, you are going to create a Public Service Announcement that informs the public of the issues you have learned about and why it is so important for all of us to care about solving it. You may choose any type of PSA that helps deliver your message. Make sure to include possible solutions to this issue for all contributors.

5 | INPUT AND MODELING:



1. Put students in pairs or small groups.
2. Provide them with material needed to create their PSA.
3. Allow time for students to discuss, research, and create their PSA.

WHY WE SHOULD CARE: A PSA

5 | INDEPENDENT PRACTICE:



1. Students will work together to create a Public Service Announcement informing the public of issues that are affecting runoff and our world's water.
2. They may choose how to create their PSA (newspaper article, poster, commercial, etc.).

5 | WRAP-UP (REVIEW, ASSESS, CHALLENGE):



1. Students will share their PSA with their class and their family and discuss what they learned.
2. A challenge could be requested to have groups compare and contrast and discuss most effective strategies.

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