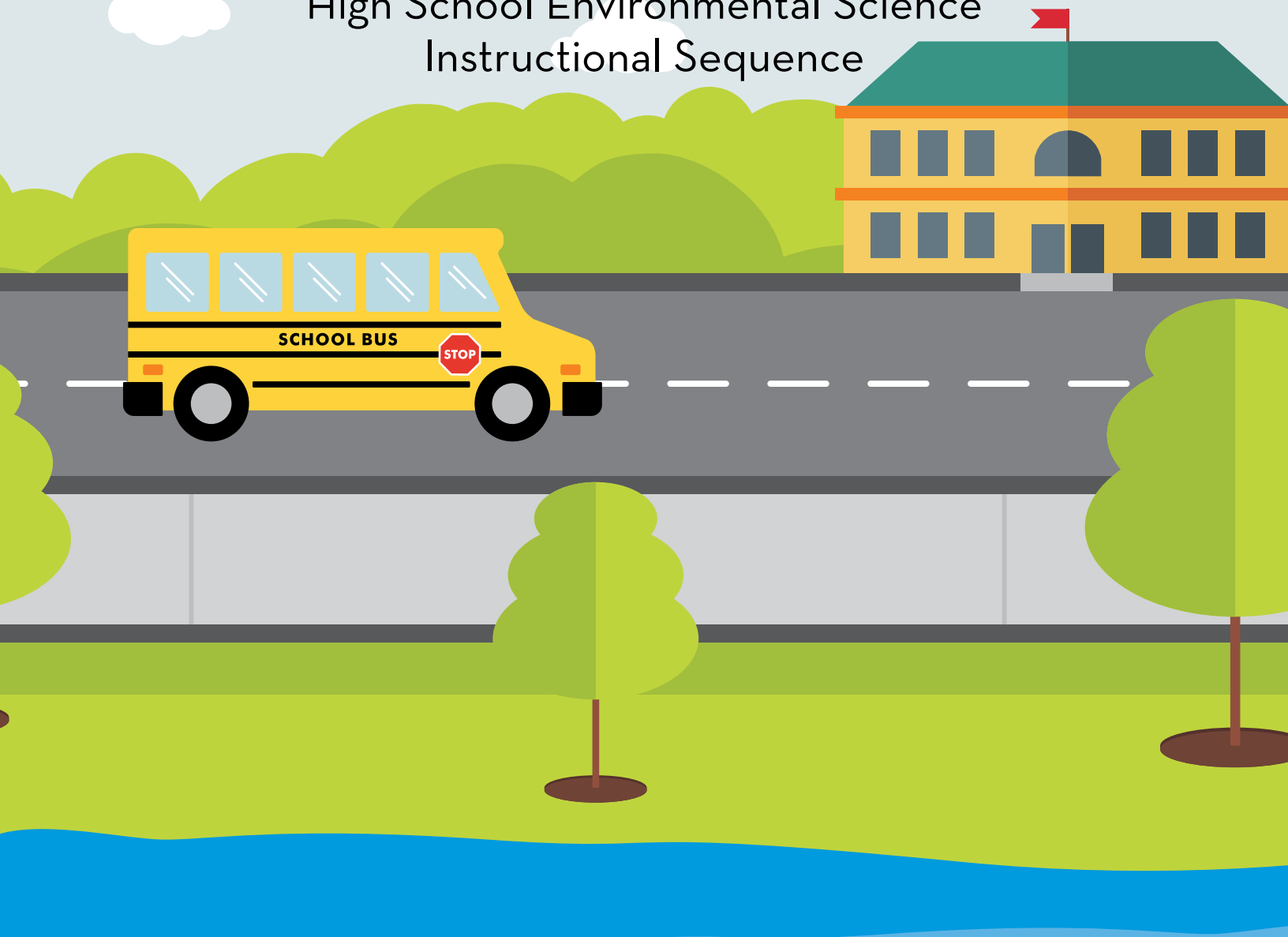
District of Columbia
Office of the State Superintendent of Education

INTERACTIONS AND STEWARDSHIP OF THE WATERSHED

High School Environmental Science Instructional Sequence



This high school environmental science instructional sequence was created to support teaching the Next Generation Science Standards through the Biological Sciences Curriculum Study (BSCS) 5E instructional model. Developed by District of Columbia teachers, these lessons include real-world contexts for learning about environmental science through a lens that encourages student investigation of local issues.

The lessons also support Scope and Sequence documents used by District local education agencies:
Unit *3*: Earth and Human Activity:
Chesapeake Bay and Anacostia Watershed Analysis Advisory 3 and 4

Acknowledgements:
Molly Smith, Cardozo Education Campus

This curriculum resource can be downloaded online:
https://osse.dc.gov/service/environmental-literacy-program-elp

Overview and Goal of the Lesson: Students will experience their watershed using three methods that will culminate in a long-term action plan. They will begin with a survey of their schoolyard to observe (with testing) the local interactions between water, land, and humans. Then they will move to the classroom to research the history of, and current issues with the Anacostia and Potomac River watersheds. Students will use a model to investigate water runoff patterns for various surfaces in order to develop an explanation for the effects of human disruptions on water resources. Student understanding of watershed stewardship imperatives will be evaluated by their development of an appropriate action plan to maintain and regularly test the quality of water runoff at storm drains adjacent to the campus.

Essential Question(s):

How has human reliance on natural resources affected economic, social, environmental, and geopolitical systems?

How are anthropogenic (human caused) changes disrupting ecosystems and threatening the survival of some species?

NGSS Emphasized and Addressed in this Lesson Sequence:

PERFORMANCE EXPECTATIONS	SCIENCE AND ENGINEERING PRACTICES	DISCIPLINARY CORE IDEAS	CROSSCUTTING CONCEPTS
HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. **HS-ESS3-1.** 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. **HS-LS2-7.** Design, evaluate, and refine a solution for reducing impacts of human activities on the environment and biodiversity. **HS-ETS1.** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.	**Constructing Explanations and Designing Solutions** • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. ***Connections to Nature of Science*** **Scientific Investigations Use a Variety of Methods** • Science investigations use diverse methods and do not always use the same set of procedures to obtain data. • New technologies advance scientific knowledge. **Scientific Knowledge is Based on Empirical Evidence** • Scientific knowledge is based on empirical evidence. • Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	**ETS1.A Defining and Delimiting Engineering Problems** • Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. **ESS2.C. The Roles of Water in Earth's Surface Processes** • The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, ***dissolve and transport materials,*** and lower the viscosities and melting points of rocks. **ESS3.A Natural Resources** • Resource availability has guided the development of human society. LS2.C. Ecosystem Dynamics, Functioning, and Resilience - Anthropogenic changes in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the Natural World** • New technologies can have deep impacts on society and the environment, including some that were not anticipated. **Science Is a Human Endeavor** • Science is a result of human endeavors, imagination, and creativity. • Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.

Materials

ITEM	QUANTITY	PURPOSE
Interactive whiteboard or other similar projection equipment	1	information presentation throughout lessons
Topographic maps of school grounds on portable device (viewer.nationalmap.gov) or printed copies	1 per group	to use as reference on school grounds walk and when locating storm drains, trash receptacles, impervious/pervious surfaces and other features
Clipboards, schoolyard map outline, data sheet or rubric	1 set per group	recording field data (map will be outline for students to add locations of storm drains, trash and recycling receptacles, natural features, surface type, temperatures, and other observations)
Temperature probes or thermometers (if other probes or sensors such as CO_2 are available, allow students to collect such data)	at least 3 per class	measuring temperatures (and other data) at various locations
Containers of water	4-5 gallons per class	pouring on surfaces to observe permeability and flow rate/direction
Electronic device (computer, tablet, phone)	1 per 2 students	researching Potomac River Watershed and Anacostia River
Information organizer	1 per student	efficient collection of information on rivers during research activity
Materials for runoff investigation: bricks, gravel, clay, sand, plastic sheets, sod, leaves	several samples	demonstration of effects of water flow
Trays/bins	1 per group	contain runoff materials and water; remind students that materials other than water should not be put down drain
Food coloring, powder	3-4 shared food coloring bottles	representing pollutants for runoff investigation
Straws	several per group	to represent storm drains - some may be buried; others left on surface
Bits of paper and plastic	several per group	to represent trash for runoff investigation
Watershed map	1 per class	contact patricia.doan@dc.gov at the Department of Energy and Environment for map(s) for classroom display
Whiteboards or big paper	1 per group	watershed background exchange C-E-R display

5E Lesson Sequence

TOTAL DURATION: THREE DOUBLE BLOCKS (240 MINUTES)				
5E MODEL STAGE		**TEACHER AND STUDENT ACTIONS**		**NOTES**
Engage	80 minutes	What Teacher Does	1. WARM UP: Teacher presents pictures of trash and other evidence of the low water quality of the Anacostia River and/or Potomac River. Teacher poses questions: • How does it get to be this way? • Does the way we treat the land affect the water? Let's check it out! • Show Google map of school grounds for orientation before moving outside. 2. The teacher provides a map template, a rubric, and instructions for school ground (campus) survey (see Supporting Documents 1 and 2). 3. Teacher provides a variety of measuring devices such as temperature probes/ thermometers, meter sticks, protractors, and/or pH paper, topographic map (online) of school grounds, water in containers to pour for flow observations. 4. Teacher introduces and encourages the use of key vocabulary: erosion, permeable, impermeable, runoff, contour lines, vegetation, elevation, etc.	**Important resource for use throughout lesson:** www.dcwater.com/clean-rivers-project Determine whether your school is in the Anacostia or Potomac (Rock Creek) watershed from sites such as: • Google image search[1] • Anacostia Watershed Restoration Partnership interactive watershed maps[2] Students engage in scientific data collection to obtain baseline information in order to begin to consider human impact on the watershed. Guiding questions: • Where does rainwater that falls on campus go? • Does it matter what kind of surface the water falls on? • Is anything carried along with the water? • Where does the water go next? • Are there other ways that data can be collected? • How does the state of the schoolyard affect the Anacostia/Potomac rivers? • How confident are you that the data you are collecting is valid? • How can you be more sure that your data is valid? • Is there anything about the state of the campus that concerns you?
		What Students Do	1. Students walk school grounds recording the locations of storm water intakes, trash receptacles, vegetation, shade cover, permeable and impermeable surfaces, and shallow soil features on the campus map. 2. Students collect data including surface and air temperatures at designated locations, runoff patterns, shade cover, and other pertinent values (as considered by students). 3. Students record observations and data to complete school map and key.	
Explore	40 minutes	What Teacher Does	1. WARM-UP: Teacher shows ***A Drop's Life*** — video clip, stopping at points to clarify terms and build reference points.[3] 2. Teacher provides handout/instructions for researching aspects of Potomac and Anacostia rivers (Supporting Document 3). 3. Teacher assists students in search and note-taking strategies (scaffolding as necessary) and reminds students to refer to guiding questions.	Introduce lesson by showing ***A Drop's Life*** — a DC Water animation about water flow and treatment issues in the city: Discussion points for video: • Why is the drop getting polluted? • What is a combined sewer outfall (CSO)? What are the advantages and disadvantages of combined systems? • How is DC Water addressing the problem? • What might we need to know about our watershed?

5E MODEL STAGE		TEACHER AND STUDENT ACTIONS		NOTES
Explore	40 minutes	What Students Do	1. Students divide into six groups. Each student group completes online research on one aspect of either the Potomac River or Anacostia River: • Early history of human interactions • Geographic/geologic/hydrological features • Current use/pollution sources/ restoration efforts	**Guiding questions:** • What/where are the Anacostia and Potomac watersheds? • What are some natural features of the river systems? • How have humans interacted with and impacted the rivers BEFORE YOU? • How do people use the rivers at this time? • How do humans negatively and positively impact the rivers? Students have searched key words; good sources include ***Britannica, American Rivers***, the ***Washington Post,*** and ***DC Water Clean Rivers Project.*** **Supporting Document 3: Watershed Research** Among the six groups, ensure research topics on the rivers are not duplicated. Key vocabulary will be introduced and used in recording of information. Teacher will need to monitor and scaffold as necessary in order to keep students focused on key information that will answer the guiding questions.
Explain	40 minutes	What Teacher Does	1. Teacher models development of presentations for students. 2. Teacher provides handout for gallery walk sharing of information. 3. Teacher circulates and asks clarifying questions as they develop their presentations.	**Guiding questions:** • What/where are the Anacostia and Potomac watersheds? • What are some natural features of the river systems? • How have humans interacted with and impacted the rivers BEFORE YOU? • How do people use the rivers at this time? • How do humans negatively and positively impact the rivers? Refer to sample information organizer for potential student responses. Information exchange can be a variation of a jigsaw with students completing their organizer during interviews with other group presenters. Verbal interchanges will increase understanding and discourage simple copying of written text.
		What Students Do	1. Students prepare two-three slides or whiteboard infographic to present to others in class (as jigsaw). 2. Students share information with others in short presentation or at stations. 3. Students complete (fill in) their own watershed organizer using information from other group presentations.	

5E MODEL STAGE		TEACHER AND STUDENT ACTIONS		NOTES
Elaborate	80 minutes	What Teacher Does	1. The teacher provides materials and container for surface runoff investigation. 2. Teacher provides general parameters for using model: Don't make a mess that you don't want to clean up, share materials, keep it simple—only change one variable at a time, predict outcome and evaluate validity of evidence. 3. Teacher may model one potential aspect such as using a mister (light rain) versus water can/sprinkler (heavy rain) using a think-aloud. 4. Teacher will show students DC Water's Green Infrastructure site and initiate discussion of strategies to mitigate the problem of surface runoff and related CSOs.[4]	Supporting Document 4: Investigation of Runoff from Various Surfaces *Note: This investigation is also part of a different 5E lesson sequence that focuses entirely on runoff in the watershed.*[5] Use the (modified) argument-driven whiteboard presentation strategy:
		What Students Do	1. Students prepare the whiteboard: Write the guiding question(s) to be addressed. Possibly write a sub-question that narrows and drives the procedure. 2. Students make a claim/prediction about outcome. 3. Students set up and run the experiment. 4. Students record observations on whiteboard in ***evidence*** section. 5. Students justify the claim by providing an explanation for the behavior. 6. Students will respond to other student questions/arguments during sharing session.	Student groups set up an experiment that responds to the guiding questions: • What is the effect of water flow on natural and artificial surfaces? • How do components of a watershed interact? • What happens to pollutants that are near a water system? • How does this model represent my school situation? ***Students will use information from this surface runoff lab to justify their action plan in <u>Evaluate</u> stage.*** Students make a claim that guides their procedure. Data is collected and recorded. The claim may be modified based on the observed evidence. A reasoning or justification explanation that supports the evidence is added to the whiteboard. After groups have finished their experiments, they circulate to see what others did and engage in discussion.

5E MODEL STAGE		TEACHER AND STUDENT ACTIONS		NOTES
Evaluate	80 minutes for developing the plan, then ongoing	What Teacher Does	1. Teacher redistributes campus maps and challenges students to critique their schoolyard's effect on the watershed. 2. Teacher instructs students to refer to surface runoff lab and watershed research to ask the questions: How can runoff from my school impact the Anacostia River or the Potomac River? How can students at my school ensure minimal impact? 3. Teacher provides a blank sample *action template* to help guide student activity (Supporting Document 5).	Now that students know more about the manner in which water interacts with the geosphere and pollutants enter river systems, students will reexamine their own school environment. As a class, an action plan is developed that addresses stewardship of the watersheds (see Supporting Document 5 for templates). Students will develop a plan to regularly monitor and improve the quality of water entering storm drains adjacent to the campus. A calendar schedule will be set up and followed. Community service hours may be awarded. Extension: Students will collaborate with other community members (nearby schools, neighborhood groups) to improve storm drain water quality.
		What Students Do	1. Students return to the schoolyard with an eye for what can be done to mitigate the problems associated with runoff. 2. Students develop an action plan (with justification) to improve the quality of runoff water as it leaves campus. 3. Students set schedule for ongoing action as necessary and then implement the plan. 4. Student committee corresponds with Trinh Doan at DOEE to inform her of their action and for feedback.	

Footnotes

1 https://goo.gl/images/hu3AXf

2 http://anacostia.net/maps/watershed.html

3 /www.dcwater.com/clean-rivers-project

4 www.dcwater.com/projects/green-infrastructure-design-challenge

5 Runoff in the Watershed instructional sequence can be found on the OSSE website: https://osse.dc.gov/node/1113336.

SUPPORTING DOCUMENTS

Supporting Document 1:

Campus grounds survey

Instructions: Refer to the guiding questions and the rubric. Tour the campus and record pertinent features. Complete one or two map templates per group and then combine the features, checking for accuracy and clarity. Submit one map per group.

Guiding questions:

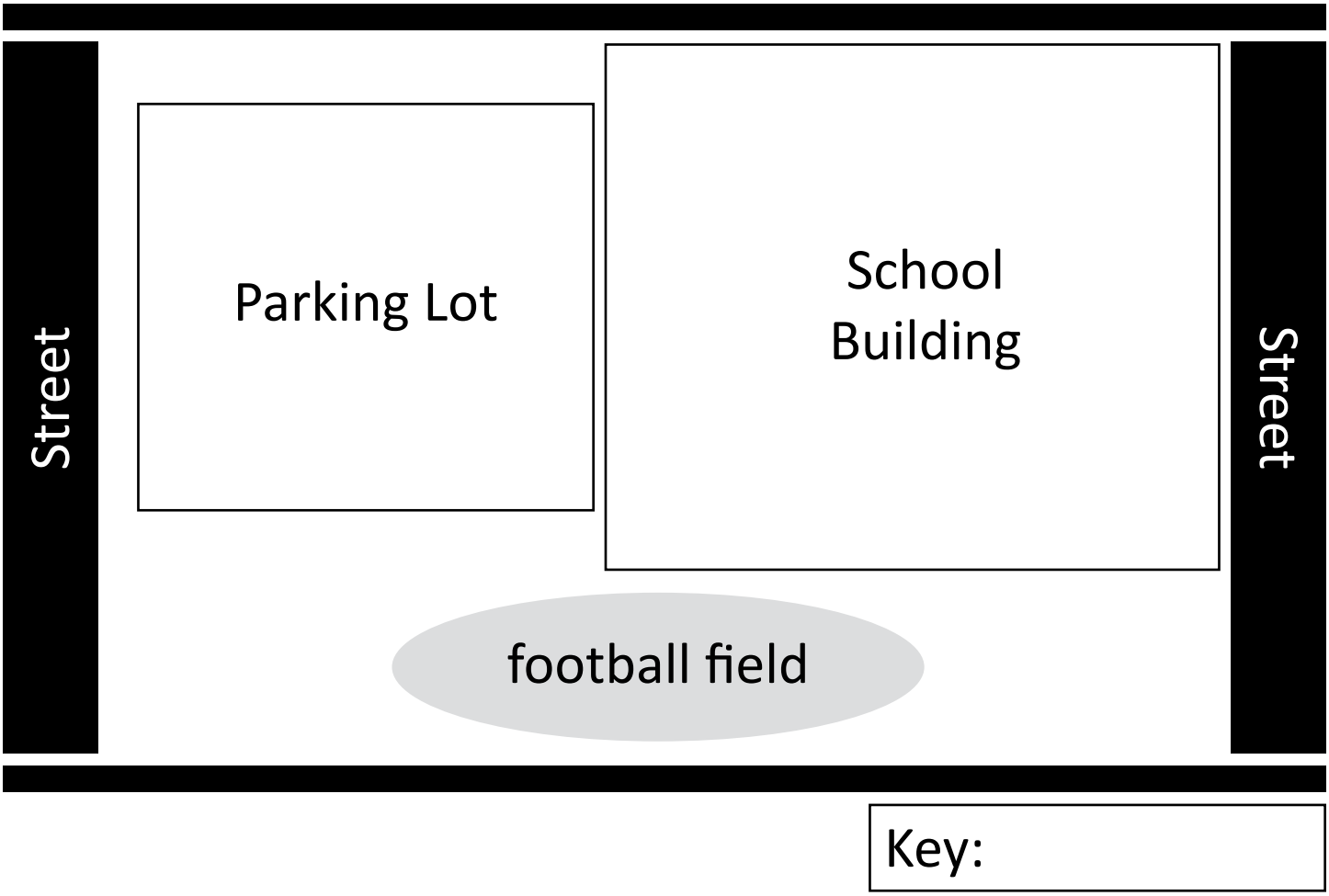
1. Where does rainwater that falls on campus go?
1. Does it seem to matter what kind of surface the water falls on?
2. Is anything carried along with the water?
3. Where does the water go next?
2. Are there other ways that data can be collected?
3. How might the state of the schoolyard affect the Anacostia and Potomac rivers?
4. How confident are you that the data you are collecting is valid?
4. How can you be more sure that your data is valid?
5. Is there anything about the state of the campus that concerns you?

Campus Survey Rubric

Aspect	Description	Possible points	Points earned
Participation	present on activity date active participation during field survey	5 0 3 2 1 0	
Campus features	marked location of 5 major structures (e.g., buildings) marked location of 5 ground surfaces (e.g., parking lot) marked location of 5 living things (e.g., tree, flowers) marked location of 5 small, man-made structures (e.g., trash cans) marked location of all storm drains	5 4 3 2 1 0 5 4 3 2 1 0 5 4 3 2 1 0 5 4 3 2 1 0 5 2 0	
Collected data	temperature at three locations permeability of three locations water flow from three locations other measurements (list)	6 4 2 0 6 4 2 0 6 4 2 0 6 4 2 0	
Response to guiding questions	1. Where does rainwater that falls on campus go? 2. Does it seem to matter what kind of surface the water falls on? 3. Is anything carried along with the water? 4. Where does the water go next? 5. Are there other ways that data can be collected? 6. How might the state of the schoolyard affect the Anacostia and Potomac rivers? 7. How confident are you that the data you are collecting is valid? 8. How can you be more sure that your data is valid? 9. Is there anything about the state of the campus that concerns you?	2 1 0 2 1 0 2 1 0 2 1 0 2 1 0 2 1 0 2 1 0 2 1 0 2 1 0	

Supporting Document 2:

Campus map sample template



Supporting Document 3:

Watershed Research: Potomac and Anacostia Rivers

Objective: Students will research essential background information on the Potomac and Anacostia rivers in order to explain how reliance on natural resources (water) drives the need for stewardship.

Instructions: Students will choose or be assigned one aspect of one of the rivers to research. They will search their river using key terms (history, pollutants, uses). Common, easily accessible sources include Britannica, American Rivers, or Washington Post article about Anacostia history.[1] Students read through the text and record information that addresses their topic. Students will complete their organizers by exchanging information in a variation of a jigsaw.

Sample organizer with possible student responses:

Anacostia River Watershed	**Potomac River Watershed**
History/past development **Guiding question: How have humans interacted with and impacted the Anacostia River *BEFORE YOU*?** • Native Americans lived on river for 10,000 years. • English settlers cut down forests to grow tobacco • Farming techniques caused a lot of silt to enter the river • Chemical contamination from coal gasification plant, Navy Yard, trash dumping	History/past development **Guiding question: How have humans interacted with and impacted the Potomac River *BEFORE YOU*?** • Many Native Americans lived along the river for more than 10,000 years • Explored by Europeans starting in 1600s • Canals were built along the river in Virginia and in Maryland • Became source of DC drinking water in 1864 -- water intake system installed at Great Falls and Washington Aqueduct built for storage • River became very polluted with runoff from farms and coal mines and raw sewage • President Lyndon Johnson called it "national disgrace" (1960s)
Current status/uses/sources of pollutants **Guiding question: How do people use the river at this time? How do humans negatively and positively impact the river?** • Small boat marinas located along north shore of river • Trails on both sides of river • Raw sewage during heavy rains, urban runoff (trash and chemicals going into storm drains), chemicals leaking from Navy Yard • Cleanup efforts include DC bag law, new wastewater tunnels, annual volunteer clean-up days to collect trash	Current status: uses/sources of pollutants **Guiding question: How do people use the river at this time? How do humans negatively and positively impact the river?** • Source of drinking water for all of DC • Recreational uses: fishing, boating, kayaking • Sewage releases during heavy rains, urban runoff (trash and chemicals entering storm drains), leaking coal ash ponds • Mixed sex fish found possibly from pharmaceuticals in sewage or treated sewage • Clean up efforts: DC bag law, new wastewater tunnels, (sewage and storm water that goes through the Blue Plains Wastewater Treatment Facility is cleaner than the Potomac River)

1 www.washingtonpost.com/local/the-history-of-the-anacostia-river/2012/05/01/gIQA1VuAxT_story.html?utm_term=.1bbfda7e48f7

Anacostia River Watershed	Potomac River Watershed
Geography/hydrology **Guiding question: What/where is the Anacostia watershed? What are some natural features of the river system?** • Starts in Montgomery County and Prince George's County • Primary tributaries include Watts Branch, Sligo Creek, Northeast Branch and Northwest Branch • Kenilworth Park and Aquatic Gardens are adjacent the river empties into the Potomac River at Haines Point across from the airport • Much smaller and more shallow compared to Potomac	Geography/hydrology **Guiding question: What/where is the Potomac watershed? What are some natural features of the river system?** • The watershed covers Maryland, Pennsylvania, Virginia and DC • It is tidal below Chain Bridge (Little Falls), which means that the level of water varies through the day with high tides and low tides • Empties into the Chesapeake Bay • The salinity of the water increases in the lower part of the river due to mixing with bay/ocean water

Supporting Document 4:

Investigation of Runoff from Various Surfaces

Objective: Students will investigate the amount of water that drains off of varying surfaces in order to identify potential problems and solutions to urban runoff.

Materials: sample surfaces: bricks, pieces of wood, concrete, squares of sod; graduated cylinders, timer, foil and other materials that students may use to collect/divert the water that runs off. Additional materials that represent pollutants and litter can be provided. Large bins can be used to contain the water and surfaces. Alternatively, the experiment may be done outside.

Student Procedure:

1. Design a method for determining the amount of runoff from various surfaces.
2. Collect and record data in table.
3. Analyze data by comparing rates and quantities of runoff.
4. Present data to peers (in order to broaden scope of inquiry).
5. Research and discuss methods used in the District by accessing www.dcwater.com/projects/green-infrastructure-design-challenge

If bins are not available at school, these are inexpensive and reusable.

Supporting Document 5.

Watershed Action (task organizer sample)

Action objective: In order to decrease the volume of pollutants entering the water treatment system or the river, students will remove trash from storm water intakes on school grounds.

Rationale: In most parts of the city, sewer lines and storm drains combine and the water is treated at the wastewater treatment facility. Anything that goes down the drain must be removed. Trash must be removed and sent to a landfill. During heavy rain events, the combined sewers overflow directly into the local rivers and streams, which means that any trash that goes down the intakes, goes directly into our rivers.

	Details	People Involved	Time Consideration
Materials needed to carry out plan	Gloves, trash container, recycling container		
Procedure/ instructions	1. Carry gloves and trash and recycling receptacles to storm drain at street. 2. Remove debris from around storm drain. 3. Dispose of collected materials properly.		
Creating schedule	Create schedule with student names		
Data recording	Take pictures before and after each clean-up Written inventory of collected materials		

Watershed Action (task organizer sample)

Action objective: In order to reduce the discharges from combined sewer outfalls (CSOs), a rain garden will be established at X location on school property.

	Details	People Involved	Time Consideration
Materials needed to carry out plan			
Procedure/ instructions			
Creating schedule			
Data recording			
Costs			

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