Designing for Resilience – A Stormwater Challenge

Grade: Grade 7
Place of Focus: English High School schoolyard and surrounding neighborhood
Participatory Science Protocol: Community-Based Flood Resilience and Green Infrastructure Survey from the City of Boston – a participatory tool that allows residents to report flooding issues and contribute to city planning decisions
Partner(s): Boston Water and Sewer Commission (BWSC), City of Boston Environment Department / Green Infrastructure Division

Massachusetts Curriculum Framework for Science and Technology/Engineering Standards

- **MS-ESS3-5:** Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.
- **MS-ESS3-3:** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- **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.
- **MS-ETS1-2:** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Science and Engineering Practices

- Asking questions and defining problems
- Planning and carrying out investigations
- Analyzing and interpreting data
- Designing solutions
- Engaging in argument from evidence
- Communicating information

Learning Objectives

By the end of the field lesson, students will be able to:

- Explain how stormwater moves through different types of surfaces in the schoolyard
- Describe how the permeability of various surfaces affects flooding and infiltration
- Identify locations most vulnerable to flooding in the school environment
- Make connections between schoolyard flooding and broaden patterns caused by climate change

By the end of the unit, students will be able to:

- Analyze data to identify long term changes in temperature and precipitation patterns
- Use models to explain how rising global temperature impacts Earth's water and carbon systems
- Explain the role of human activities in contributing to an imbalance in Earth's carbon system
- Evaluate various community based solutions based on criteria including effectiveness, feasibility and equity
- Communicate evidence based recommendations that promote resilience and reduce climate related risks in their community

Pre-Visit Learning

Leading up to this field experiment, students will have already engaged in lessons from the OpenSciEd Unit 7.6 "*How do changes in Earth's system impact our communities and what can we do about it? Earth's Resources & Human Impact: Droughts & Floods*" exploring how changes in Earth's temperature and precipitation patterns are linked to climate change.

Students begin the unit by examining abnormal drought and flood events across the U.S., linking them to rising temperatures and asking, *How do changes in Earth's system impact our communities and what can we do about it?*

In the first lesson set, they investigate how temperature changes affect evaporation, precipitation, and water systems.

In the next lesson set, they explore how human activities disrupt Earth's carbon system, causing rising temperatures.

In the final lesson set, students work to solve the problem, recognizing it as a carbon imbalance. They come to understand that seemingly simple fixes, like eliminating fossil fuels, are more complex in practice.

This leads them to explore how communities can prepare for the changes they are facing, build resilience, and address challenges at the local level. This is where the capstone project begins, directly aligning with the unit's focus and giving students a chance to apply their learning in a real-world context.

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Pre-Visit Learning

At this point in the unit they will have:
- Analyzed data to observe shifts in climate variables over time
- Investigated how increasing temperatures influence the water cycle
- Developed models to explain changes in earth's water and carbon systems
- Examined human activities that contribute to greenhouse gas accumulation and system imbalance

In addition to the OpenSciEd lessons leading up to this project, to prepare for the field lessons students will:
- Review safety protocols and fieldwork expectations.
- Participate in a Student Investigation Planning Session:
  - Brainstorm possible methods for tracking stormwater flow (reviewing maps of permeable/impermeable surfaces, identifying slopes and high points, locating catch basins, pouring water, using balls to track slope direction, looking for sediment deposits or stains, reviewing contour maps).
  - Develop a mapping procedure and agree on symbols for low points, flow paths, and watershed boundaries.
  - Plan the infiltration test by suggesting possible methods, determining how to add a specific amount of water to different surfaces, deciding how to measure the time until infiltration is complete, and recording observations of what the water does as it moves or soaks in.
- Be introduced to the Flood Survey at the beginning of the year, with the understanding that survey submissions will be ongoing throughout the year whenever flooding or pooling is observed in the schoolyard or surrounding community.

Essential Questions

- How do changes in Earth's system impact our communities?
- What can we do to reduce the effects of climate change in our local environment?

Guiding Questions

1. How does water move through our schoolyard during a rainstorm?
2. What areas of our school or neighborhood are most affected by stormwater runoff?
3. How do different types of surfaces affect water infiltration?
4. What is green infrastructure and how can it help reduce flooding and pollution?
5. What can we do to improve how our school manages stormwater?

Field Visit Preparations

Time

This investigation will take place across three 55-minute class periods, following the structure and objectives of BWSC's Grade 7 Green Infrastructure Curriculum (Lessons 7.2 and 7.3).

Materials and Supplies

Day 1

- Printed maps of schoolyard
- Clipboards
- Pens/pencils
- Water/tennis balls (depending on method selected by students to trace stormwater) *(cont. next page)*

Materials and Supplies (cont.)

Day 2
- Water
- Measuring cups
- Timers
- Data table
- Clipboards
- Pens/pencils

Day 3
- Maps of schoolyard
- Clipboards
- Pens/pencils
- Reflection handout

Logistics

- Bathrooms available in school
- Meeting point: Main entrance of English High School
- Emergency contact: School nurse
- Adult chaperones and staff will be stationed throughout the site

Scientific Protocol

The stormwater investigation will follow structured protocols designed to ensure accurate, comparable data across groups. Students will work in small teams, each member responsible for a specific role. Within each group, students will rotate through the following roles.

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Scientific Protocol

Roles:

Data/Observation Note Recorder – Writes down measurements, observations, and any important notes on the data sheet during all activities.

Timekeeper – Operates the stopwatch during infiltration tests and keeps the group on schedule.

Map Specialist – Updates the group's site map, labels features accurately, and ensures all symbols and notes are clear.

Materials Manager – Distributes and collects all group supplies, ensures tools and materials are handled responsibly, and returns them to the designated collection point at the end of the visit.

1. Mapping Protocol

Purpose: Identify high and low points in the schoolyard, observe stormwater flow paths, and document potential problem areas.
Overview: Students will work in assigned zones using aerial maps to mark visible slopes, low points, and drainage features. Flow paths will be tested by rolling brightly colored tennis balls from elevated points to track where water would naturally move. Arrows and symbols will be added to maps using a shared key for consistency. Observations will include locations of puddling, pooling, or other hazards.

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Scientific Protocol (cont.)

2. Infiltration Protocol

Purpose: Measure how quickly water infiltrates different schoolyard surface types to assess drainage capacity and flood risk.
Overview: At multiple surface locations (asphalt, compacted soil, grass, gravel), students will set up infiltration rings, pour a measured amount of water, and record the time for complete infiltration. Data will be collected over multiple trials for each surface type to ensure reliability. Results will be compared to mapped flow paths to identify areas most at risk for flooding.

3. Green Infrastructure Observation Protocol

Purpose: Document existing green infrastructure (GI) features and identify opportunities for additional GI to improve stormwater management.
Overview: Students will conduct a guided walk with BWSC or City of Boston Green Infrastructure staff, noting the type, location, and condition of existing GI. Students will also identify and mark potential sites for new GI based on observed drainage issues or low points.

4. ArcGIS Flood Survey (Yearlong data collection)

Purpose: The Community-Based Flood Resilience and Green Infrastructure will be introduced at the beginning of the school year as part of the unit's emphasis on community science and climate resilience. This tool allows students to log local flooding observations using an online form accessible by phone or Chromebook.
Overview: At the start of the school year, students will complete a baseline submission within the first month to establish an initial record of local flooding patterns. Over the course of the year, they are required to complete at least two additional submissions, ideally following significant rain events, to capture changes over time. Students who wish to engage more deeply in environmental monitoring may complete additional surveys for extra credit.

Field Visit Outline

Introduction

On-Site Expectations

- Stay within the assigned boundaries at all times.
- Remain with your group and keep pace with your team.
- Handle all tools and materials responsibly.
- Use respectful communication with classmates, teachers, and guest experts.

Safety Considerations

- Be aware of uneven ground, puddles, and slippery surfaces.
- Dress appropriately for the weather and wear closed-toe shoes.

Learning Tasks

<u>Class Session 1: Visual Observations, Predictions and Initial Mapping</u>

1. Quick safety recap and on-site orientation.
2. Students conduct visual observations in assigned zones and make predictions about stormwater flow.
3. Apply chosen methods (identifying slopes and high points, water flow path tracking, ball tests) to map predicted stormwater flow.
4. Mark low points, flow paths, and watershed boundaries on site maps.
5. Evaluate predictions, compare group findings, and combine results into a preliminary schoolyard watershed map.

<u>Class 2: Infiltration Test and Additional Mapping</u>

1. Groups conduct infiltration tests on different surfaces (asphalt, gravel, compacted soil, grass).
2. Compare infiltration rates.
3. Identify and map areas most vulnerable to flooding.
4. Combine the water flow mapping and infiltration data to refine map.

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Learning Tasks (cont.)

Class 3: Green Infrastructure Assessment with Experts

1. Welcome visitors from the BWSC.
2. Take a guided walk through of the schoolyard with experts focusing on identifying existing or potential green infrastructure features.
3. Document observations through notes and sketches.
4. Conclude field work with student reflections. Reflections will guide follow up class sessions.

Reflections

Students will be prompted to select one or two questions from the provided list that resonate most with them and respond thoughtfully. Their responses should draw on their own experiences, ideas, and insights from the day's work.

- What is one thing you saw over our 3 day visit that made you curious about our community's relationship with water?
- How does what we learned connect to your own life, your family or your neighborhood?
- If you could design one change to make our school or neighborhood more resilient what would it be and why?
- How might your voice and ideas contribute to making real change in our community's climate resilience?

Post-Visit Learning

In additional sessions back in the classroom, students will transform their stormwater investigation data into a School Community Resilience Plan. This phase mirrors OpenSciEd Lesson 17.

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Post-Visit Learning

Day 1: Establishing Criteria and Reviewing Data

Students co-construct a Criteria Checklist for an effective resilience plan based on prior examples, expert input, and class discussion. The checklist emphasizes defining the problem, explaining causes, and including both short-term adaptation and long-term mitigation strategies. Students revisit their schoolyard maps, infiltration results, and field notes. They then use the Climate Explorer to connect current vulnerabilities with future precipitation and temperature projections.

Day 2: Identifying Stakeholders and Selecting Solutions

Students identify stakeholders within the school and surrounding community, such as younger students, facilities staff, and nearby residents, and outline their specific needs and vulnerabilities. Using Water and Carbon Solution Cards alongside original ideas, groups select a balanced set of solutions that address both immediate stormwater challenges and long-term carbon reduction.

Day 3: Peer Review and Plan Refinement

Groups participate in a jigsaw-style peer feedback session, evaluating each other's plans against the Criteria Checklist. They incorporate peer and teacher feedback to strengthen the scientific reasoning, equity considerations, and feasibility of their proposals.

Day 4: Finalizing and Communicating the Plan

Students finalize their School Community Resilience Plans, ensuring they clearly define the problem, explain causes, and present evidence-based solutions. Plans are presented in the groups' chosen format such as a poster, slideshow, infographic, or letter to authentic audiences including school administration, BWSC partners, or community members.

Full Unit Outline

This unit integrates the OpenSciEd unit "How do changes in Earth's system impact our communities and what can we do about it?" with a place-based stormwater investigation at the English High School schoolyard. Students move from studying the global drivers and impacts of climate change to applying that knowledge locally, culminating in the design of a School Community Resilience Plan that addresses flooding and stormwater management challenges.

1. Framing the Problem
Students begin with the global perspective, analyzing climate datasets to identify long-term trends in temperature and precipitation. They develop models of Earth's water and carbon systems and investigate the role of human activities in disrupting these systems. Case studies introduce how different communities experience and respond to climate change impacts.

2. From Global to Local
The focus shifts to Boston's projected climate hazards, such as increased heavy rainfall, flooding, and extreme heat. Students connect these projections to potential impacts on their own school community, setting the stage for targeted investigation and solution design.

3. Field Investigation
Students conduct a hands-on investigation of their schoolyard to collect data on stormwater flow, infiltration rates, and existing or potential green infrastructure. Observations and measurements provide the evidence base for the resilience planning work to follow.

4. Post-Visit Learning
Students synthesize field data, climate projections, and stakeholder needs to design evidence-based solutions. Working collaboratively, they develop and refine a School Community Resilience Plan that addresses both short-term adaptation and long-term mitigation strategies. *(cont. next page)*

Full Unit Outline

5. Presentation and Reflection
The unit culminates in presentations to authentic audiences, such as school leaders, BWSC representatives, or community members. Students reflect on the role of science in guiding local decision-making, identify unanswered questions, and propose possible next steps for building climate resilience in their community.