Planning for Rain (Learning Experience #1)
Lesson Plan

Summary

Students work in teams as they play the role of city planners and civil engineering consultants in Lancaster, Pennsylvania. They research potential "gray" and "green" infrastructure solutions to the challenge of the overburdening of wastewater treatment systems during times of excessive rainfall. Teams develop an implementation plan for the City of Lancaster and present the plan for consideration during a mock town meeting.

Objectives

The students will:

- work productively as a part of a project team.
- use a variety of resources to investigate the background information necessary for this project.
- research and summarize information about gray and green infrastructure techniques used to reduce stormwater produced by flow from impervious surfaces in urban and suburban areas.
- research and summarize information about GIS, LiDAR and GPS technology and data.
- research and summarize information about the history and current problems faced by municipalities required to meet new federal clean water standards.
- discover the advantages and disadvantages of green infrastructure techniques.
- plan a project that will result in management of stormwater in a sustainable way using data from new technologies.
- design and carry out a fair test of part of their plan using a model.
- keep accurate, complete records in a journal.
- communicate their ideas and results to classmates.

Materials for *Planning for Rain* (Learning Experience #1)
A packet containing a copy of each of the following documents per group:

- *Building for the Future* (Student Sheet #1)
- *Meeting the Challenge:* Gray vs. Green (Student Sheet #2)
- *A Techie's Eye View* (Student Sheet #3)

General Supplies for LE #1

- Notebooks, small binders or folders to be used as journals (1 per student)
- Chart paper and markers
- Computer with Internet access for each group

Materials for Combined Wastewater Treatment Simulation

- Two (2) disposable foil baking pans (approx. dimensions- 30cm x 24cm x 6cm)
- Scissors with pointed ends (one pair)
- 3L water, tinted with 12 drops of green food coloring (represents residential/ industrial wastewater)
- 11.5L water tinted with 20 drop of red food coloring (represents runoff from impervious surfaces)
- Three (3) student assistants

Target Student Grade Level: 8-12

Subject Areas
Environmental science, ecology, biology, geography, history, language arts, social sciences

Timeline
Teacher preparation: 45 minutes
Student Learning Experience: 90 minutes

Setting: Classroom lab with a sink; library or computer lab

Skills
Research in print materials and on web sites; organize information; problem-solve as part of a team; communicate to team and classmates; design and carry out an experiment

Vocabulary
Load; gray infrastructure; green infrastructure; pervious surface; impervious surface; combined wastewater collection system

Advance Preparation Needed for *Planning for Rain*

- Make copies of the student sheets listed, one for each project team.
- Provide chart paper and markers or access to technology that will allow students to present their ideas to their classmates.
- Gather materials for the Combined Wastewater System Simulation.
- If time permits, invite a city planner or civil engineer to visit your class for a discussion about careers and comparison of final student work to real green/gray infrastructure plans in your region.

Essential Question for *Planning for Rain*: *How can city and municipal officials plan in advance in order to reduce the load on our wastewater treatment plants during episodes of heavy rain?*

Post the scenario and essential questions and instruct the students to write a preliminary answer in their journals, leaving space for additional ideas as they work through the learning experience. Students will reflect upon the essential question at the end of *Planning for Rain* (Learning Experience #1).

Introduce this scenario with a class simulation using a model to demonstrate how a *combined wastewater system* works. The demonstration should be conducted in a location where water may be poured and things are able to get wet. (i.e. a classroom counter next to a sink). You will need three student assistants for the demonstration.

Combined Wastewater System Simulation

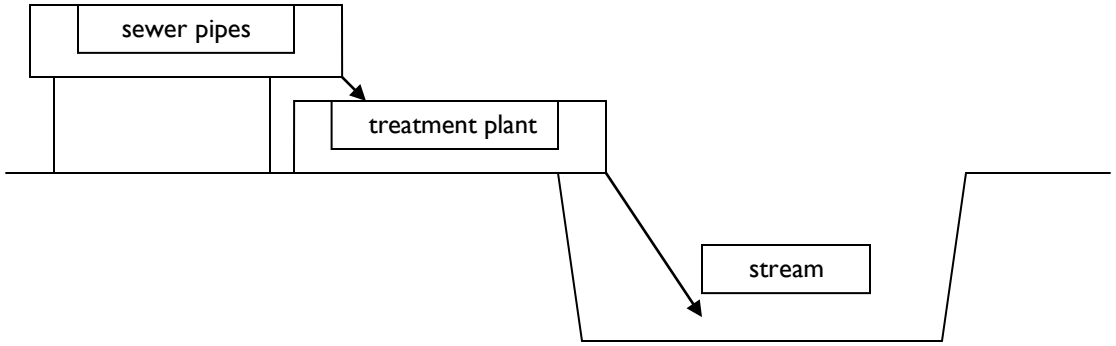
Required Materials and Resources

- Two (2) disposable foil baking pans (approx. dimensions- 30cm x 24cm x 6cm)
- Scissors with pointed ends (one pair)
- 3L water; tint with 12 drops of green food coloring (represents residential/ industrial wastewater)
- 11.5L water; tint with 20 drop of red food coloring (represents runoff from impervious surfaces)
- Three (3) student assistants

Advanced Preparation Required for the Simulation

- Use scissors with pointed ends to cut a hole about 2 cm^2 in the middle of the base of one side the first baking pan.
- Cut a hole about 1 cm x 2 cm in the middle of the base of one side of a second baking pan.
- Use a stack of books or other supports to place the pan with the larger hole above and to the side of the other pan so that water poured
- into the top pan will flow into the lower one.
- Place the second pan on the counter next to the sink with the hole extending slightly over the sink.

The upper pan represents a city's ***combined wastewater collection system***. Combined wastewater collection systems are constructed in a manner where pipes are used to carry sewage from residential and industrial buildings, connect to additional pipes transporting runoff water from roofs, parking lots and streets with all wastewater ending in a holding tank for eventual treatment.
The lower pan represents the city's sewage treatment plant where all of the wastewater is treated for removal of pollutants before it flows through the effluent pipe (the smaller hole) into a nearby stream (represented by the sink).



Simulation Round #1:
Instruct student #1 to slowly pour 1 L of water into the upper pan at the same time that student #2 pours 0.5 L into the same pan. This represents a sunny day with average amounts of wastewater from houses and businesses flowing into the system (student #1), plus storm sewer water from activities like washing cars and hosing down sidewalks (student #2).

Lead a class discussion during which the students address the following questions:
- *Did you observe any potential problems with the combined system?*
- *Was all of the wastewater treated before it was released into the stream?*

Simulation (Round #2):
Instruct student #1 to slowly pour 1 L of water into the top pan while student #2 quickly pours 3 L of water into the top pan. This represents a day with average amounts of wastewater plus storm sewers carrying runoff from a moderate rainstorm.

- *Ask the class how the system is handled the wastewater flow differently than in round #1.*

Simulation Round #3:

Instruct student #1 to slowly pour 1 L of water into the top pan while students #2 and 3 each pour 4 L of water into the top pan as quickly as possible. Water should flow over the top of the lower pan and into the sink without being treated. This represents a day with storm sewers carrying water from a heavy downpour.

Lead a class discussion during which the students address the following questions:

- *How is the system handling the wastewater flow during this round?*
- *Was all of the wastewater treated before it emptied into the stream?*
- *What happened to the excess water carrying pollutants from houses, businesses, parking lots and streets?*
- *Would you want to swim, fish, or boat downstream from this area?*

Instruct students to make a science journal entry describing their observations with suggestions for ways that the model's wastewater overflow could be slowed or eliminated.

This demonstration illustrates the problem faced by older cities located within the Chesapeake Bay watershed such as Lancaster, Pennsylvania. The combined wastewater systems of the City of Lancaster currently have sufficient capacity to meet the Total Maximum Daily Load of pollutants (TMDL) standards required by the EPA 85% of the time. The City could face costly fines if the capacity of their combined sewer/ wastewater treatment system fails to meet the EPA standards 100% of the time.

Instruct students to respond to the following questions in their science journals:

- *Why do you think the EPA has placed the six Chesapeake Bay watershed states on a "pollution diet?"*
- *Where could you locate the answer to this question?*

Procedure

1. Assign students to project teams of three or four people. Each team member should have a task: researcher (may have two of these), recorder, communicator. Grouping students with a variety of abilities will promote peer teaching and differentiation of instruction.

2. Inform students that each team represents a consulting group of city planners and civil engineers. As consultants the groups have been engaged by the City of Lancaster to design a project that will allow the city to solve its wastewater overflow problem in a sustainable way at a reasonable cost to the taxpayers. Encourage students to think about what they observed during the simulation and what they have seen occur in their neighborhood both during and after a large rainfall. Students will work with others on the team to create a potential solution and action plan to address wastewater overflow in Lancaster.

3. Before teams begin their work, students should create a list documenting the information needed in order to address the challenges in upgrading the wastewater collection and treatment systems and where to locate the information. Group lists should be recorded in each student's science journal.

4. Student teams will begin their challenge by discussing what members may already know about the wastewater that flows down inside and outside drains and into a treatment plant. Post a chart like *Building for the Future* (Student Sheet #1) and have each team share at least one of their answers and ideas on the chart.

5. Instruct students to research operational definitions for the following systems that may be commonly found in urban and suburban areas: **gray infrastructure, green infrastructure, and pervious/impervious surfaces**. Students should be able to describe the meanings of each term and provide an example of each during a class discussion.
   Note: Teams should answer question #1 the top portion of *Meeting the Challenge: Gray vs. Green* (Student Sheet #2) before completing the table, "Reduction of Wastewater During Wet Weather."

6. After the teams have developed a plan and organized it into the table, they will be instructed to design a public relations campaign to persuade the citizens of Lancaster to participate in reduction of wastewater, even if it will result in slightly higher taxes. The team's public relations (PR) plan should be recorded in their journals since students will reflect on them later in the module.

7. Ask students to imagine that they need to draw a map of the City of Lancaster that includes every building, road, park, tree and parking lot within its borders. How would officials have accomplished this task 60 years ago? How would the map be created today? *A Tech-savvy Bird's-eye View* (Student Sheet #3) tasks students with exploring the recent developments in technology that are used by modern city planners and engineers in the development of plans and in the production of visual images to be used in presentations to clients.