Classroom Lesson Development

Title of Lesson	**How Water Flow and Soil Composition Affect Watersheds and Water Quality - An Inquiry Based Lesson**
RET Project Connection	Akram Alshawabkeh's Civil and Environmental Engineering lab specializes in rapid characterization of soils including: soil composition, soil moisture content and various methods of soil remediation addressing sub-surface contamination. Although my assigned work in the lab comprised primarily of monitoring electrolytic reactions over time, I gained content information regarding the complexity of soil and ground water flow and the technological and engineering challenges taken into consideration during soil remediation projects. As a result of the RET experience, I set out with three major goals for developing this lesson: The lesson will be relevant and will enrich the existing 7th grade earth science curriculum, therefore building deeper understainding through inquiry based investigations. The lesson will incorporate a design/engineering component. Students will apply content knowledge and skills to learning about the local watershed and local environmental issue that effects their water qualiity.
RET Teacher	Susan Agger
School	Thomas E. Maynard Ecology Center at Fresh Pond
Town/District	Cambridge Public Schools District
Subject(s) taught	Environmental Science/Life Science/Earth Science
Subjects covered in lesson	Earth Science, Environmental Science, Technology & Engineering
Grades appropriate	Grade 6, 7 & 8
Lesson duration	Five hour inquiry based investigation with additional pre-activity lessons and post-activity lessons.
Goals/Objectives of lesson	Students will be able to identify and interpret three features on a topographical map. Students will be able to determine the height and shape of specific land features from contour lines and legend scale of a topographical map. Students will interpret and read the topographical map of the Lusitania wet meadow (before and after) then translate the information to a three dimensional stream table model.

Using prior knowledge of soil composition, erosion, deposition and materials characteristics, students will construct, test and observe stream table models for water flow and absorption and spread of soil contaminants.

Background information

The Cambridge seventh grade earth science unit, Prentice Hall - Dynamic Earth, covers characteristics of and the interrelationship of the geosphere and the hydrosphere. Because of the scope of the unit and the lack of instructional time, the following topics are often eliminated or covered superficially in the curriculum: contour and topographical maps, watersheds, groundwater flow, soil contamination, erosion and deposition. These topics are listed in the Massachusetts Science and Technology/Engineering Framework for grades 6-8. Every year since 2001, questions relating to these topics have been included in the 8th grade science MCAS test.

By participating in a locally relevant, hands-on, inquiry-based investigation at the Maynard Ecology Center, students will have a content rich experience that will help build their understanding of these topics. During this experience students will use stream tables, various building materials and local detailed topographic maps.

The terminal fresh water reservoir for Cambridge is located on the Fresh Pond Reservation, a 162 acre urban green space which is used for multi-purposes. On the northeast side of the reservation is a wooded area that collects and holds spring melt water and rainwater during heavy rain and storm events. Often, this accumulated water washes over heavily traveled pavement and flows directly into the Fresh Pond Reservoir carrying with it surface and sub-surface contaminants into the municipal water supply.
In an attempt to address the problem, the Cambridge Water Department, with the help of a bioengineering firm, created a wet meadow in the area designed to improve water quality. The recent project includes extensive soil augmentation and the creation of hummocks or bio-swales to direct surface water to a holding area. The water retention area has been sculpted and planted with native wetland plants. The combination of wetland plants, gravel layers, conduits and soil mixtures helps to slow down water and sediment flow, naturally filter and absorb excess water and settled nutrients and soil contaminants thus improving water quality.

Essential questions

How do different types of maps represent natural and man made features?
How does the downhill movement of water and sediments impact watersheds?
How do soil and rock composition influence the movement of water above ground and underground?
Through engineering and design, how has man modified and impacted the course of these natural processes?

Links to Frameworks and Standards

National

Earth and Space Science - Content Standard D:

•Land forms are a result of a combination of constructive and destructive forces. Constructive forces include crustal deforamtion, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion.
•Soil consists of weathered rocks and decomposed organic material from dead plants, animals, and bacteria. Soils are often found in layers, with each having a different chemical composition and texture.
•Water, which covers the majority of the earth's surface, circulates through the crust, oceans, and atmosphere in what is known as the "water cycle." Water evaporates from the earth's surface, rises and cools as it moves to higher elevations, condenses as rain or snow, and falls to the surface where it collects in lakes, oceans, soil, and in rocks underground.
•Water is a solvent. As it passes through the water cycle it dissolves minerals and gases and carries them to the oceans.

Science and Technology - Standard E:

•Scientific inquiry and tehnological design have similarities and differences. Scientists propose explanations for questions about the natural world, and engineers propose solutions relating to human problems, needs, and aspirations. Technological solutions are temporary' technologies exist within nature and so they cannot cotravene physical or biological principles; technological solutions have side effects; and technologies cost, carry risks, and provide benefits.
•Science and technology are reciprocal. Science helps drive technology, as it addresses quesitons that demand more sophisticated instruments an provides principles for better instrumentation and technique. Technology is essintial to science, because it provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable due to factors such as quantity, distance, location, size, and speed. Technology also provides tools for investigation, inquiry, and analysis.
•Perfectly designed solutions do not exist. All technological solutions have tradeoffs, such as sefety, cost, efficiency, and appearance. Engineers often build in back-up systems to provide sfety. Risk is part of living in a highly technological world. Reducing risk often results in new technology.
•Technological designs have constraints. Some constrains are unavoidable, for example, properties of materials, or effects of weather and friction; other contraints limit choices in the design, for example, environmental protection, human sefety, and aesthetics.
•Technological solutions have intended benefits and unintended consequences. Some consequesnces can be predicted, others cannot.

Science in Personal and Social Perspectives – Content Standard F:

•Natural Environment may contain substances (for example, radon and lead that are harmful to human beings. Maintaining environmental health involves establishing or monitoring quality

standards related to use of soil, water, and air.
•Human activities also can induce hazards through resources acquisition, urban growth, land-use decisions, and waste disposal. Such activities can accelerate many natural changes.

State

Earth and Space Science, Grades 3-5

•The Water Cycle #10 – Describe how water on earth cycles in different forms and in different locations, including underground and in the atmosphere

Earth and Space Science, Grades 6-8

•Mapping the Earth #1 – Recognize, interpret, and be able to create models of the earth's common physical features in various mapping representations, including contour maps.
•Earth's History #6 Describe and give examples of ways in which the earth's surface is built up and torn down by natural processes, including deposition of sediments, rock formation, erosion, and weathering.

Technology/Engineering, Grades 6-8

Materials, Tools, and Machines
Broad Concept: Appropriate materials,tools,and machines enable us to solve problems, invent and construct.

Engineering Design
Broad Concept: Engineering design is an iterative process involving modeling and optimizing for developing technological solutions to problems within given constraints.

•2.1 Identify and explain the steps of the engineering design process,i.e., identify the need or problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s) and redesign.
•2.2 Demonstrate methods of representing solutions to a design problem, e.g., sketches, orthographic projections, multi view drawings.

Bioengineering Technologies
Broad Concept: Bioengineering technologies explore the productionofmechanical devices, products, biological substances, and organismsto improve health and/or contribute improvement to our daily lives.

Local

CPS Curriculum: Grade 7 Earth Science:
•Earth Scientists use representations and models, such as contour maps and satellite images, to help understand the earth.
•Content Outcome #11: Students will construct countour maps to model the surface of the earth.
•Students will describe and give examples of ways in which the Earth's surface is built up and torn down by natural processes, including deposition of sediments, erosion, and weathering.

Materials required

sand, gravel, clay, modeling clay, laminated topographic maps of Lusitania wet meadow, perforated coffee cans to simulate rain, buckets, rulers, yardsticks, food coloring or other inert dye, contour ring forms, timers, large graduated cylinders and conventional and clear bottom stream tables,

Lesson development

Pre-field trip lessons include:
Venus Topography Box Activity - From this activity students will learn about: models & simulations, scale and structure.
During this activity students will use the following inquiry skills: observing systematically, using instruments, exploring, recording, inferring, imagining and communicating.

Pre-field trip readings (homework):
"Water Underground" - Three pages from Holt textbook
"Cambridge Watershed" - Introduction and background - reviewing the design/engineering goals of the recent Lusitania wet meadow and bio-swale creation in order to improve water quality.
From these readings students will build vocabulary, activate prior knowledge, access background information about the Cambridge watershed, and form their own questions.

Field trip experience at the Maynard Ecology Center:
Introductions/Field trip learnning goals and procedures
interactive watershed demonstration

Students will receive individual laminated maps to label and identify features and size dimensions on topographical map of wet meadow using felt markers.

Outdoor walk to the wet meadow site to observe actual land features and characteristics of the wet meadow.

Using topographical maps with contours, students will work together to interpret, translate and design stream table models using different soil types and materials on stream tables.
Students will construct, predict, test their models using coffee can rain simulator, observe, revise, test again using dye contaminant, interpret their results and observations and explain to other groups.

Post-field trip lessons:
Sense-making of water table model experience, discussion and follow up questions.

Possible visit from engineer from the Bioengineering Firm or Fresh Pond Reservation to answer questions and discuss career opportunities in engineering.

References

Prentice Hall Science - Dynamic Earth Teacher's Curriculum Guide
Foss - Landforms Teacher Guide
Massachusetts Science and Technology/Engineering Curriculum Framework - October 2006
National Science Education Standards, National Research Council, National Academy Press, Feb. 2001
"Water Underground" reading from Holt

Venus Topography Box - Mapping Actiivity - Project Astro Resource Notebook

Exploratorium Institute for Inquiry: Workshops
http://www.exploratorium.edu/ifi/workships/fundamentals/streamtable/index.html

Cambridge Water Department - Northeast Sector Project
http://cambridgeMA.gov/cwd/northeast sectorproject