Creating STEM Education Units with Project WET

Workshop Ideas / Group Assignments

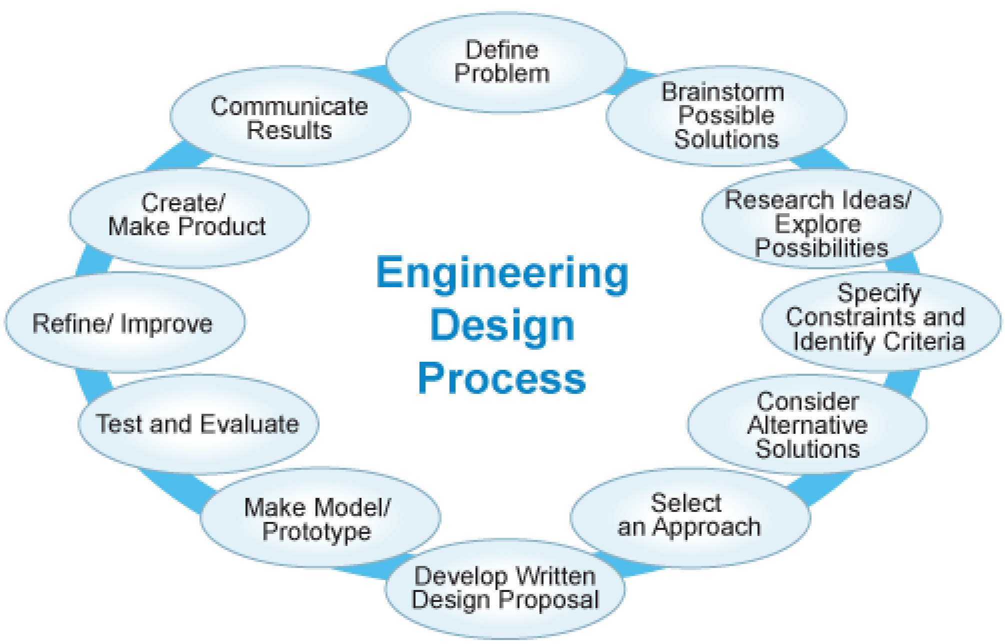
STEM Unit ideas **with Project WET and The Urban Watershed – Stormwater Edition**

- Surface Water
- Rainwater
- Groundwater
- Urban Water Distribution System and School Water Audit program
- Physical Properties of Water
- Non-Point Source Pollution
- Water Chemistry
- Water Quality
- Water Quantity
- Water Cycle

Six characteristics to incorporate

1. STEM lessons focus on real-world issues and problems. In STEM lessons, students address real social, economic, and environmental problems and seek solutions. Have the class identify a **real-world problem** within a topic or theme on campus.

2. STEM lessons are guided by the engineering design process.



The EDP provides a flexible process that takes students from identifying a problem—or a design challenge—to creating and developing a solution. In this process, students define problems, conduct background research, develop multiple ideas for solutions, develop and create a prototype or model, and then test, evaluate, and redesign them. The focus is on developing solutions.

3. STEM lessons immerse students in hands-on inquiry and open-ended exploration. In STEM lessons, the path to learning is open ended, within constraints (like available materials). The students' work is hands-on and collaborative, and decisions about solutions are student-generated. Students communicate to share ideas and redesign their prototypes as needed. They control their own ideas and design their own investigations.

4. STEM lessons involve students in productive teamwork. Helping students work together as a productive team is never an easy job. It becomes exponentially easier if all STEM teachers at a school work together to implement teamwork, using the same language, procedures, and expectations for students.

5. STEM lessons apply rigorous math and science content your students are learning. In your STEM lessons, you should purposely connect and integrate content from math and science courses. Students can then begin to see that science and math are not isolated subjects, but work together to solve problems. This adds relevance to their math and science learning. In STEM, students also use technology in appropriate ways and design their own products (also technologies).

6. STEM lessons allow for multiple right answers and reframe failure as a necessary part of learning.

STEM web resources:

TeachEngineering

NASA STEM lesson

USGS Water Education

National Geographic GIS

STEMWorks

Standards

NGSS Performance Expectations for Earth Systems

2-ESS2-1. Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.

2-ESS2-2. Develop a model to represent the shapes and kinds of land and bodies of water in an area.

2-ESS2-3. Obtain information to identify where water is found on Earth and that it can be solid or liquid.

3-ESS2-1. Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.

4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.

4-ESS2-2. Analyze and interpret data from maps to describe patterns of Earth's features.

5-ESS2-2. Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.

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.

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

GSE Earth and Space Science

S1E1. Obtain, evaluate, and communicate weather data to identify weather patterns.

S2E3. Obtain, evaluate, and communicate information about how weather, plants, animals, and humans cause changes to the environment.

S3L2. Obtain, evaluate, and communicate information about the effects of pollution (air, land, and water) and humans on the environment.

S4E3. Obtain, evaluate, and communicate information to demonstrate the water cycle.

S4E4. Obtain, evaluate, and communicate information to predict weather events and infer weather patterns using weather charts/maps and collected weather data.

S5E1. Obtain, evaluate, and communicate information to identify surface features on the Earth caused by constructive and/or destructive processes.

S6E3. Obtain, evaluate, and communicate information to recognize the significant role of water in Earth processes.

S7L4. Obtain, evaluate, and communicate information to examine the interdependence of organisms with one another and their environments.

S8P5. Obtain, evaluate, and communicate information about gravity, electricity, and magnetism as major forces acting in nature.

SES3. Obtain, evaluate, and communicate information to explore the actions of water, wind, ice, and gravity as they relate to landscape change.

SES5. Obtain, evaluate, and communicate information to investigate the interaction of solar energy and Earth's systems to produce weather and climate

SES6. Obtain, evaluate, and communicate information about how life on Earth responds to and shapes Earth's systems.

GSE Math

MGSE6.NS.7b Write, interpret, and explain statements of order for rational numbers in real-world contexts.

MGSE6.NS.3 Fluently add, subtract, multiply, and divide multi-digit decimals using the standard algorithm for each operation.

MGSE6.EE.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.

MGSE6.G.1 Find area of right triangles, other triangles, quadrilaterals, and polygons by composing into rectangles or decomposing into triangles and other shapes; apply these techniques in the context of solving real-world and mathematical problems.

MGSE7.EE.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.

Surface Water Unit

Objectives:

- Identify the components of a watershed
- Simulate a watershed and begin to understand how it functions
- Predict where water will flow in a watershed
- Recognize that population growth and settlement cause changes in land use.
- Analyze how land use variations in a watershed can affect the runoff of water.
- Understand how surface water is managed through containment and distribution.
- Using Google Earth and Web2.0 tools to analyze real-life location.

Standards:

NGSS PE Earth Systems Science

2-ESS2-1. Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.

5-ESS2-2. Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.

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.

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

Georgia Standards of Excellence Science

S2E3. Obtain, evaluate, and communicate information about how weather, plants, animals, and humans cause changes to the environment.

S5E1. Obtain, evaluate, and communicate information to identify surface features on the Earth caused by constructive and/or destructive processes.

S6E3. Obtain, evaluate, and communicate information to recognize the significant role of water in Earth processes.

S8P5. Obtain, evaluate, and communicate information about gravity, electricity, and magnetism as major forces acting in nature.

SES3. Obtain, evaluate, and communicate information to explore the actions of water, wind, ice, and gravity as they relate to landscape change.

WET Activities:

1. **Seeing Watersheds pg. 187**
    - What is a watershed?
    - What watersheds do we live in?
    - What watersheds supply our water?

Part 1 Experiment with different surfaces (wax paper and paper towel), share claims based on evidence

- What happens when water drops on a flat surface?
- What happens when water drops on a slope?
- What happens when water drops on a peak?
- How does the size of the water drop affect the way it flows down a slope?
- Can you set up a water drop race?

Continue with activity as written, use local watershed maps.

2. **Color Me a Watershed pg. 239**
   - How do growth and land development affect the watershed?
   - What happens to runoff?

The Urban Watershed – Stormwater Edition Activities:

3. **Watershed in Your Hand pg. 15**
   - What is the difference between a natural and man-made watershed?
   - What happens to water in each type of watershed?

4. **Greening the Asphalt pg. 103**
   - How can water be managed in a city environment?

Design Challenge: Stormwater management

Real-world problem: Urban Stormwater needs to be managed to reduce erosion and runoff, and increase ground absorption and water distribution.

Each group will design a neighborhood that employs water management systems that include the following:

- Porous concrete
- Berms and Swales
- Rain Barrels and Cisterns
- Rain Gardens
- Curb cuts to basins

Step 1: Define the Problem you are trying to solve

Step 2: Develop Design Criteria

Students define problem, conduct background research, develop multiple ideas for solutions, develop and create a prototype or model. Support design claims based on evidence.

Research each of these materials using all resources at your disposal.

Discover how you can quantify the amount of water involved

Rainwater Unit

Objectives

- Understand the Engineering Design Process
- Calculate that the amount of water that could be harvested off of a portion of roof.
- Design a model of a rainwater harvesting system and rain garden to control runoff and erosion.
- Design a mathematical model to test the rainwater harvesting system.
- Make claims based on evidence
- Apply understanding of watershed dynamics to real-life objective of capturing and storing surface water.

Standards:

NGSS PE Earth Systems Science

3-ESS2-1. Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.

GSE Earth and Space Science

S1E1. Obtain, evaluate, and communicate weather data to identify weather patterns.

S2E3. Obtain, evaluate, and communicate information about how weather, plants, animals, and humans cause changes to the environment.

S4E3. Obtain, evaluate, and communicate information to demonstrate the water cycle.

S4E4. Obtain, evaluate, and communicate information to predict weather events and infer weather patterns using weather charts/maps and collected weather data.

SES5. Obtain, evaluate, and communicate information to investigate the interaction of solar energy and Earth's systems to produce weather and climate

GSE Mathematics

MGSE6.G.1 Find area of right triangles, other triangles, quadrilaterals, and polygons by composing into rectangles or decomposing into triangles and other shapes; apply these techniques in the context of solving real-world and mathematical problems.

MGSE7.EE.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.

WET Activities

1. **Storm Water pg. 395** add maps of local area to identify surfaces
   - What are the pervious surfaces surrounding your school and how do they work?
   - What are the impervious surfaces and what happens when it rains?
   - How could you best manage runoff at your school?

2. **The Thunderstorm pg. 209**
   - Are there seasonal changes to the amount of rainfall in your area?
   - Record and map rainfall

3. **Just Passing Through pg. 163**
   - How do slope and plant material control water flow?
   - What are the BMPs to reduce erosion?

4. **Rainy Day Hike pg. 169**
   - Where are the areas of runoff and most erosion?
   - Is there an ideal area for a raingarden? Are there gutter downspouts where water could be collected?

The Urban Watershed – Stormwater Edition Activities

5. **How Much Water Falls Here? pg. 67**
   - What is the volume of water that falls onto an area?
   - Why is it important to slow runoff from impervious surfaces?

6. **Rain Gardens and Rain Barrels pg. 134**

Design Challenge: Manage Stormwater at your school address

Real-world problem: Stormwater needs to be managed at our school address to reduce erosion and runoff, and increase ground absorption and water distribution.

Students will

- Design rainwater harvesting systems
- Design landscaping that will help manage stormwater runoff
- Design Infrastructure to care for the plants and excess water

Calculating Runoff

What would you need to know to calculate the amount of runoff from a particular place?

V_{runoff} (gal) = A(ft^2) x Rainfall x C_w (C_w is runoff coefficient)

- C_w is a percentage of water that runs off of a particular type of surface.
- It would be a fraction of 100, with no units
  - Soccer Field $C_w = 0.17$
  - Gravel $C_w = 0.65$
  - Asphalt $C_w = 0.90$
  - Typical Rooftop $C_w = 0.90$

V_{runoff} (gal) = A(ft^2) x Rainfall x C_w (C_w is runoff coefficient)

- Rainfall is usually measured in inches and area in square feet
- 1 ft = 12 inches
- 1 ft^3 = 7.48 gallons

So our conversion factor will be:

$$\left(\frac{7.48gal}{ft^3}\right)\left(\frac{ft}{12in}\right)=\frac{0.623gal}{ft^2\cdot in}$$

- V_{runoff} (gal) = A(ft^2) x Rain(in) x $\left(\frac{0.623gal}{ft^2\cdot in}\right)$ x C_w

1. Design a Rainwater Harvesting System

- Understand the Engineering Design Process
- Calculate that the amount of water that could be harvested off of a portion of roof.
- Design a model of a rainwater harvesting system.
- Design a mathematical model to test the rainwater harvesting system using “Excelets” http://academic.pgcc.edu/~ssinex/excelets/
- Make claims based on evidence

Step 1: Define the Problem you are trying to solve

Sustaining plants that can control stormwater year round through the most efficient use of available water.

Step 2: Develop Design Criteria

1. *How much water do your plants need?*
2. *Where is your water coming from?*
3. *How much rain can you harvest in total and month by month?*
4. *Would there be times when you have to add or discharge water?*
5. *Where are you delivering your water?*

6. *How are you delivering your water?*

Step 3: Identify Design Constraints

* Annual and monthly rainfall
* Best Location for plants
* Storage capacity of barrels
* Money
* Space
* Overflow

Step 4: Create the Engineering Model

How much water could you harvest off a portion of your roof?

- What is your Claim:
- What Evidence (Data) Supports the Claim:
- Reasoning (links claim and evidence):

What is the maximum amount that the system would need to handle in one month?

- What is your Claim:
- What Evidence (Data) Supports the Claim:
- Reasoning (links claim and evidence):

Draw your model, address each design constraint

Step 5: Evaluating Model and redesigning for need

How many Rain Barrels do we need in our system? Consider:

* *What is the area of land that we want to water?*
* *What are the plants' water requirements?*
* *How much space do we have for the rainwater harvesting system?*
* *How much money do we have to build our system?*
* *How many 55 gallon drums will be used to store water?*

2. Landscape Design to control stormwater

Design a rain garden in an area where stormwater runoff collects or erosion occurs near an impervious surface area.

What types of plants are best?
How many plants will you need?
How are these plants cared for?
What planting design is most effective to control stormwater runoff?
What preparation is needed for the soil and drainage in area?

3. Rainwater distribution system

How will we distribute the water to the plants efficiently?

Who will maintain the system?

How will overflow or empty barrels be handled?

Annual Water Requirements for different landscape types: (inches/sq ft/year) (1 in=0.62 gal/ft2)

Xeriscape Vegetation		Non-native & Ornamental		
Low Water Use	Medium Water Use	High Water Use	Citrus	Turf
9.87	19.74	34.16	49.34	60.73

Groundwater Unit

Objectives:

- Characterize the groundwater system in terms of its components, composition, and its role in the hydrologic cycle.
- Demonstrate the interconnection between surface water and groundwater.
- Employ science and engineering practices of analysis, comparison and modeling to develop understanding of groundwater behavior and response to human involvement.
- Apply understanding of groundwater to real-life objective of finding a contaminant source or using water.
- Explain that engineers use mathematical modeling to make predictions about a design problem.
- Describe how engineers take water samples and analyze data to determine where groundwater contaminants come from and where they are going.
- Identify several methods for cleanup of contaminated groundwater used by engineers.
- Understand the work of a geohydrologist and the STEM connections to that career path.

Standards:

NGSS

4-ESS2-2. Analyze and interpret data from maps to describe patterns of Earth's features.

5-ESS2-2. Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.

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.

MS-ETS1-1 Engineering Design Students who demonstrate understanding can:
Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

GSE Earth and Space Science

S2E3. Obtain, evaluate, and communicate information about how weather, plants, animals, and humans cause changes to the environment.

S3L2. Obtain, evaluate, and communicate information about the effects of pollution (air, land, and water) and humans on the environment.

S5E1. Obtain, evaluate, and communicate information to identify surface features on the Earth caused by constructive and/or destructive processes.

S6E3. Obtain, evaluate, and communicate information to recognize the significant role of water in Earth processes.

S7L4. Obtain, evaluate, and communicate information to examine the interdependence of organisms with one another and their environments.

S8P5. Obtain, evaluate, and communicate information about gravity, electricity, and magnetism as major forces acting in nature.

SES6. Obtain, evaluate, and communicate information about how life on Earth responds to and shapes Earth's systems.

WET Activities

1. **Get the Ground Water Picture pg. 143**
    - What is groundwater?
    - What parts make up the groundwater system?
    - Is groundwater static? If not, how does water move through the groundwater system?
    - Why is groundwater important
    - Who needs information about the groundwater system and how do they get it?

2. **A Grave Mistake pg. 315**
    - How do we find out what is happening underground in the groundwater system?

    What is your Claim:

    What Evidence (Data) Supports the Claim:

    Reasoning (links claim and evidence):

3. **The Pucker Effect pg. 363**

Hydro-geologists are called upon to characterize a contamination site.

- How do they locate the length and breadth of a contamination plume?
- Where is the most likely source of contamination in your well field?
- How did you locate the contamination?
- How could you improve the accuracy of your location?
- Graph it, cite evidence and reasoning to substantiate your claims

4. **Make a Mural pg. 515**

Design Challenge: Locate a contaminant spill

Student teams locate a contaminant spill in a hypothetical site by measuring the pH of soil samples. Then they predict the direction of groundwater flow using mathematical modeling. They also follow the steps of the engineering design process to come up with alternative treatments for the contaminated water. (TeachEngineering.org: Groundwater Detectives)

Real-world issue: Groundwater is vulnerable to surface activity and is related to surface water. How does a geohydrologist assess movement of water through a local groundwater system?

Discussion = How do hydro-geologists Manage a groundwater system?

Step 1: Define the Problem you are trying to solve

Step 2: Develop Design Criteria

Step 3: Identify Design Constraints

Step 4: Create the Engineering Model

- What is your Claim:
- What Evidence (Data) Supports the Claim:
- Reasoning (links claim and evidence):

Step 5: Evaluating Model and redesigning for need

Urban Water Management System Unit

Objectives:

- Apply the Engineering Design Process.
- Calculate the percentage of fresh water available for human use on Earth.
- Describe major water user categories and how each consumes water.
- Demonstrate the complexity of sharing water resources with all users in a watershed.
- Provide reasons why humans should monitor what enters the water system.
- Providing clean water for human use is a complicated and costly process.
- Calculate water use at home and its cost.
- Apply understanding of the process of clean water distribution and how to control its overuse and cost.

Standards:

NGSS Performance Expectations for Earth Systems

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

GSE Earth and Space Science

S2E3. Obtain, evaluate, and communicate information about how weather, plants, animals, and humans cause changes to the environment.

S3L2. Obtain, evaluate, and communicate information about the effects of pollution (air, land, and water) and humans on the environment.

S5E1. Obtain, evaluate, and communicate information to identify surface features on the Earth caused by constructive and/or destructive processes.

S6E3. Obtain, evaluate, and communicate information to recognize the significant role of water in Earth processes.

S8P5. Obtain, evaluate, and communicate information about gravity, electricity, and magnetism as major forces acting in nature.

SES3. Obtain, evaluate, and communicate information to explore the actions of water, wind, ice, and gravity as they relate to landscape change.

SES6. Obtain, evaluate, and communicate information about how life on Earth responds to and shapes Earth's systems.

GSE Economics

SS1E2 Explain that scarcity is when unlimited wants are greater than limited resources.

SS1E3 Describe how people are both producers and consumers.

SS3E1 Define and give examples of the four types of productive resources.

SS4E2 Identify the elements of a personal budget (income, expenditures, and saving) and explain why personal spending and saving decisions are important.

SSEF1 Explain why limited productive resources and unlimited wants result in scarcity, opportunity costs, and tradeoffs for individuals, businesses, and governments.

WET Activities:

1. **A Drop in the Bucket pg. 257**
   - How much water do we really have?
2. **8-4-1 One for All pg. 299**
   - Who uses water and what are their needs?

3. **A-maze-ing Water pg. 231**
    - How do activities in your home affect water quality?
4. **Urban Waters pg. 413**
    - What careers are involved in providing reliable and safe water to homes and ensuring that used water is transported treated properly?
5. **Money Down the Drain pg. 351**
    - How much water and money are wasted due to leaky fixtures?

The Urban Watershed – Stormwater Edition Activities:

6. **River to River pg. 35**
    - What is involved in cleaning our water for use?
7. **Personal Water Audit pg. 125**
    - How much water do you and your family use?

Design Challenge: Design a School Water Audit Program

Real-life problem: School water use is undocumented and assessment is necessary to determine waste and inefficiency.

Draw a concept map showing what is involved in providing reliable and safe water to homes and ensuring that used water is treated properly (suggest Prezi)

Add to your concept map showing various uses of water in volume in homes, businesses, and schools.

Create a plan to assess water use at the school (indoor and outdoor) and the function of faucets.