Raising the Green Roof:

An Elementary Water Cycle Unit

University of Missouri Missouri S&T

August 2021

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Lesson 1: The Problems

Lesson Summary

Ecological problems created with current city development patterns

Outline of Activities

Pre-model	10 minutes
Activity 1.1: The Barren Landscape – Compare rain in the city vs. nature (**Discussion, Video** & Worksheet)	10 minutes
▪ **Worksheet 1.1: Nature vs. Urban**	15-20 minutes
Activity 1.2: Can you catch the water – Watershed (**Discussion**, Hands-on with plastic tarps and spray bottles, Worksheets)	10 minutes
▪ **Hands-on/Worksheet 1.2.1**: Watershed Model	30-40 minutes
▪ **Game/Worksheet 1.2.2 (Optional):** Bingo Worksheet	15-20 minutes
Activity 1.3: From Rain to Drain – Examine water flow on your school (**Walking Tour** to school campus with water to pour on various surfaces, Worksheet, Discussion)	15 minutes [outside]
▪ **Worksheet 1.3.1: Where Does the Stormwater go?**	15 minutes
▪ **Worksheet 1.3.2 (Extension): How much stormwater runoff at school can you reduce?**	15 minutes
Activity 1.4 (Optional): Urban Heat Island	15 minutes

**Please record the highlighted activities using Swivl*

Preparation Alert

Lesson	Materials need to be provided by	
	Teachers	**Students**
1.3	Before the walk around with students, plan a route to pinpoint the location of storm water fixtures (downspouts, scuppers, floor grating, storm water drains, etc.). This is an OK activity to do rain or shine	Bring a raincoat if it will be raining

Model 1

Refer to Student Modeling Packet

(10 minutes)

Activity 1.1. The Barren Landscape

Lesson:	Problems	Day 1 Time Frame: 15 mins	Grade level: 4
Desired Outcome from Lesson: Surfaces in a built environment absorb less water than the natural environment.			
Topic of Lesson: The impact of the built environment on the water cycle process			
Students' Goals of the Day: Students will be able to identify two different types of environment (natural and rural) and compare how they interact in a rain event.			
Essential Vocabulary: ▪ ***Barren Landscape*** – Surfaces on the earth that have little or no soils and plants. ▪ ***Impervious Surfaces*** – Surfaces, such as asphalt, roofs, and sidewalks, where water cannot readily absorb into the ground. ▪ ***Natural environment (rural)*** – Open land with low population density, therefore fewer homes or other buildings. ▪ ***Permeable Surfaces*** – Surfaces where water can readily absorb into the ground. ▪ ***Stormwater Runoff*** – Rainfall that flows over the ground surface. ▪ ***Urban Environment (built)*** – A human settlement with high population density and infrastructure, such as cities, towns, or suburbs.			

Teaching

Material

- Worksheet 1.1 (one per student)
- Powerpoint presentation
- Video Designing Neighborhoods for People and Wildlife on Vimeo

Instruction

- Student groups of 3-5
- Distribute Worksheet 1.1
- Evaluating the Settings:
  - Show two photos in Lesson 1 PowerPoint presentation, the urban setting and the rural (natural) setting.
  - Ask students to label the pictures in Worksheet 1.1

Discussion Questions (Follow worksheet prompts within the group)

- What are the differences between the two environments?
- What will happen if it rains in both environments.
- What elements in the scene would create an increase or decrease in stormwater runoff in each environment?
- What does the water pick up along the way in each environment?
- Note the potential for erosion in the natural environment
- Potential to pick up pollutants in the urban environment on the way to the drain
- Ask: which landscape is barren? A or B?

Play Video

- Show ASLA Video – Designing Neighborhood for People and Wildlife (5 min) Designing Neighborhoods for People and Wildlife on Vimeo

Worksheet 1.1. Nature vs Urban

Name:_____ Class:_____ Date:_____

		
1. What will happen when it rains?		
2. Where will all the stormwaters go to?		
3. List characteristics in the picture that would **increase** the movement of water (stormwater runoff)		
4. List characteristics in the picture that would **decrease** the movement of water (stormwater runoff)		
5. List pollutants that rainwater could pick up		

Answer sheet 1.1. Nature vs. Urban

Name:_____ Class:_____ Date:_____

	A 	B 
1. What will happen when it rains?	- muddy - puddles - flood - erosion - increased levels of water surfaces in the rivers and creeks	- rainwater will go to the drains - storm water drain may overflow during a heavy storm - flood - increased level of water surfaces in the rivers and creeks
2. Where will all the stormwaters go to?	- River, creek, lake, sea	- Stormwater drains - River, lake, sea
3. List characteristics in the picture that would **increase** the movement of water (stormwater runoff)	- Valleys - Slopes in the landscape	- Steep surfaces - Road, street, parking lot, and other hard surfaces
4. List characteristics in the picture that would **decrease** the movement of water (stormwater runoff)	- Plants, trees, grass, forest - Flat surfaces	- Parks
5. List pollutants that rainwater could pick up	- Nitrogen from the soil erosion - Animal droppings	- Trash - Oil dropping - Hydraulic fluid - Pesticide - Dog's poop

Activity 1.2. Can You Catch the Water?[1]

Lesson:	Problems	Day 2 Time Frame: 45 mins (w/ 15mins optional extra)	Grade level: 4
Desired Outcome from Lesson: Students will understand how the water flow in the landscape and how pollutant can affect water source			
Topic of Lesson: Introduction to the water cycle in the natural environment			
Students' Goals of the Day: Students will be able to model water catchment basin using everyday objects to form hills, mountains, valleys, and water sources			
Essential Vocabulary: ▪ ***Catchment basin*** – Where your water comes from. ▪ ***Gravity –*** An invisible force that pulls objects toward each other. Earth's gravity is what keeps you on the ground and makes things fall. ▪ ***Hydrosphere*** – All the waters on and over the earth's surface, such as lakes, seas, and clouds. ▪ ***Impervious Surfaces*** – Surfaces, such as asphalt, roofs, and sidewalks, where water cannot readily absorb into the ground. ▪ ***Landforms*** – Natural parts of the earth and land such as mountains, hills, valleys, rivers, streams. ▪ ***Model*** – A small object that represents another larger object. ▪ ***Permeable Surfaces*** – Surfaces where water can readily absorb into the ground. ▪ ***Pollutant*** – A substance that pollutes something, especially water or the atmosphere. ▪ ***Topography*** – The surface features of a place or region on a map that shows landform locations and elevations. ▪ ***Urban (built) Environment*** – A human settlement with high population density and infrastructure, such as cities, towns, or suburbs. ▪ ***Water cycle*** – How water circulates through the earth and atmosphere. ▪ ***Watershed*** – The boundary of an area where waters flow to the same catchment basins ▪ ***Water quality*** – Characteristic of water that determines its suitability for various uses.			

[1] Adapted from Tech Engineering: Can You Catch the Water? (for Informal Learning) - Sprinkle - TeachEngineering

Teaching

PLEASE RECORD THIS LESSON ON SWIVL

Material (by teacher)

- Blank notecards and pencils

Pre-Activity Discussion

- **Brainstorm:** Have students write down everything they know about streams or rivers and everything that affects rivers and streams (3 minutes).
- Write the items on the board. Categorize them in **water quality** (pollution), **precipitation** (climate, weather, rain, snow, dry, etc.), **location** (landforms, mountains, plains, valleys, hills, etc.), **life** (animal life, plant life, human activities, soil, etc.), **human impact** (dams, diversions, buildings, factories, water collection, canals, levees). If they don't say these words, teachers can prompt them.

Instruction

- All the things we just listed and discussed affect our water source that will determine whether the source of water is clean enough to use for drinking or showering. Have you ever looked carefully at a water stream or river? Did it look clean or muddy? Many things can affect the water in rivers or streams. Sometimes the water looks really clean, but it may not be clean because of invisible pollutants or tiny bugs that live in the water. How can we tell if the water is clean?
- Let's first figure out where this water comes from and how it gets to a specific stream or river.
- We will now create a watershed and catchment basin model.

Hands-on Activity: Watershed model

Material (provided)

- A variety of objects to build landforms, such as small cups, jars, bowls, plates, rocks, blocks, crunch paper towels, etc.
- Sheet of lightweight plastic, ~1x1 m (a slit-open trash bag works well)
- Spray bottle filled with water to deliver "rain" to the catchment basin
- Masking tape to hold items in place, to secure the plastic sheet
- Sponge (green and another color)
- Food coloring
- Little rocks or something heavy that can weigh down plastic

Material (by teacher)

- Worksheet 1.2.1 – one per group
- Newspaper

Instruction

Divide the class into teams of three students. Provide each team with a work area (1.5 x 1.5m each), material, and worksheets. This activity can be done outside if preferable/possible.

Part 1

- Distribute the Material. Each group will have 1 set of everything
- **Create Landforms:** You will design your own landform using the provided materials. The landform can look any way you want. The tallest objects represent mountains, the other objects represent hills, lakes, and plains. Suggest that they arrange objects to create valleys and low spots.

- **Lay the ground:** Next, have students lay the plastic sheet over the top of their entire area (land), including all the land-form objects. Have them loosely model the plastic around

the covered objects. Use masking tape to secure the positions of the objects and the plastic as much as needed.

- **Predict:** On their worksheets, have students write down their predictions about what will happen if it rains on their model. Where will the water go? Will it go faster in some places? Why?

Part 2 (this part can be done the next day if time runs out)
Students will now simulate the water cycle on their land forms.

- Distribute **Worksheet 1.2.1** and take a photo of your watershed model.
  - **Define the Features:** Choose one small pool or puddle of water on your models to be the water collection designated site for the people who live on this land.
  - Using the model, **define catchment basin and watershed**. Explain that the places where the water goes, where it hits, where it flows are all in the catchment basin for that site.
  - The **watershed** is the basin boundary or edge of the plastic wrap.
  - **Label** the features in your worksheet.

- **Make it rain:** Use the spray bottle to create rain on top of the highest mountain (the tallest object). Continue the rain until streams, rivers, and lakes form. Watch how the water moves from the mountaintop down into the model.

- **Watch the Flow:** what directs the flow of water through a watershed or catchment basin? Why does it go one way and not the other? How do different catchment basins and watersheds develop? Water flow is directed through rivers and streams by **gravity**.

- **Experiment:** Conduct the following experiments within your catchment basin to simulate real-life natural and human-caused activities that could happen in a catchment basin and/or watershed. Adapt your model for one of these scenarios and use the spray bottle to make it rain again. How does the flow of water change?

  - What happens if a dam is put into the stream that flows into your catchment basin?
  - What happens if a forest is planted above the catchment basin
  - What happens if we build an industry or factory that generates pollution
  - What happens when people use the water from your steam that flows into your catchment basin to irrigate their crops?

- Complete **Worksheets 1.2.1.** Conclude by holding a class discussion to share and compare results.

Post-Activity Assessment

***Closing Discussion*:** Lead a class discussion by asking the following questions and posing the following scenarios to the students in their groups:

- What factors affected where the rain flowed in our catchment basins?
- What would happen to the water in the valley if you poured a pile of salt on the mountain above your catchment basin? (This might represent mining, mineral, and chemical waste.)
- What are three things that might happen to your catchment basin that would affect water quality?
- Suppose the community in a watershed near yours needed some drinking water. How could an engineer help move some of your water to share with the other watershed?
- How might the flow of water in a catchment basin be different in different seasons?
- How might the flow of water in a catchment basin be different in different climates?
- What kinds of human activities might affect the catchment basin?
- How might engineers help clean up the industry pollution to a catchment basin?

Worksheet 1.2.1. Can you Catch the Water?

Name:_____ Class:_____ Date:_____

Direction:

1. Take a photo of your model.
2. Label where is the watershed and catchment basin on the photo of your model
3. As you experiment with your catchment model, answer the questions below by labeling the photo.

Answer questions # 1-5 by labeling the model.

1. ***Prediction:*** What will happen if it rains on your catchment basin model? Where will the water go? Will it go faster in some places? Why?
2. Watch the water flow to your collection site. Where does it come from?
3. What elements in your model determine the watershed?
4. What elements in your landscape determine what water will be part of your basin?
5. What elements in your model determine the direction of water flows?

Answer questions no 6-9 on the lines below.

6. What happens if a dam is put into a stream that flows into your catchment basin?

_____

_____

7. What happens if a forest is placed above your catchment basin? [Use sponge to mimic a forest]

_____

_____

8. What happens if an industry that causes pollution moves into your basin? [Now pretend that your sponge is a factory by putting pollution (food dye) on the bottom of sponge and seeing where it goes when it rains.]

_____

_____

9. What might happen if someone uses the water from your stream that flows into your catchment basin for irrigating his or her crops or to take away to another city?

_____

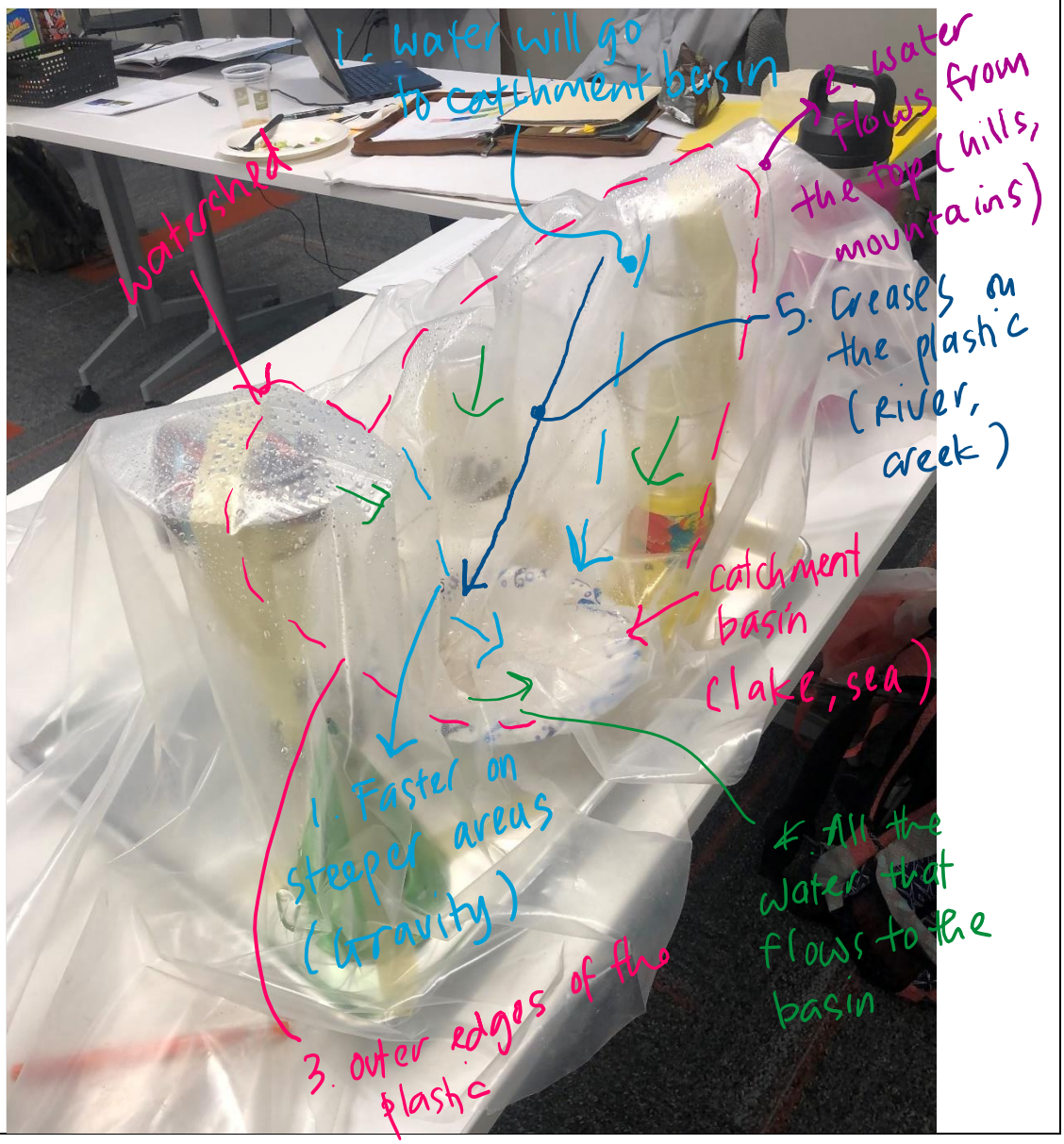
_____

Answer sheet 1.2.1. Can you Catch the Water?

Name:_____ Class:_____ Date:_____

Direction:

1. Take a photo of your model.
2. Label where is the watershed and catchment basin on the photo of your model
3. As you experiment with your catchment model, answer the questions below by labeling the photo.



Answer questions # 1-5 by labeling the model.

1. ***Prediction:*** What will happen if it rains on your catchment basin model? Where will the water go? Will it go faster in some places? Why?
2. Watch the water flow to your collection site. Where does it come from?
3. What elements in your model determine the watershed?
4. What elements in your landscape determine what water will be part of your basin?
5. What elements in your model determine the direction of water flows?

Answer questions # 6-9 on the lines below.

6. What happens if a dam is put into a stream that flows into your catchment basin?

   The water stream will stop and will not reach the catchment basin.
7. What happens if a forest is placed above your catchment basin? (Use sponge to mimic a forest) The water stream will be absorbed by the tree roots and eventually go to the catchment basin underground (the aquifer)
8. What happens if an industry that causes pollution moves into your basin? (Now pretend that your sponge is a factory by putting pollution (food dye) on the bottom of sponge and seeing where it goes when it rains. The pollutant will pollute the catchment basin.
9. What might happen if someone uses the water from your stream that flows into your catchment basin for irrigating his or her crops or to take away to another city?

   The catchment basin will receive less water and eventually dry up.

Game: Watershed Bingo (optional)

Material

- Worksheet 1.2.2 – one per student

Instruction

- Give each student a sheet of paper to draw a large tic-tac-toe board—a 3 x 3 grid with nine squares—that fills the entire paper.
- Have students randomly write the following vocabulary words, one per square (see below): **basin, catchment basin, gravity, landforms, model, topography, water cycle, water quality, and watershed**. Note: Direct students to write the terms in any square they want, which creates a variety of bingo boards.
- Next, have students walk around the room and find other students who can define the vocabulary terms and write down their definitions. Students must find a different student for each word. When a student has all terms defined, s/he shouts "bingo!" Continue until two or three students have bingo.
- The students who shout "bingo!" to share their definitions with the class.

Catchment Basin Where your water comes from.	**Water Cycle** How water circulates through the atmosphere.	**Model** A small object that represents in detail another, often larger object.
Water Quality Characteristics of water that determine its suitability for various uses.	**Watershed** Boundary between catchment basins that are next to each other.	**Landforms** Natural parts of the earth and land such as mountains, hills, valleys, rivers, streams.
Basin An open, enclosed area that usually holds water.	**Topography** The surface features of a place or region on a map that shows landform locations and elevations.	**Gravity** The downward pull of a planet that determines the flow of water.

Worksheet 1.2.2. Watershed Bingo

Name:_____ Class:_____ Date:_____

Activity 1.3. From Rain to Drain

Lesson:	Problems	Day 3 Time Frame: 45 mins	Grade level: 4
Desired Outcome from Lesson: Students will be able to identify stormwater runoff, watershed, and sewershed in a built environment			
Topic of Lesson: Heavy storms can cause hazards in the built environment.			
Students' Goals of the Day: Students will understand the water flow in their school setting			
Essential Vocabulary: ▪ ***Impervious Surfaces*** – Surfaces, such as asphalt, roofs, and sidewalks, where water cannot readily absorb into the ground. ▪ ***Permeable Surfaces*** – Surfaces where water can readily absorb into the ground. ▪ ***Pollutant*** – A substance that pollutes something, especially water or the atmosphere. ▪ ***Rainwater pipe*** – A pipe that attaches to the side of a home to collect rainwater from the roof. ▪ ***Roof Drain*** – A drain *that* collects rainwater on the roof. ▪ ***Scupper*** – A hole in the side of a building for draining water. ▪ ***Sewershed*** – describes an area of land and how water flows through the built environment; over the streets, sidewalks, buildings, and how it drains into pipes that carry it to treatment plants or surrounding water bodies. ▪ ***Stormwater Runoff*** - Rainfall that flows over the ground surface. ▪ ***Urban (built) Environment*** - A human settlement with high population density and infrastructure, such as cities, towns, or suburbs. ▪ ***Watershed*** – The boundary of an area where waters flow to the same catchment basin.			

Walking Tour

PLEASE RECORD THE INDOOR DISCUSSION ON SWIVL

Prepare

- Identify a few good spots on your school grounds where you can see pavement, grass, down spouts, gutters, and drains.

Material (by teachers)

- 1-2 buckets of water
- A clipboard for each student
- **Worksheet 1.3** (one for each student)
- Red markers for each student to bring in the walking tour
- Color pencils to color the worksheet in the classroom
- Calculator
- Power Point Presentation

Instruction

- **Discussion:** Do you know where the water goes after a heavy rainstorm in your school?
- **Slides**: Play power point presentation[2]
- Distribute Worksheet 1.3

School Campus Stormwater Walking Tour[3]

Utilize the school grounds to examine the water flow on your campus. This can be done rain or shine!

- **Explore & Discuss:** Walk around the school as a class with bottles of water (not needed if rain is visible). If no rain is visible, have students imagine if it is raining at school
  - Think back: Ask what students notice about stormwater flow around their school building based on what they have learned in previous lessons
- **Examine water flow:** Show how water interacts with different surfaces
  - Pour water into the soil
  - Pour water to pavement/asphalt/concrete/compacted soil/gravel and watch where the water goes
  - Follow the water to the stormwater outlet
- **Examine built environment features**: What features help or hinder water flow?

[2] https://www.asla.org/greenroofeducation/managestormwater.html

[3] Newtown Creek Alliance

  - Stormwater fixtures on the building: roof gutter, downspout, scupper, stormwater outlet/drain. Teachers can help pinpoint the locations on the map, so they are coordinated.
  - Talk about the landscape design
- **Examine what are the pollutants likely to go into the storm drain**: Oil from the cars in the parking lot, trash, plastics, pesticide from the landscape area.

Post-Walking Tour – Back to the Classroom

- Have the students form groups of 2-3.
- Complete **worksheet 1.3.1** within the group.
- Complete **worksheet 1.3.2** for extension

Worksheet 1.3.1. Where does the stormwater go in your school?

Name:_____ Class:_____ Date:_____

- Identify impervious surfaces on the map and color the hardscape brown.
- Mark the stormwater drains that you see in the parking lot with dots or crosses
- Draw blue arrows showing how the water might flow in your school in the storm event.
- Answer the questions below.

1. List the impervious surfaces you can identify in your school

_____

_____

2. List the permeable surfaces you can identify in your school?

_____

_____

3. List pollutants that are likely to go into the stormwater drain

_____

_____

4. How will these pollutants affect our waterways?

_____

_____

Christa McAuliffe School

Nieman Elementary School

Answer sheet 1.3.1. Where does the stormwater go in your school?

Name:_____ Class:_____ Date:_____

- Identify impervious surfaces on the map and color the hardscape brown.
- Mark the stormwater drains that you see in the parking lot with dots or crosses
- Draw blue arrows showing how the water might flow in your school in the storm event.
- Answer the questions below.

1. List the impervious surfaces you can identify in your school

Road, playground, sidewalk, building's roof, parking, sport's field.

2. List the permeable surfaces you can identify in your school?

Grass, ground

3. List pollutants that are likely to go into the stormwater drain

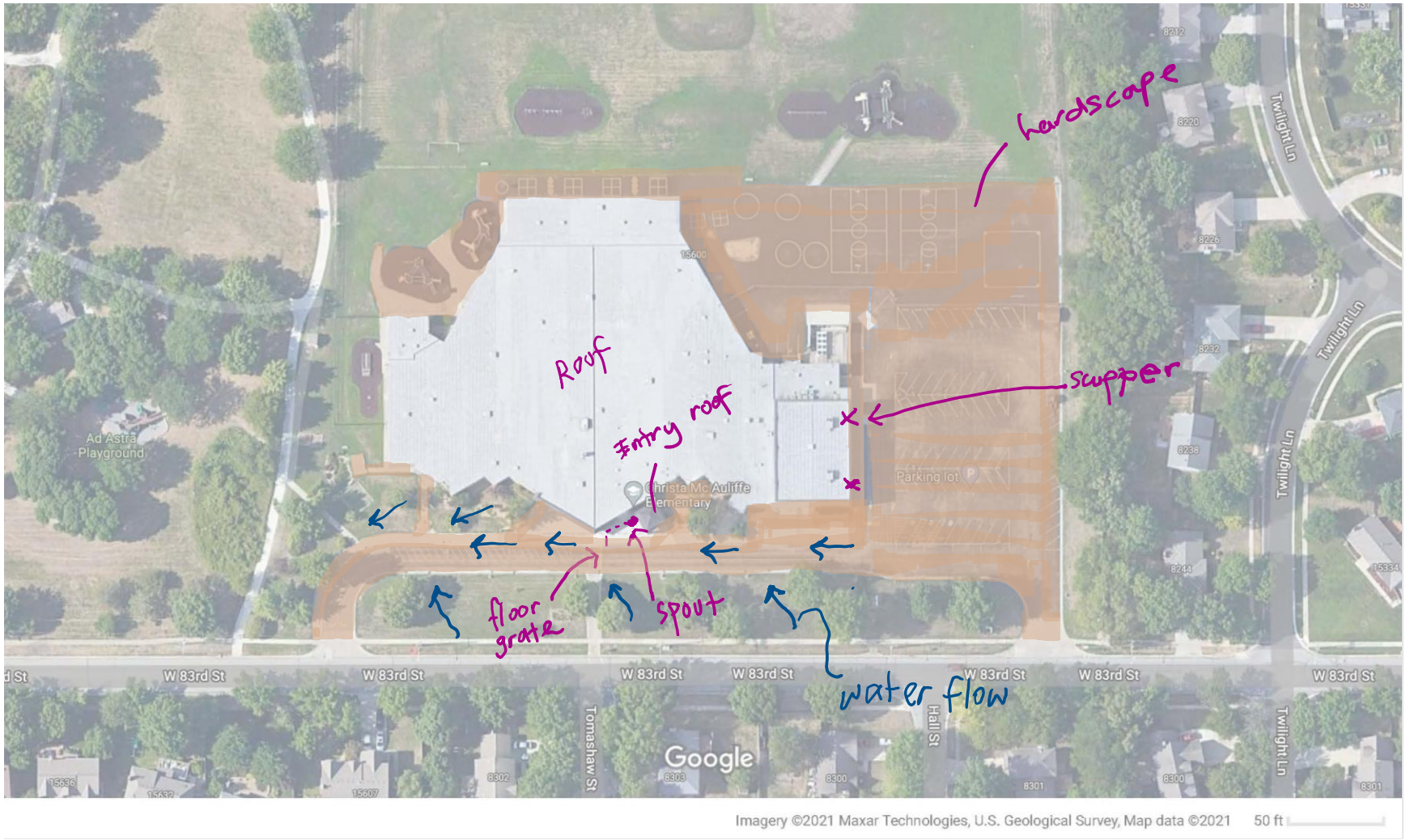
Oil from parked cars, trash, plastics, pesticide

4. How will these pollutants affect our waterways?

They will go to the stormwater drain and eventually go to the catchment basin, the source of our clean water for drinking, showering, and washing.

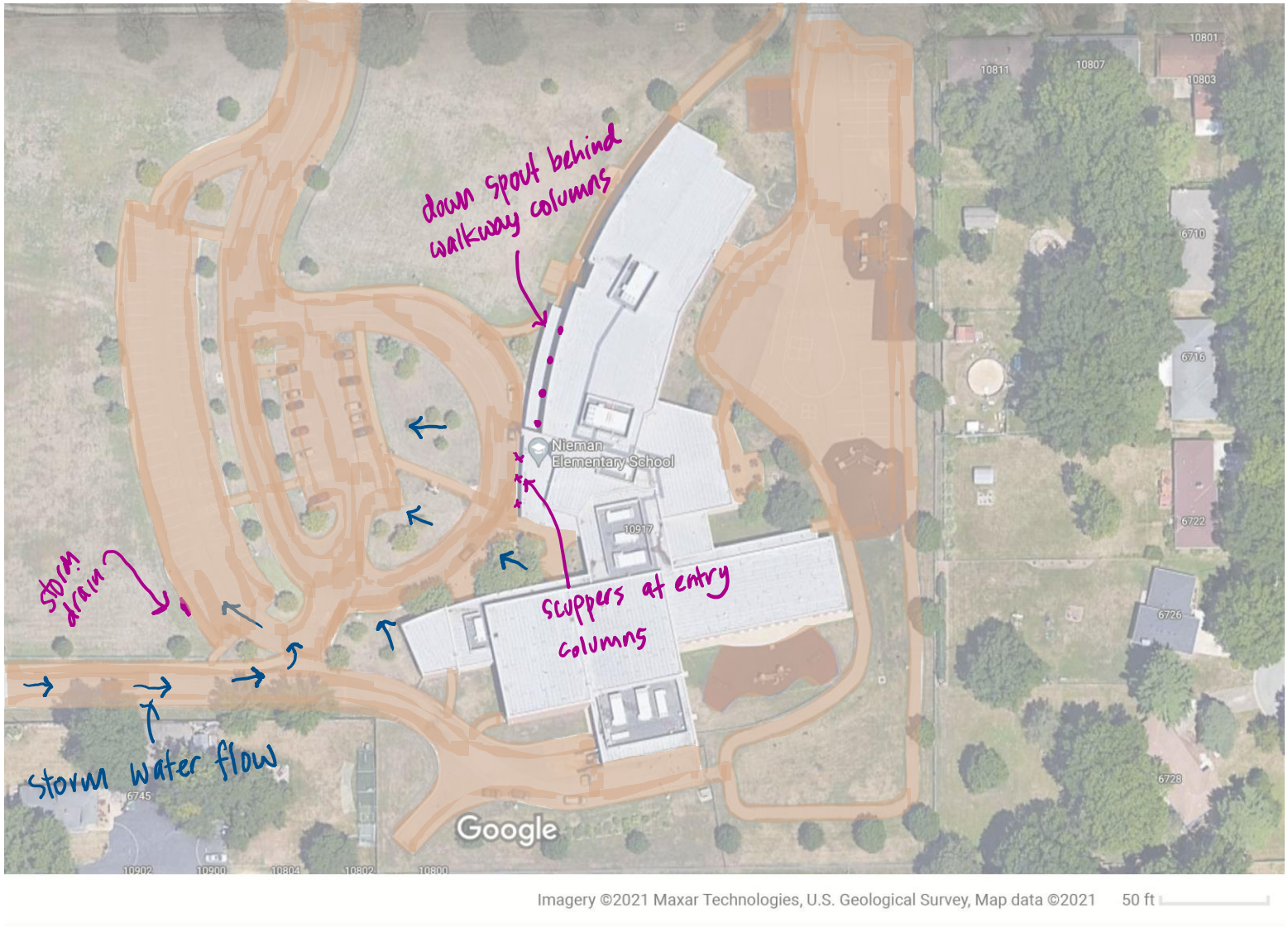
Christa McAuliffe School

This is an example of the school map mark-up in the school walk-around.



Nieman Elementary School

This is an example of the school map mark-up during the walk-around.



Worksheet 1.3.2. How much stormwater runoff at School can you reduce?

1. **Let's begin by finding the area (in square feet) for different surfaces on your campus!** Look at the map of your school, outline the surfaces and write the area:

   Hardscapes (parking, road, sidewalks…): Hardscape Area = 102,500 ft^2

   School building roof: Roof Area = 70,000 ft^2

   Now add those numbers together to find the total area of impervious surfaces:

   _____ ft^2 + _____ ft^2 = _____ ft^2
   Hardscape area | Roof Area | Total Impervious Surfaces Area

2. **Now calculate how many gallons of water hit those Impervious Surfaces.** A typical rainstorm can bring more than an inch of rain. Using **1 inch of rain accumulation** (height). 1 in of rain is equal to 0.083 feet. Use the formula below to find out how the number of cubic square feet you have on impervious surfaces:

   _____ ft^2 × 0.083 ft = _____ ft^3
   Total Impervious Surfaces Area | Total cubic square feet of rain

   Now, Using 1 ft^3 to 7.48 gallon conversion to find how many gallons of stormwater runoff are created by the impervious surfaces on your school campus

   _____ ft^3 × 7.48 = _____ gallons
   Total cubic square feet of rain | **Total gallons of stormwater runoff**

3. **You just calculated how many gallons of rainwater might hit impervious surfaces on your school campus. Why does this matter?**

Bonus: If you put a green roof on your school building, how many gallons of stormwater could you save from the drain? (You may use the backside of this sheet for your calculations).

Answer sheet 1.3.2. How much stormwater runoff at McAuliffe can you reduce?

4. **Let's begin by finding the area (in square feet) for different surfaces on your campus!** Look at the map of your school, outline the surfaces and write the area:

   Hardscapes (parking, road, sidewalks…): Hardscape Area = 102,500 ft^2

   School building roof: Roof Area = 70,000 ft^2

   Now add those numbers together to find the total area of impervious surfaces:

102,500 ft^2	+	70,000 ft^2	=	172,500 ft^2
Hardscape area		Roof Area		Total Impervious Surfaces Area

5. **Now calculate how many gallons of water hit those Impervious Surfaces.** A typical rainstorm can bring more than an inch of rain. Using **1 inch of rain accumulation** (height). 1 in of rain is equal to 0.083 feet. Use the formula below to find out how the number of cubic square feet you have on impervious surfaces:

_172,500 ft^2__	×	0.083_ft	=	_ 14,317.5 ft^3
Total Impervious Surfaces Area				Total cubic square feet of rain

   Now, Using 1 ft^3 to 7.48 gallon conversion to find how many gallons of stormwater runoff are created by the impervious surfaces on your school campus

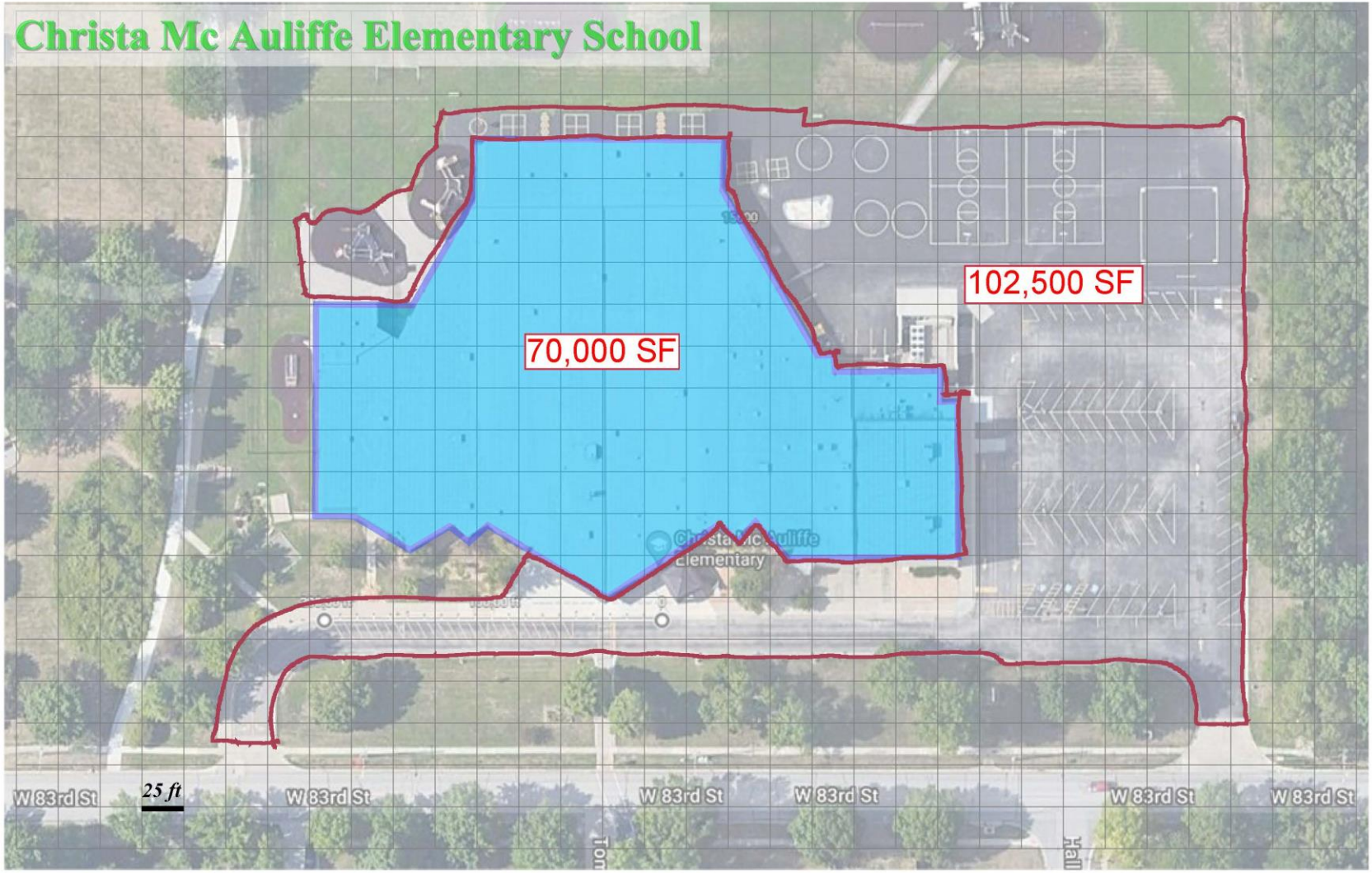
_____ _14,317.5 ft^3_____	×	7.48	=	107,095 gallons
Total cubic square feet of rain				**Total gallons of stormwater runoff**

6. **You just calculated how many gallons of rainwater might hit impervious surfaces on your school campus. Why does this matter?**

   It matters because too many impervious surfaces can cause flooding and make our water source polluted. It can also make the environment hotter and drive out natural habitats.

Bonus: If you put a green roof on your school building, how many gallons of stormwater could you save from the drain? (You may use the backside of this sheet for your calculations).

Christa Mc Auliffe Elementary School



Answer sheet 1.3.2. How much stormwater runoff at Nieman can you reduce?

1. **Let's begin by finding the area (in square feet) for different surfaces on your campus!** Look at the map of your school, outline the surfaces and write the area:

   Hardscapes (parking, road, sidewalks…): Hardscape Area = 137,500 ft^2

   School building roof: Roof Area = 57,500 ft^2

   Now add those numbers together to find the total area of impervious surfaces:

137,500 ft^2	+	57,500 ft^2	=	195,000 ft^2
Hardscape area		Roof Area		Total Impervious Surfaces Area

2. **Now calculate how many gallons of water hit those Impervious Surfaces.** A typical rainstorm can bring more than an inch of rain. Using **1 inch of rain accumulation** (height). 1 in of rain is equal to 0.083 feet. Use the formula below to find out how the number of cubic square feet you have on impervious surfaces:

195,000 ft^2	×	0.083 ft	=	16,185 ft^3
Total Impervious Surfaces Area				Total cubic square feet of rain

   Now, Using 1 ft^3 to 7.48 gallon conversion to find how many gallons of stormwater runoff are created by the impervious surfaces on your school campus

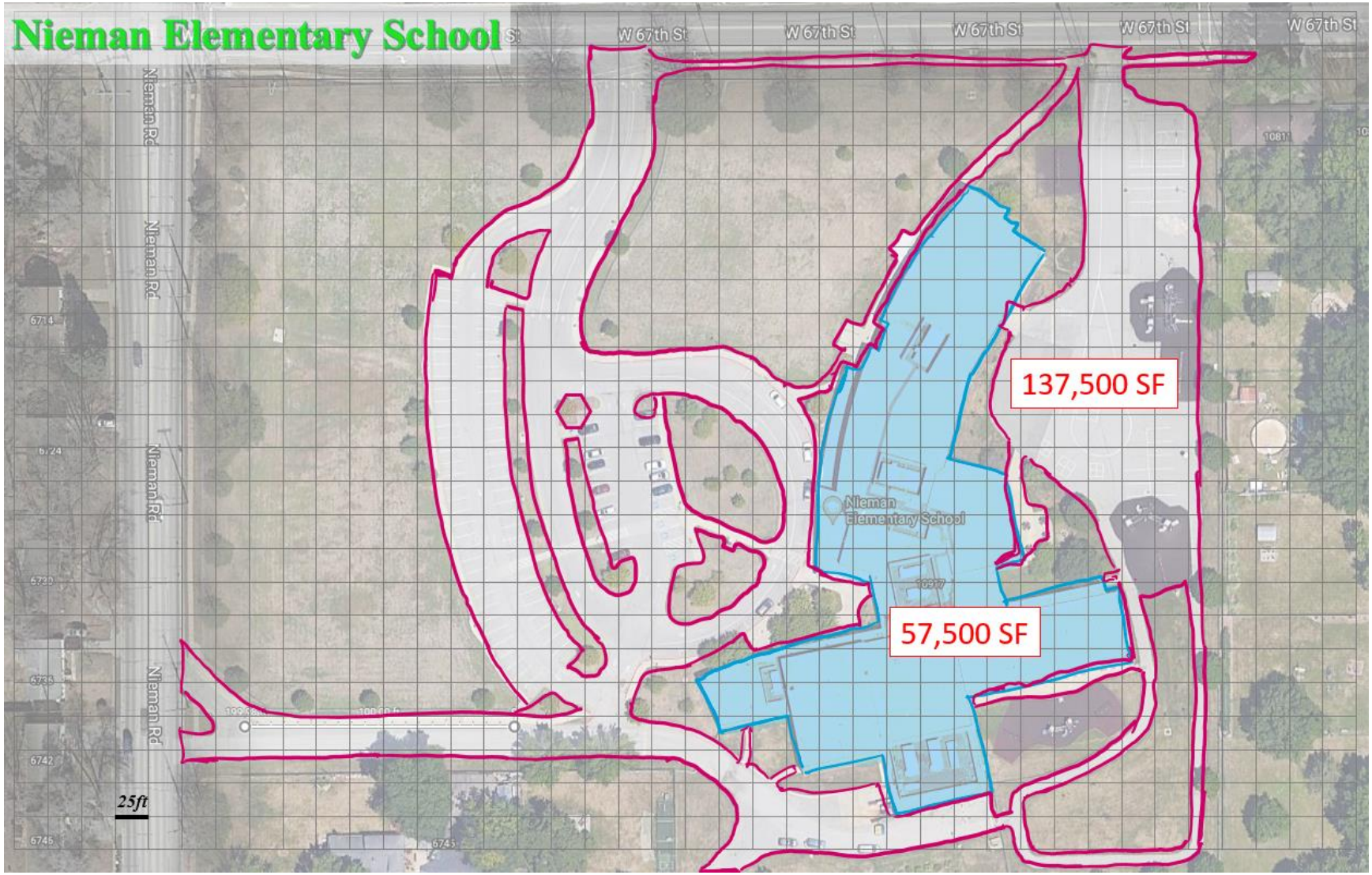
16,185 ft^3	×	7.48	=	121,064 gallons
Total cubic square feet of rain				**Total gallons of stormwater runoff**

3. **You just calculated how many gallons of rainwater might hit impervious surfaces on your school campus. Why does this matter?**

   It matters because too many impervious surfaces can cause flooding and make our water source polluted. It can also make the environment hotter and drive out natural habitats.

Bonus: If you put a green roof on your school building, how many gallons of stormwater could you save from the drain? (You may use the backside of this sheet for your calculations).

Nieman Elementary School



Activity 1.4. Urban Heat Island (Optional)

Lesson:	Problems	Day 4 Time Frame:	Grade level: 4
Desired Outcome from Lesson: Students understand what Urban Heat Island is			
Topic of Lesson: What is Urban Heat Island, why it happens, and what are the problems caused by Urban Heat Island.			
Essential Vocabulary: ▪ ***Urban Heat Island* –** A city experiences much warmer temperatures than nearby rural areas. It has to do with how well the surfaces in each environment absorb and hold heat.			

Instruction

- Play ASLA video: https://www.asla.org/sustainablelandscapes/Vid_UrbanForests.html

Background information

Poor air quality has led to an explosion of asthma cases and other health problems among vulnerable populations, including children, the elderly, and low-income residents. **Each year bad air causes two million deaths worldwide**. Also, in the U.S., there have been 8,000 premature deaths from excessive heat over the past 25 years. Urban heat islands, which are caused, in part, by sunlight being absorbed by paved surfaces and roofs, lead to higher surface temperatures, up to 90 degrees. Atmospheric air temperatures are also higher: in the day by up to 6 degrees, and at night, by up to 22 degrees. Vulnerable populations also face greater risks of heat exhaustion.[4]

Increasing the tree canopy in cities is one way to fight both poor air quality and urban heat islands. Research shows significant short-term improvements in air quality in urban areas with 100 percent tree cover. There, trees can reduce hourly ozone by up to 15 percent, sulfur dioxide by 14 percent, and particulate matter by 13 percent. **U.S. trees remove some 784,000 tons of pollution annually, providing $3.8 billion in value**. Furthermore, a single large healthy tree can remove greater than 300 pounds of carbon dioxide from the atmosphere every year. In fact, New York City's urban forest alone removes 154,000 tons of CO2 annually. Through their leaves, trees also provide evaporative cooling, which increases air humidity. Shaded surfaces maybe 20-45 degrees cooler and evapotranspiration can reduce peak summer temperatures by 2-9 degrees.[5]

[4] *World Health Organization (WHO) and Heat Island Impacts, U.S. Environmental Protection Agency (E.P.A.)*
[5] *"Heat Island Mitigation: Trees and Vegetation, U.S. Environmental Protection Agency (E.P.A.) and "Sustaining America's Trees and Forests," David J. Nowak, Susan M. Stein, Paula B. Randler, Eric J. Greenfield, Sara J. Comas, Mary A. Carr, and Ralph J. Alig, U.S. Forest Service.*

Lesson 2: Water Cycle

Lesson Summary

How the water cycle works across natural and urban environments.

Outline of Activities

Activity 2.1: Introduction to Water Cycle - Evaporation, Condensation & Precipitation (Discussion, Video, Solar Bowl Demonstration outside, Worksheet)	15 minutes
- **Demonstration: DIY water cycle (solar bowl)**	15 minutes
▪ **Worksheet 2.1.1: Introduction to Water Cycle**	15 minutes
▪ **Worksheet 2.1.2: Solar Bowl Predictions**	15 minutes
Activity 2.2: Water Cycle Experiment (Different water temperatures in mason jars and observe the behavior of water, Worksheet)	20 minutes
- **Worksheet 2.2**: Water Cycle Experiment	25 minutes
Activity 2.3: Plant Transpiration – Observe and measure how plants release water into air (Discussion, Observation of plant transpiration, Worksheet)	40 minutes [outside]
- **Worksheet 2.3**: Measuring Plant Transpiration	20 minutes
Activity 2.4: Water cycles in nature and city (Discussion and Writing about water journey in the urban environment)	10 minutes
- **Worksheet 2.4**: The Story of Water Journey	30 minutes
Mid-Model	20 minutes

**Please record the highlighted activities using Swivl*

Preparation Alert

Lesson	Materials need to be provided by	
	Teachers	**Students**
2.1	Bowl needs to sit in the sun for several hours Kettle (use warm water if there is no sun)	-
2.2	Kettle – need boiling water Ice cubes **Freeze 6 ice packs one day before the lesson**	-
2.3	Bring the potted plants and research each species	-

Activity 2.1. Introduction to Water Cycle

Lesson:	Water Cycle	Day 5 Time Frame: 45 mins	Grade level: 4
Desired Outcome from Lesson: Students will be able to explain the process of the water cycle			
Topic of Lesson: The water cycle is how water circulates between the Earth's oceans, atmosphere, and land. This cycle is made of evaporation, condensation, and precipitation.			
Students' Goals of the Day:			
Essential Vocabulary: ▪ ***Clouds*** – Tiny droplets of condensed water vapor floating high above the ground. ▪ ***Condensation*** – Water that collects as droplets on a cold surface when humid air is in contact with it. ▪ ***Evaporation*** – The process of turning water from liquid into vapor. ▪ ***Hydrosphere –*** All the waters on the earth's surface, such as lakes and seas, and sometimes including water over the earth's surface, such as clouds. ▪ ***Precipitation*** – Water that falls to the ground. Come in 3 main forms: rain, snow, and hail. ▪ ***Vapor*** – Water in gas form. ▪ ***Water cycle*** – The cycle of the water evaporating, condensing, and precipitating on earth. It has been happening for millions of years.			

Teaching

PLEASE RECORD THIS LESSON ON SWIVL

Material

- **Worksheet 2.1.1** (to be done while waiting for Solar Bowl to complete the water cycle process)
- Water cycle video: Khan Academy video
- Optional: Generation Genius Water Cycle video. This video can be accessible for a month for new users.

Instruction

- Have the students sit in groups of 3-5
- **Discussion**: what do you know about the water cycle, or what is one of the steps in the water cycle?
- Have students take 5 minutes and write down all the ways they use water and have them compile the ideas on the board
- Have students discuss with their group if the water on earth today is the same water dinosaurs used?
- Watch the water cycle video.

- **Ask** students:
  - What is the water doing in each activity? Is it staying in the same form or changing forms? (changing forms) What form is it taking on? (vapor or gas, liquid, solid)
  - What does it take to cause water to change forms? (energy) Where does the energy come from in the video? (various ways of producing heat)
  - Do you think the water ever disappears entirely? (no) Why or why not? (because it just changes form, it doesn't go away)

- Proceed to Solar Bowl Demonstration

Demonstration DIY Water Cycle (Solar Bowl)[6]

Material (provided)

- Roll of plastic wrap
- Big rubber band or tape
- few coins or a piece of rock

Tip:

1. The more surface area the water has to evaporate, the faster it works
2. If you do not have a hot and sunny day, you can simulate it by using hot water

Material (by teacher)

- 1 large clear bowl
- 1 small clear bowl
- A small amount of grass and dirt
- Kettle (if it is not sunny outside, use hot water to speed up the process)
- 1 Cup of water
- Worksheet 2.1.2 for each student

Instruction

1. Fill the large bowl with water (about ½ inch deep).
2. Add the grass and dirt.
3. Place the smaller bowl in the middle of the big one (should be at least 3x size difference).

4. Cover the large bowl with plastic wrap and secure it with the rubber band.
5. Place the coins in the center of the plastic wrap, so it slants down towards the small bowl.

6. Place the bowl outside in the sun (or at the window sill) for few hours. *Put a reminder to retrieve the solar bowl so you won't forget!*

[6] Adapted from Generation Genius.

Discussion

- Distribute Worksheet 2.1.2 and have students write their predictions on the solar bowl experiment (question no. 1 & 2). What do you think will happen in the different bowls while they sit in the sun? What will the color of water in the small bowl be?
- Record their ideas on the board to refer to later.
- While waiting for the solar bowl to finish the water cycle process. Have students complete Worksheet 2.1.1

7. Retrieve the Solar Bowl. Have the class gather around to observe what has occurred in the different bowls. Write their observations on **Worksheet 2.1.2 (questions # 3 & 4).** Compare the predictions. Using the class list of water cycle processes generated from the information learned in the video, identify the water cycle processes in the two bowls (evaporation, condensation, and precipitation). Ask students to describe the differences between the water left behind in the big bowl and the water collected in the small bowl. (The water in the big bowl still contains the grass and dirt. The water in the small bowl should be clear and possibly warm.)

Closing Questions

1. **How old is water on earth?**
   - Water on earth has been here for millions of years! It is constantly being recycled through the water cycle.
2. **What are the forms of water found on earth?**
   - Solid, liquid, and gas (vapor)
3. **What causes water to change from vapor to a liquid or a liquid to a solid?**
   - Water changes form in response to changing temperatures. When the temperature becomes colder, water vapor becomes liquid water. When the temperature becomes warmer, liquid water becomes water vapor.
4. **What happens to a puddle of water on a sunny day?**
   - The sun heats the water, causing it to evaporate and become water vapor. That causes the puddle to dry up. The water vapor then rises up into the atmosphere, where it may condense and eventually fall back down to earth as rain.
5. **How do we know there is water vapor in the air?**
   - Some evidence: clouds, feeling the moisture on our skin on a humid day, and seeing droplets form on the outside surface of cold drinks (condensation).
6. **Where do clouds come from?**
   - Clouds are the result of water vapor that is condensing into tiny water droplets. Eventually, the droplets get big enough to fall back down to earth as rain, snow, or hail.
7. **Does water become cleaner when it evaporates into water vapor? Why or why not?**
   - Yes, generally, water becomes cleaner when it evaporates. Particles in water typically do not evaporate into vapor when water does, so particles are left behind when water vapor rises.
8. **Where does rain come from?**

- Rain comes from evaporated water that has risen into the atmosphere, where it condenses into a cloud. That means clouds are made of water! The water droplets eventually get too large and fall to the earth as rain.)

9. **Summary:**
   - **Evaporation:** liquid to vapor
   - **Condensation:** vapor to liquid
   - **Cloud:** condensed water
   - **Precipitation:** when condensation water is big enough to fall back on earth

Worksheet 2.1.1. Introduction to Water Cycle

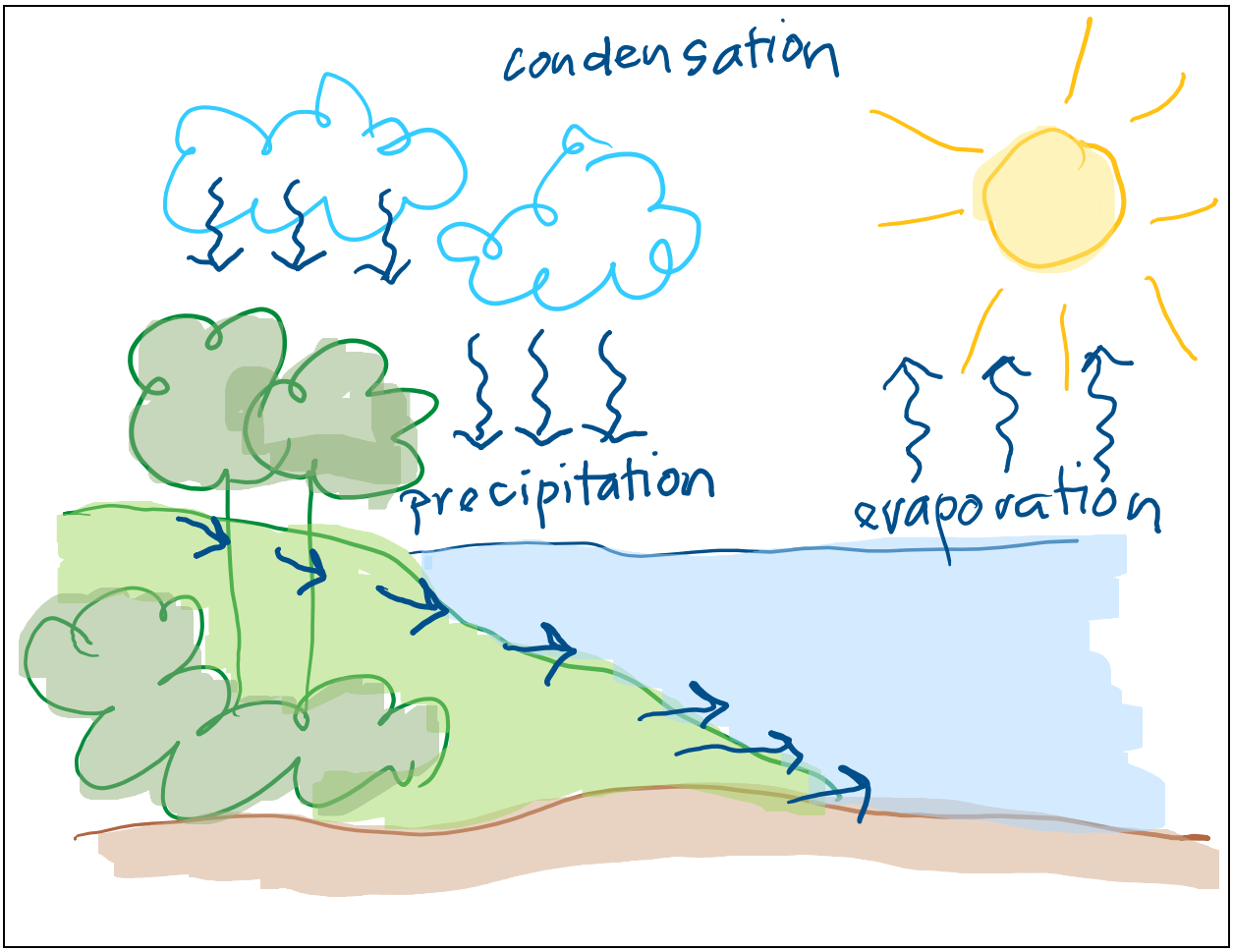
Name:_____ Class:_____ Date:_____

1. Water vapor is the way to describe which form of water?
   a. Liquid b. gas c. solid d. ice
2. What is it called when a gas turns into a liquid?_____
3. What is it called when a liquid turns into a gas?_____
4. True or false? when water droplets form on the outside of a glass of water, that water is seeping through the glass from inside._____
5. Explain how it can be that the water we drink today was also around millions of years ago._____
   _____
   _____
6. What is dew and how does it form?_____
7. Draw and label a model of the water cycle.

Answer sheet 2.1.1. Introduction to Water Cycle

Name:_____ Class:_____ Date:_____

1. Water vapor is the way to describe which form of water?
   a. Liquid b. gas c. solid d. ice
2. What is it called when a gas turns into a liquid? condensation_____
3. What is it called when a liquid turns into a gas? evaporation_____
4. True or false? when water droplets form on the outside of a glass of water, that water is seeping through the glass from inside. False_____
5. Explain how it can be that the water we drink today was also around millions of years ago. The water on earth is not being created on earth, and it does not leave the earth. The water is recycled through the water cycle process. Water evaporates from the liquid form (sea, lakes, rivers, etc.), condensates, rises to the clouds, and precipitates as rain, hail, snow back to earth.
6. What is dew, and how does it form? When humid air come in contact with cold air
7. Draw and label a model of the water cycle.



Worksheet 2.1.2. Solar Bowl Predictions

Name:_____ Class:_____ Date:_____

1. What **do you think** will happen to the solar bowls while they sit in the sun?

_____

_____

2. What **do you think** the color of the water in the small bowl will be after it sits in the sun?

_____

_____

3. What **actually happened** to the solar bowls while they sit in the sun?

_____

_____

4. What was **the color of the water** in the small bowl after it sat in the sun?

_____

Why?_____

Claim-Evidence-Reasoning Explanation (extension)

Tell the class that they made a claim that water evaporated out of the big bowl and then condensed on the plastic covering the bowls and precipitated into the small bowl.

Ask: How did they tell—or what is the evidence—that showed that evaporation and condensation took place? These are the students' observations: there is less water in the big bowl, and there is water in the small bowl when there wasn't any before. There may also be water droplets on the plastic covering, and the water in the small bowl may be warm.

Ask students to identify the scientific process they know about, which the solar bowl demonstrated, that supports their claim—their reasoning: the steps of the water cycle.

Generate a class CER statement using the sentence framework:

> *I think [include claim here]. I think this is because [include evidence here]. This matches what I know about [including reasoning here].*

Answer Sheet 2.1.2. Claim-Evidence-Reasoning Explanation (Extension)

Name:_____ Class:_____ Date:_____

1. What **do you think** will happen to the solar bowls while they sit in the sun?

_____

_____

2. What **do you think** the color of the water in the small bowl will be after it sits in the sun?

_____
_____

3. What **actually happened** to the solar bowls while they sit in the sun?

The water in the big bowl reduced; there is water on the plastic cover, there is water in the small bowl.

What was **the color of the water** in the small bowl after it sat in the sun? clear

Why? The dirt and grass were left behind in the bowl because they were too heavy to evaporate

Claim-Evidence-Reasoning Explanation

Tell the class that they made a claim that water evaporated out of the big bowl and then condensed on the plastic covering the bowls and precipitated into the small bowl.

Ask: How did they tell—or what is the evidence—that showed that evaporation and condensation took place? These are the students' observations: there is less water in the big bowl, and there is water in the small bowl when there wasn't any before. There may also be water droplets on the plastic covering, and the water in the small bowl may be warm.

Ask students to identify the scientific process they know about, which the solar bowl demonstrated, that supports their claim—their reasoning: the steps of the water cycle.

Generate a class CER statement using the sentence framework:

> *I think [include claim here]. I think this is because [include evidence here]. This matches what I know about [including reasoning here].*

I think evaporation, condensation, and precipitation took place because:

- there is less water in the big bowl

- there are water droplets on the plastic covering

- there is water in the small bowl when there wasn't any before

This matches what I know about evaporation, condensation, and precipitation. The solar bowl is like the earth and the water being recycled through water cycle processes.

Activity 2.2. Water Cycle Experiments

Lesson:	Water Cycle Experiment	Day 6 Time Frame: 45 mins	Grade level: 4
Desired Outcome from Lesson: Students will be able to model the water cycle and know the differences between precipitations, condensation, and evaporation.			
Topic of Lesson: Explore, observe and describe the water cycle through a model, demonstration, and depiction.			
Students' Goals of the Day: Students will experience the process of the water cycle in real-time.			
Essential Vocabulary: ▪ ***Clouds*** – Tiny droplets of condensed water vapor floating high above the ground. ▪ ***Condensation*** – Water that collects as droplets on a cold surface when humid air is in contact with it. ▪ ***Evaporation*** – The process of turning water from liquid into vapor. ▪ ***Hydrosphere*** – All the waters on the earth's surface, such as lakes and seas, and sometimes including water over the earth's surface, such as clouds. ▪ ***Precipitation*** – Water that falls to the ground. Come in 3 main forms: rain, snow, and hail. ▪ ***Vapor*** – Water in gas form ▪ ***Water cycle*** – The cycle of the water evaporating, condensing, and precipitating on earth. It has been happening for millions of years.			

Hands-on Activity[7]

Material (to be prepared by teachers)

- A kettle with boiling water
- Freeze 6 ice packs provided in the kit one night before
- Bring ice cubes (if freezer is not available in the school)

Material (provided)

- 3 mason jars labeled as Jar 1
- 2 mason jars labeled as Jar 2
- 3 mason jars labeled as Jar 3
- 6 ice packs (MU only sent one set per school, teachers may need to share!)
- A pitcher with cold water with ice
- 1 bottle of Hair spray

Instruction:

- Have students break into a group of 3
- Each group will have 1 type of mason jar. The group with Jar 1 and 3 will require an ice pack each.
- Distribute worksheet 2.2
- Follow the instructions for each jar below and do the worksheet as a group. The water cycle process can be labeled with different colors (evaporation – red, condensation – blue, precipitation – green)

Mason jar 1

- Pour 50ml of boiling (warm) water into mason jar 1 and put the plastic lid with ice on top of the first mason jar.
- Have students make observations and write what happens to mason jar 1 in the worksheet. Explain that the hot water rises up (evaporation) in vapor form. In this part,

[7] Adapted from 2018 5th Grade Watershed Curriculum, Worchester Polytechnic Institute

the students should observe water on the side of the glass as condensation. They might even see water droplets rush down the side of the glass as precipitation.

Mason jar 2

- Distribute cold water and ice to mason jar 2. Condensation will start to form up on the outside surface of the glass.
- Have students observe and label what is happening to mason jar 2 in the worksheet. Explain that condensation always happens to the warm side of the glass. (compare the location of condensation in jar 1 and jar 2). There are 3 forms of water in jar no. 2 (vapor, liquid, and solid)

Mason jar 3

- Pour 50ml of boiling water into mason jar 3 and place the ice pack on top of the jar.
- Wait for 1-2 minutes
- Walk around and spray hairspray into mason jar 3 groups. The condensed water will attach itself to the hairspray and create a cloud-like feature.
- Wait for 1-2 minutes
- Remove the plate of ice/ice pack from mason jar 3 and watch the cloud of hairspray evaporating into the air
- Have students observe and label what is happening to mason jar 3 in the worksheet.

Worksheet 2.2. Water Cycle Experiment

Name:_____ Class:_____ Date:_____

Direction: As you complete the experiment, observe what happens to the jar. Diagram & label what you see happening inside the beaker in the worksheet. Color code the process. (This worksheet can be done as a class activity.)

Draw what happens in your jar in the box below.

Each group will present their finding and draw the findings of other jars from your friend's presentation.

Jar 1: Hot water with icepack on top

Jar 2: **Cold water with ice**

Jar 3: Hot water with ice pack on top + hairspray

Answer sheet 2.2. Water Cycle Experiment

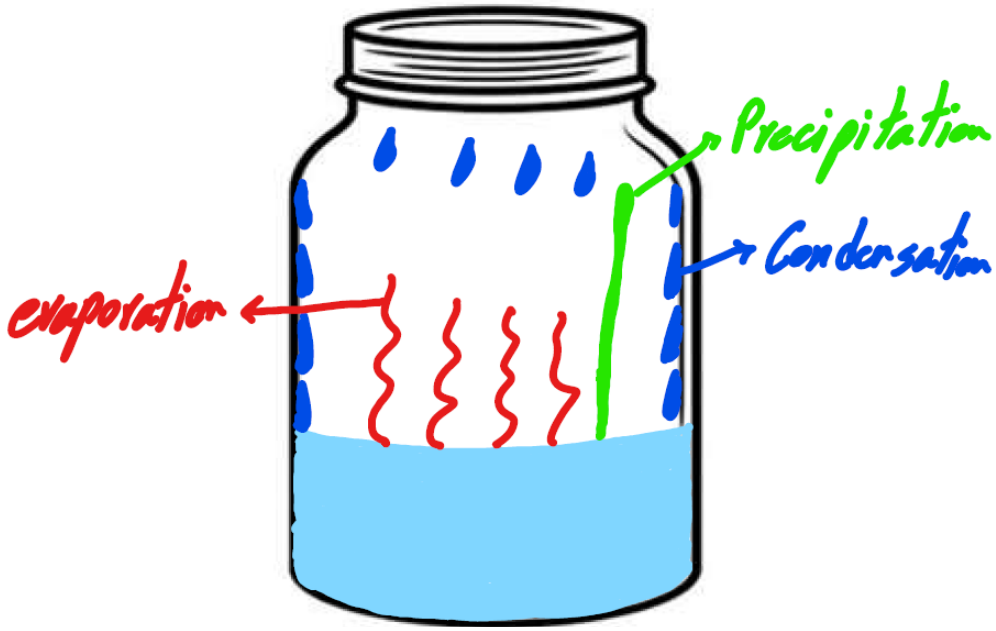
Name:_____ Class:_____ Date:_____

Direction: As you complete the experiment, observe what happens to the jar. Diagram & label what you see happening inside the beaker in the worksheet. Color code the process. (This worksheet can be done as a class activity.)

Draw what happens in your jar in the box below.

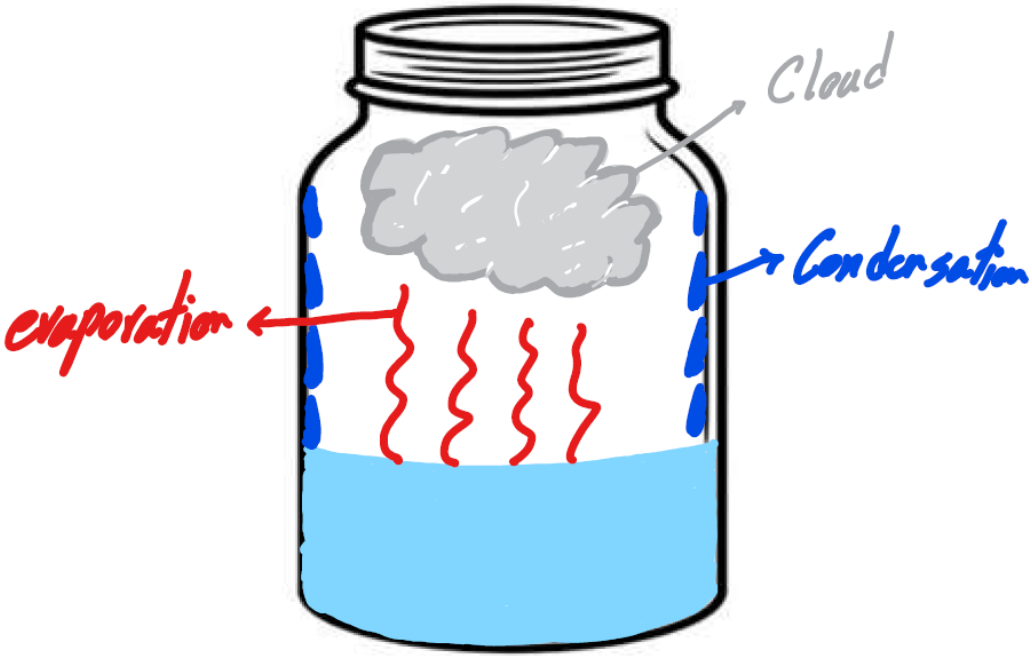
Each group will present their finding and draw the findings of other jars from your friend's presentation.

Jar 1: Hot water with icepack on top



Jar 2: Cold water with ice

Jar 3: Hot water with ice pack on top + hairspray



Activity 2.3. Plant Transpiration

Lesson:	Water Cycle	Day 7 Time Frame: 45 mins	Grade level: 4
Desired Outcome from Lesson: - Explain what the rate of a reaction is and how it applies to the urban water cycle. - Calculate the transpiration rate of reaction for a plant species. - Create a graph of collected data and select native plant species based on transpiration data.			
Topic of Lesson: Plant Transpiration			
Students' Goal of the Day: Students will understand that plants on the Green Roof play a role in the urban water cycle.			
Essential Vocabulary: ▪ ***Evapotranspiration*** – The process of plants releasing water into the air. ▪ ***Transpiration*** – The process of plants releasing water into the air. ▪ ***Plant uptake*** – The process of plants absorbing water and nutrients from roots to grow.			

Hands-on Activity[8]

Tip:
This activity needs sunlight and best done outdoor)

Material (provided)

- 8 plants of a native plant species. Provide at least 3 different plant species (for example; Horsetail, Tickseed, Tropical Sage, grass, Hyssop, etc.) – 1 plant per group.
- 8 produce baggies
- 8 rubber bands
- 8 black permanent marker, such as a Sharpie®
- 8 scale, accurate to 0.1 gram, such as a triple beam balance or laboratory scale
- liquid food coloring
- gallon jug half-filled with water – mix with food coloring.

Material (provided by teachers)

- Worksheet 2.3 (one per student)
- calculators
- pencils, colored pencils or markers, ruler (for graphing)
- A stopwatch or timer

Preparation before the activity

- **Gather information** on each selected native plant species: scientific name, common name, and characteristics such as light, water, and soil requirements, and height.

Instruction

1. Divide the class into groups of 2-3 students
2. Distribute worksheet 2.3 (one per student)
3. Distribute a pot of plant, a produce baggy, a rubber band, a permanent marker, a sharpie, and a scape for each group.
4. Direct students to record the time of the day, temperature, humidity, dew point, and weather conditions on their worksheet. https://www.wunderground.com/
5. Water the plants with dyed water until plant media is fully saturated. Have students predict what will happen to the dyed water as it moves through the soil and evaporates after transpiration.
6. Weigh the clean bag on the scale and record its weight to the nearest 0.1 gram.
7. Cover the plant with a plastic bag.

[8] Adapted from TE: Just Breath Green: Measuring Transpiration Rates
https://www.teachengineering.org/activities/view/usf_stormwater_lesson02_activity1

8. Set a stopwatch or timer for 10 minutes.
9. When 10 minutes are up, carefully remove the bottle/bag without letting any of the accumulated water escape.
10. Place the plastic bottle/bag on the scale and record its weight on the worksheet.
11. Replace the bottle/bag on the plat and repeat steps 7-10 in 20 and 30-minute increments, respectively. Record your observations in the worksheet.

12. While waiting for the measurements, students can;

- Record the plant species' characteristics (or have students research this information) in their worksheet
- Take a photo and label the photo in the worksheet or sketch the plant, providing a detailed drawing of its leaf or grass strand structure.

13. **Complete the first page** of worksheet 2.3 as a class activity

Extension

- **Collect transpiration data** of two other plants **from other groups.** Record them on the worksheets.
- **Return to the classroom** (or use an outdoor classroom) to discuss results and create a data plot. Use different colors or symbols to identify the line for each plant species and provide a key. Use a ruler to draw a best-fit line on the data.
- Determine the slope of the best-fit lines. To determine the slope of each line, select two points from the best-fit line (x1, y1), (x2, y2) and determine the slope (y2-y1)/(x2-x1). The slope of the line is the transpiration rate.
- Have students finish their worksheet by answering the questions on the last page.
- Conclude by leading a class discussion to share, compare and review students' results and conclusions, as described in the assessment section. Collect and review the worksheets.

Worksheet 2.3. Measuring Plant Transpiration

Name:_____ Class:_____ Date: _____

Time of day _____Temperature _____Humidity _____Dew point _____

Weather Condition _____

What do you predict that you will see accumulate on the bottle/bag? _____

Predict the color of water as it evaporates from the plant. _____ _____

Common name:	*Scientific name*:	
Time (minutes)	**Weight (g)**	**Observations (What do you see?)**
Initial weight of the plastic bag		
Trial 1: 10 minutes		
Trial 2: 20 minutes		
Trial 3. 30 minutes		

Determine the amount of transpiration:

Trial 1 weight		**Trial 2** weight		**Trial 3** weight	
	minus		minus		minus
Initial weight		**Initial weight**		**Initial weight**	
	equals		equals		equals
Trial 1 transpiration mass (g)		**Trial 2** transpiration mass (g)		**Trial 3** transpiration mass (g)	
				Total transpiration mass (g):	

Draw and describe this plant species (optional activity while waiting between trials)**:**

Plant species *Common name:*		*Scientific name*
Light req's		sketch with details:
Height		
Soil conditions		
Total transpiration mass (g)		

Extension:

Pick 2 other teams that have different plants. Copy their transpiration data, draw and describe the plant species.

Plant species common name: ***Scientific name*:**

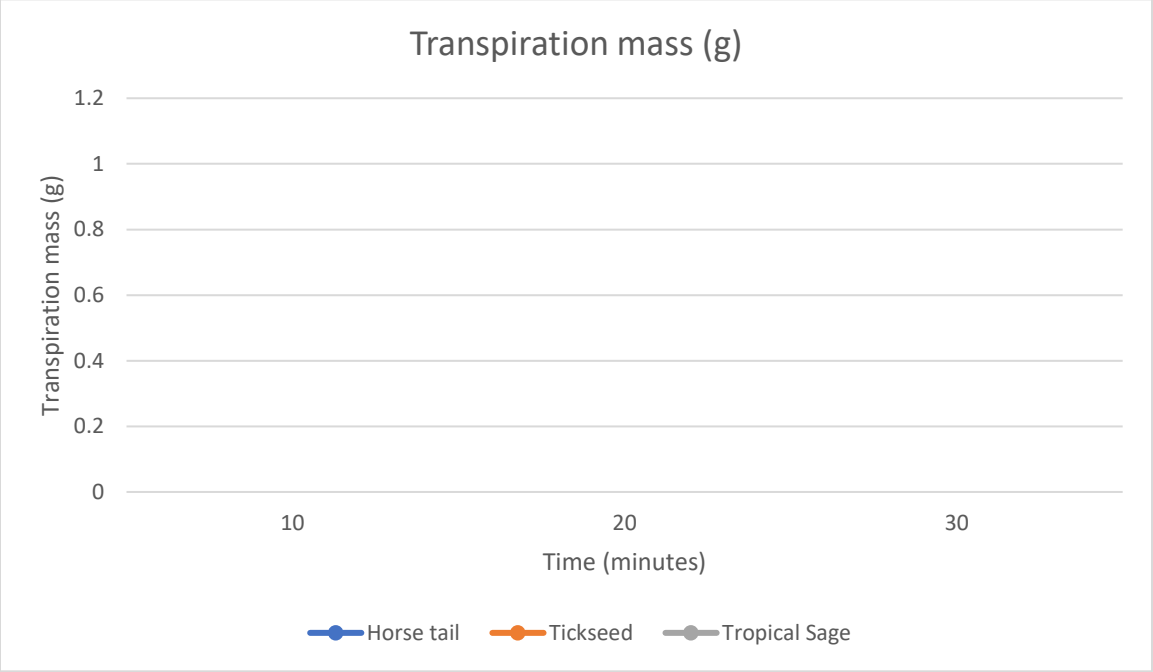
Trial 1 transpiration mass (g)		**Trial 2** transpiration mass (g)		**Trial 3** transpiration mass (g)	
Total transpiration mass (g)					
Light requirements		Sketch with details:			
Height					
Soil conditions					
Transpiration rate (ml/min)					

Plant species common name: ***Scientific name*:**

Trial 1 transpiration mass (g)		**Trial 2** transpiration mass (g)		**Trial 3** transpiration mass (g)	
Total transpiration mass (g)					
Light requirements		Sketch with details:			
Height					
Soil conditions					
Transpiration rate (ml/min)					

Graphing - do this a class activity

In one graph, plot the transpiration mass data over time for each plant species. Use different colorsand/or line styles for each plant species and create a key. The slope of the line is the transpiration mass.



Analysis Questions

Did one plant species have a higher rate of transpiration than the other? If so, what were the physical differences inthe plants? Why might this make a difference? Refer to your drawings and observations of the plants and the data you collected.

What was the color of the condensed water? Why?

.

Answer sheet 2.3. Measuring Plant Transpiration

Name:_____ Class:_____ Date: _____

Time of day 10:30 am Temperature 74 Humidity 75 Dew point 65°

Weather Condition _ Clear skies

What do you predict that you will see accumulate on the bottle/bag? _Condensed water

Predict the color of water as it evaporates from the plant. __Clear

Common name: Horsetail *Scientific name*: *Equisetum hyemale*

Time (minutes)	Weight (g)	Observations (What do you see?)
Initial weight of the plastic bag	20.0 g	The bottle is clean, clear, and dry
Trial 1: 10 minutes	21.5 g	You can begin to see water condensing on the bottle surface
Trial 2: 20 minutes	23.2 g	The bottle is no longer transparent
Trial 3. 30 minutes	24.0 g	Drops of water can be seen collecting on the sides of the bottle

Determine the amount of transpiration:

Trial 1 weight	21.5 g	**Trial 2** weight	23.2 g	**Trial 3** weight	24.0 g
minus		Minus		minus	
Initial weight	20.0 g	**Initial weight**	20.0 g	**Initial weight**	20.0 g
equals		equals		equals	
Trial 1 transpiration mass (g)	1.5 g	**Trial 2** transpiration mass (g)	3.2 g	**Trial 3** transpiration mass (g)	4.0 g
				Total transpiration mass (g)	**8.7 g**

Draw and describe this plant species (optional activity while waiting between trials)**:**

Plant species
Common name: Horsetail *Scientific name*: *Equisetum hyemale*

Light requirements	Full sun to partial shade	Sketch with details: 
Height	1-4 ft	
Soil conditions	Wet	
Total transpiration mass (g)	8.7	

Extension:

Pick 2 other teams that have different plants. Copy their transpiration data, draw and describe the plant species.

Plant species common name: Tickseed ***Scientific name*: *Coreopsis leavenworthii***

Trial 1 transpiration mass (g)	0.7 g	**Trial 2** transpiration mass (g)	1.7 g	**Trial 3** transpiration mass (g)	2.2 g
				Total transpiration mass (g)	**4.6 g**

Light requirements	Full sun	Sketch with details: 
Height	1-3 ft	
Soil conditions	Average tomoist	
Transpiration rate (ml/min)	150	

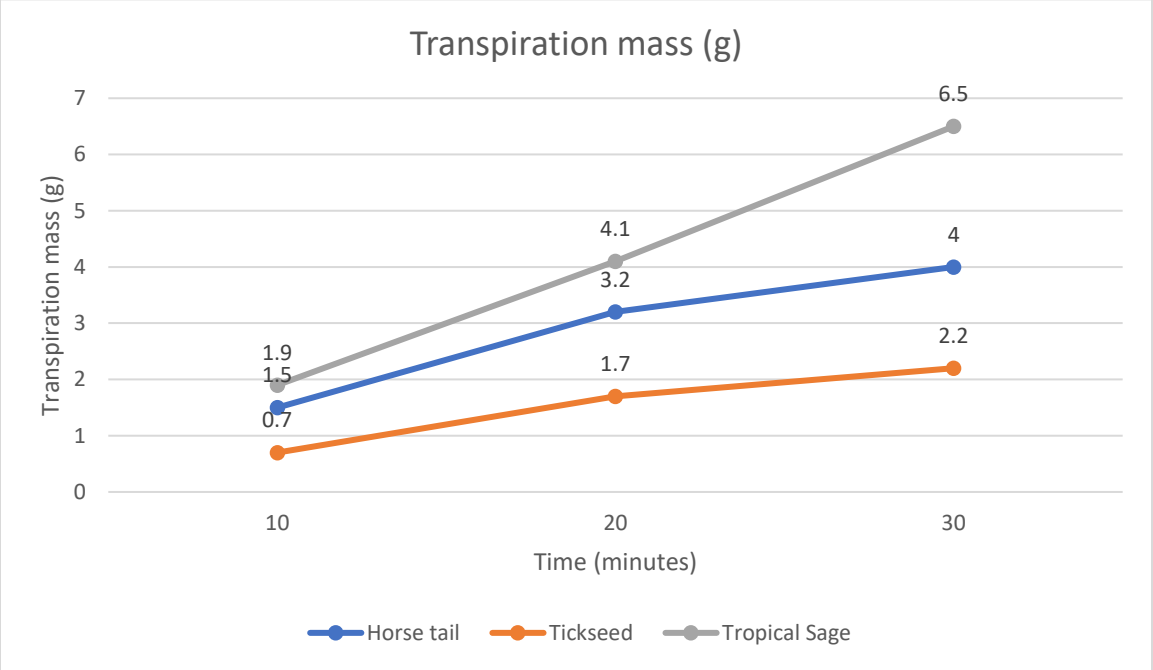
Plant species common name: Tropical Sage ***Scientific name*: *Salvia Coccinea***

Trial 1 transpiration mass (g)	1.9 g	**Trial 2** transpiration mass (g)	4.1 g	**Trial 3** transpiration mass (g)	6.5 g
				Total transpiration mass (g)	**12.5 g**

Light requirements	Full sun to partial shade	Sketch with details: 
Height	2-3 ft	
Soil conditions	Well-drained	
Transpiration rate (ml/min)	406	

Graphing - do this a class activity

In one graph, plot the transpiration mass data over time for each plant species. Use different colorsand/or line styles for each plant species and create a key. The slope of the line is the transpiration mass.



Analysis Questions

Did one plant species have a higher rate of transpiration than the other? If so, what were the physical differences inthe plants? Why might this make a difference? Refer to your drawings and observations of the plants and the data you collected.

Tropical sage had the highest transpiration rate. Its physical characteristics include a high leaf surface area to overall plant ratio compared to tickseed, and its leaves have a rough-textured surface compared to the horsetail. The increase inleaf surface area provides more area for transpiration to occur.

What was the color of the condensed water? Why?

The condensed water was clear. Only pure water can evaporate. Any pollutants in the water are adsorbed by soil orremain in the plants' organic biomass.

Activity 2.4. Natural and Urban Water Cycles

Lesson:	Water Cycle	Day 8 Time Frame: 45 mins	Grade level: 4

Desired Outcome from Lesson:
Students will understand the connection of the water cycle with the built environment

Topic of Lesson:
Natural vs. urban water cycles

Students' Goal of the Day:
Students will understand the differences in the water cycle process in natural and urban environments.

Essential Vocabulary:

- ***Aquifer*** – Below ground natural reservoir water used for cooking, drinking, bathing, and irrigation.
- ***Combined sewer*** – A series of pipes that collects and transports stormwater and wastewater.
- ***Groundwater flow*** – A horizontal flow of water beneath the ground surface
- ***Infiltration*** – The movement of water into the media layer.
- ***Media layer*** – A mix of earth materials such as sand, soil, mulch, compost, gravel.
- ***Natural Water Cycle*** – The cycle of the water evaporating, condensing, and precipitating on a natural environment such as mountains, woods, rivers, lakes, etc.
- ***Plant uptake*** – The process of plants absorbing water and nutrients to grow.
- ***Sanitary sewer*** – A series of pipes that collects and transports only wastewater and does not include stormwater.
- ***Storm sewer*** – A series of pipes that collects and transports only stormwater.
- ***Surface water*** – Water that is contained by stormwater ponds, rivers, lakes, estuaries, bays, dams, wetlands, and oceans.
- ***Transpiration*** – A process of plants releasing water into the air.
- ***Urban Infrastructure*** – A structure or system that supports the urban environment. For example, roads, bridges, buildings, water distribution, sanitary and storm sewers, stormwater, electricity lines, cables, and internet.
- ***Urban Water Cycle*** – The cycle and water movement in an urban environment (city, neighborhood, etc.).
- ***Wastewater*** – Water that exits your home through a drain.
- ***Watershed*** – The boundary of an area where waters flow to the same catchment basin

Teaching[9]

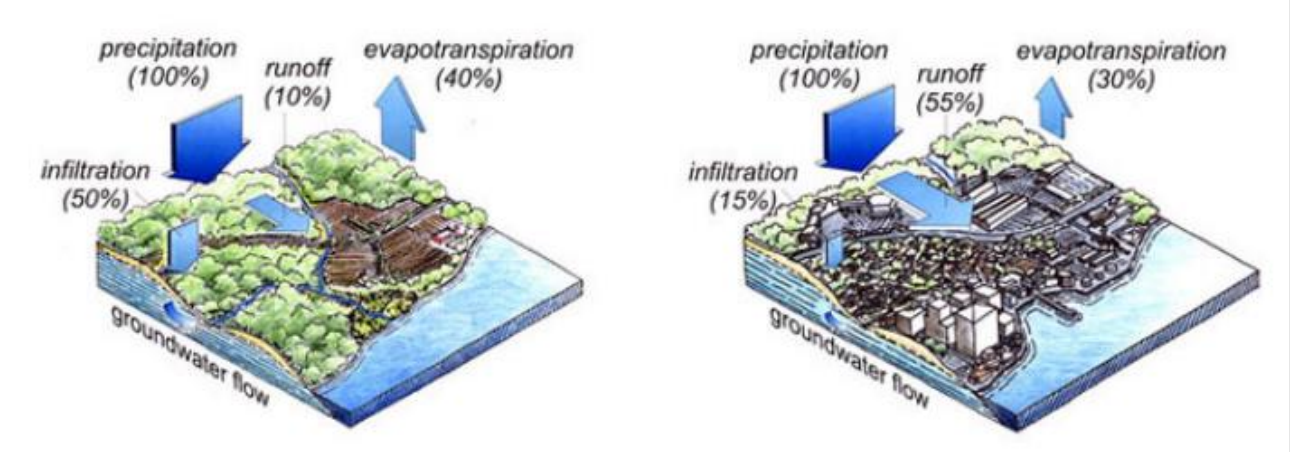
PLEASE RECORD THIS LESSON ON SWIVL

Material

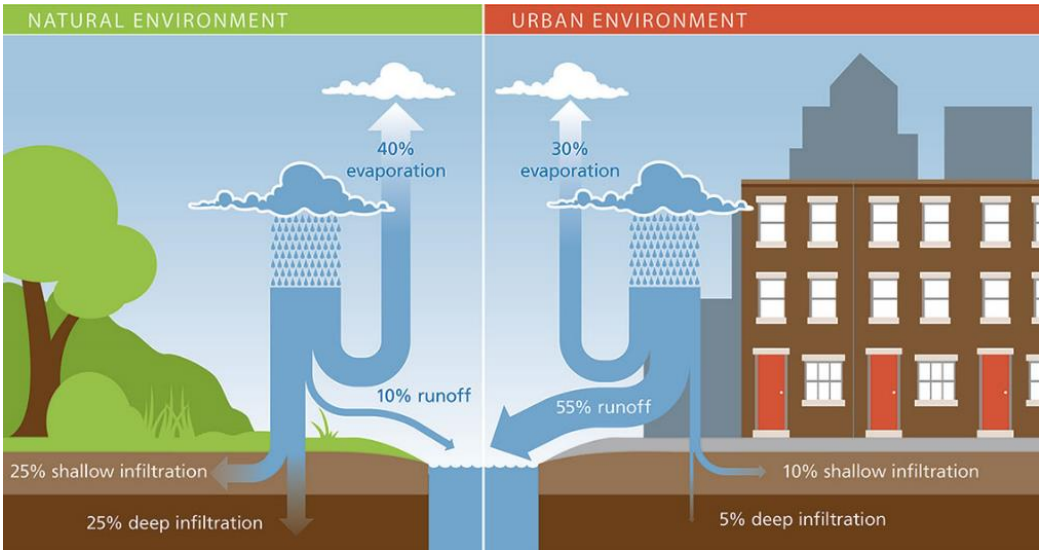
- Power point presentation
- Worksheet 2.4

Instruction

- Natural VS Urban Water Cycles: Spot the differences

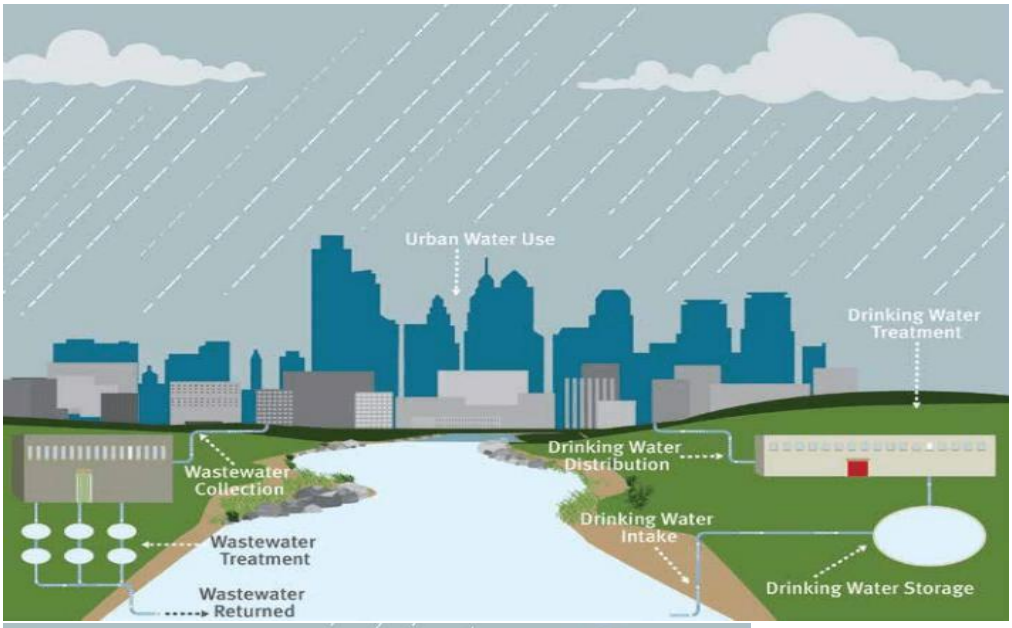


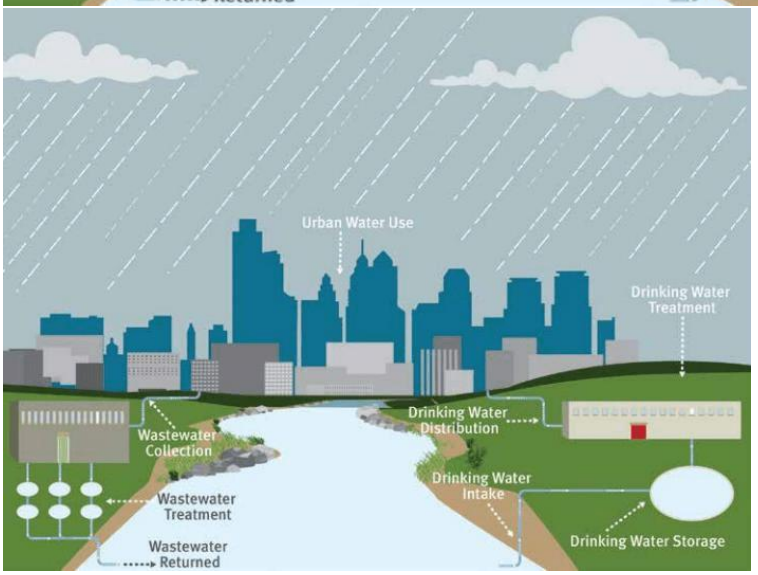
- The disruption in the urban setting
  - **Less infiltration** for plants and groundwater resources, **less Evapotranspiration** back to atmosphere.
  - MORE and faster downstream water, flooding.

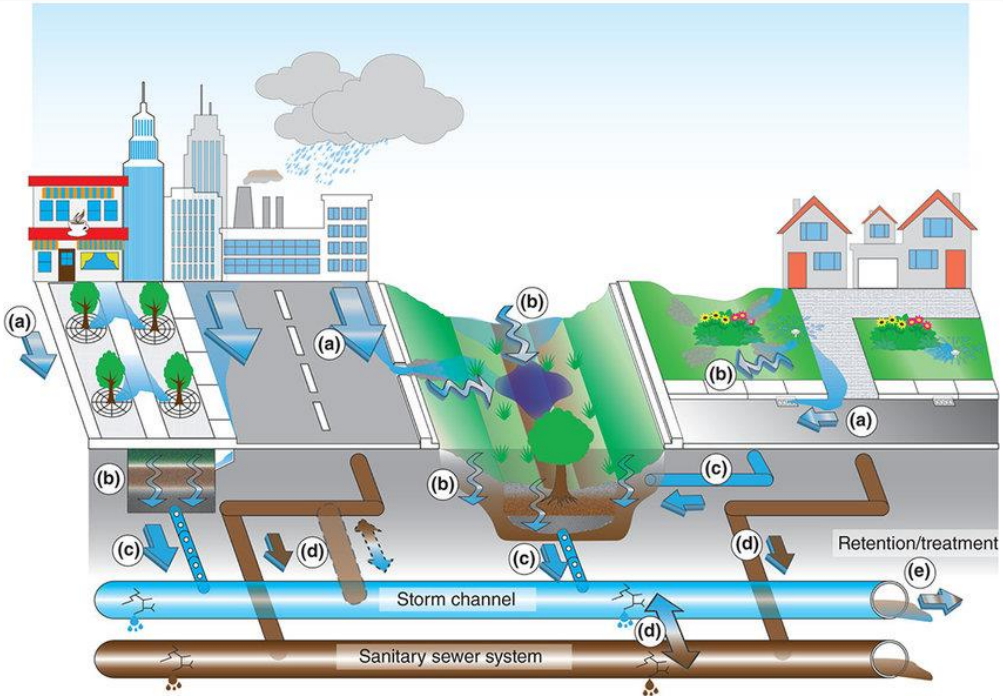


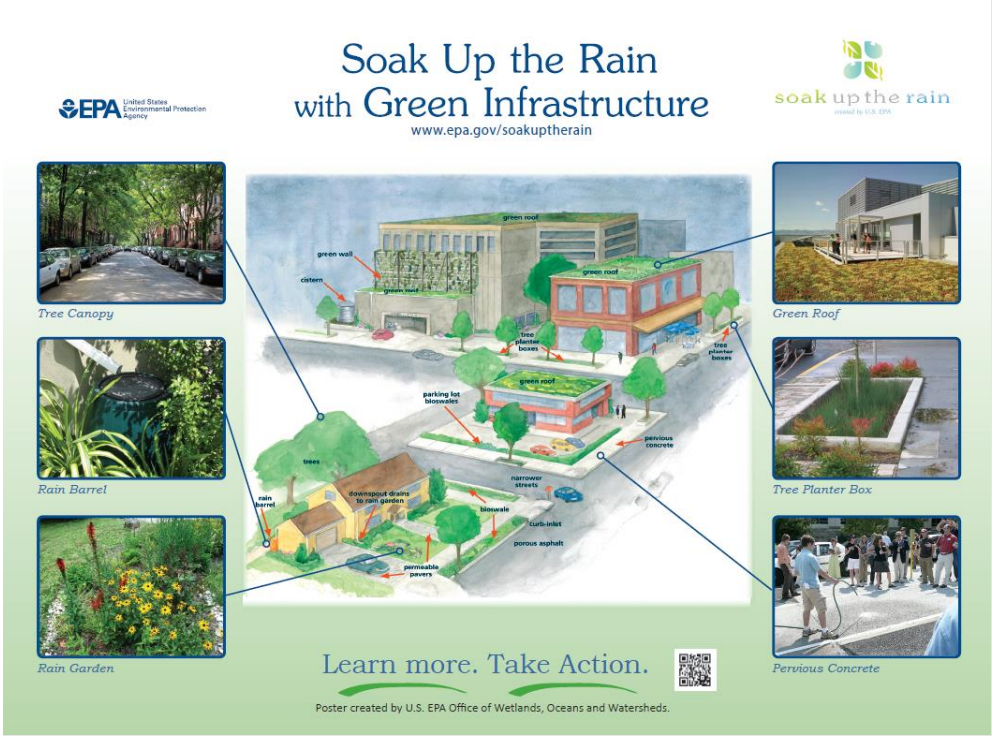
[9] https://www.teachengineering.org/lessons/view/usf_stormwater_lesson01

- **People's water needs and health** are the most important aspect of urban development and health. In an urban watershed, drinking water and waste water (sewer system) go to the catchment basin. See http://wln.ecology.uga.edu/index.php/challenges-with-watersheds/what-is-urban/ for more information.
- **Walk through the following images** to see how water goes through water cycle processes in the Urban setting.

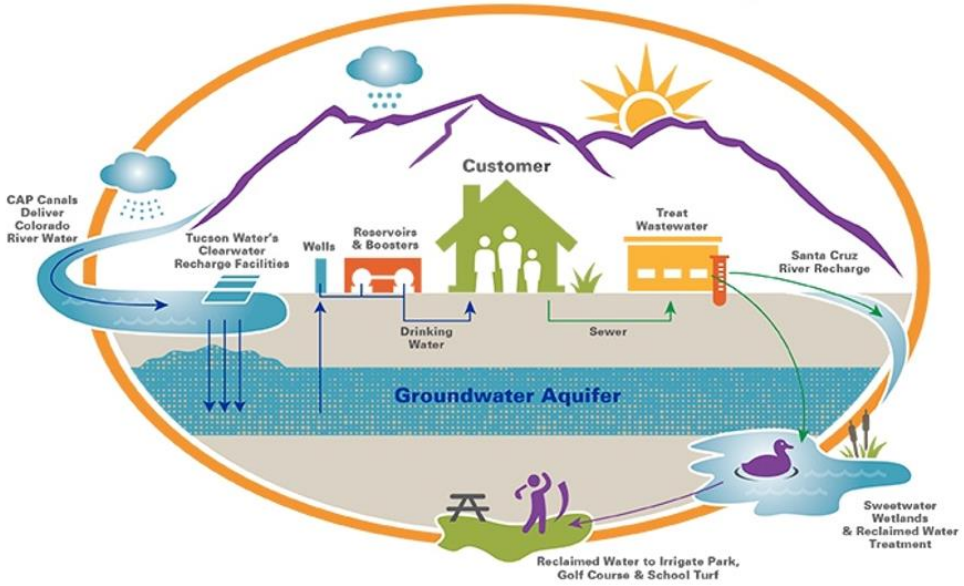





(a)
(b)
(c)
(d)
(e)
Retention/treatment
Storm channel
Sanitary sewer system


Soak Up the Rain
with Green Infrastructure
www.epa.gov/soakuptherain
EPA United States Environmental Protection Agency
soak up the rain
Tree Canopy
Rain Barrel
Rain Garden
Green Roof
Tree Planter Box
Pervious Concrete
green roof
green wall
cistern
tree planter boxes
parking lot bioswales
pervious concrete
trees
narrower streets
rain barrel
downspout drains to rain garden
bioswale
curb-inlet
porous asphalt
permeable pavers
Learn more. Take Action.
Poster created by U.S. EPA Office of Wetlands, Oceans and Watersheds.

- Urban "Stormwater" Water Cycle:



- **Worksheet 2.4 –** This activity can be done individually or as a group and can be part of ELA. The assignment can be a writing piece, an oral presentation, an interview (by 2 students), comic strip, comic strip, or a movie trailer.

Worksheet 2.4: The story of Water Journey

Name:_____ Class:_____ Date: _____

Direction: Take on the role of a journalist to describe a water droplet's point of view on the journey through the urban water cycle.

- You are a travel magazine journalist for Urban Environment Weekly
- Your assignment this week is to follow the life of a drop of water as it makes its way through the urban environment.
- Your article should Include all the descriptive details about whom the drop met and what it encountered along the way.

Model 2

Refer to Student Modeling Packet

(20 minutes)

Lesson 3: Green Roof

Lesson Summary

Understanding what Green Roofs are and how they work.

Outline of Activities

Activity 3.1: Green Roof, what, why, and who? Introduction to GR (Read Green Roof book, discussion, play video, and ppt)	30 minutes
- **Worksheet 3.1: Green Roof in Kansas City**	15 minutes
Activity 3.2: Which Roof? Understanding and testing the shapes of roofs suitable for green roof construction (Discussion, slides)	15 minutes
- **Worksheet 3.2.1**: Drawing different types of roofs	15 minutes
- **Demonstration/Worksheet 3.2.2**: Testing Roofs (Roof slopes, structural stability & material)	15 minutes
Activity 3.3: Green Roof in Detail - Layers of GR and testing water retention of GR (discussion, slides of green roof layers)	10 minutes
- **Worksheet 3.3.1**: Green Roof Construction	10 minutes
- **Demonstration & Worksheet 3.3.2**: Water Retention	20 minutes
- **Hands-on & Worksheet 3.3.3:** Water Filtration	15 minutes
Activity 3.4: Virtual Field Trip: Ask the Engineer	30 minutes
-	
Activity 3.5: How Does Green Roof Help Water Cycle in the City? (Discussion, video, slides, build a green roof shoe box)	10 minutes
- **Hands-on: Green roof shoe box**	35 minutes
Model 3	30 minutes

**Please record the highlighted activities using Swivl*

Preparation Alert

Lesson	Materials need to be provided by	
	Teachers	**Students**
3.2	Blow Dryer 1 (one) 2L bottles (optional) Ice cubes made with food coloring	
3.3	Soil - enough for every student Seeds – enough for every student	Shoe box for each student (collect 1 week prior)
3.4	Organize virtual field trip. Confirm date, time, and zoom details with the University of Missouri Research Team.	

Activity 3.1. Green Roof, What, Why, and Who?

Lesson:	Green Roof	Day: 9 Time Frame: 45 mins	Grade level: 4
Desired Outcome from Lesson: Students will be able to understand the concept of a green roof and its benefits to the city.			
Topic of Lesson: What is a green roof, who designs a green roof, and why green roof?			
Students' Goals of the Day: Students will be able to define a green roof, define key environmental benefits of green roofs in a built environment			
Essential Vocabulary: ▪ ***Dead load*** – The weight of a building's structural elements such as beams, walls, and roof. ▪ ***Extensive Green Roof*** – Green roofs with less than 6 inches thick layer of soil. ▪ ***Green roof*** – Rooftops planted with vegetation. ▪ ***Growing media*** – special lightweight soil to grow the plants that drain water well. ▪ ***Habitat*** – The place where wildlife can find food, water, and shelter. ▪ ***Intensive Green Roof*** – Green roofs with 6-12 inches thick layer of soil or more. ▪ ***Live load*** – The weight of things that are on/in a building, such as people, goods, stormwater. ▪ ***Podium –*** The base of a high-rise building which area is bigger than the tower ▪ ***Stormwater runoff*** – Rainfall that flows over the ground surface. ▪ ***Urban Heat Island –*** A city experiences much warmer temperatures than nearby rural areas. It has to do with how well the surfaces in each environment absorb and hold heat.			

Teaching

PLEASE RECORD THIS LESSON ON SWIVL

Material:

- University of Nebraska green roof video
- Green Roof Book by Vicky Sando
- Power Point Presentation
- Worksheet 3.1a and/or 3.1b

Instruction

Part 1: University of Nebraska Green Roof video (10 minutes)

- Have the students sit in groups of 3-4
- **Discussion**: What do you already know about the green roof? Write down their answers on the whiteboard.
- **Play University of Nebraska green roof video**
- **Ask:** What are the benefits of the green roof?
- Explain to the students the **role of Architects, Landscape architects, engineers, and building owners (client)** in creating a green roof.

Who can create a Green Roof? The **Building Owner (Client)** needs to have a budget (money) to build the green roof. **Architects** design the building, and they need to incorporate the green roof in the building design. The shape of the roof should be suitable to have soil and grow plants. There should be access to the roof. The roof needs to be safe for people not to fall down. **Landscape Architects** design the landscape of a building, including green roof. They decide the plant species, their locations and design the footpath, deck, seating area, water feature, etc. **Engineers** have to make sure that the roof structure is strong enough to hold the soil, plants, people, etc. Engineers also make sure that the building will have clean air, water, electricity, dirty water will go to the drain.

Part 2: "What is Green Roof?" Book (10 minutes)

- Read "What is a Green Roof" book to the students – this can also be part of a reading assignment.
- Ask the students the new things they learn about the green roof from the book, for example:
  - Types of green roof
  - Layers of green roof
  - History of green roof
  - The role of a structural engineer
  - Benefits of green roof

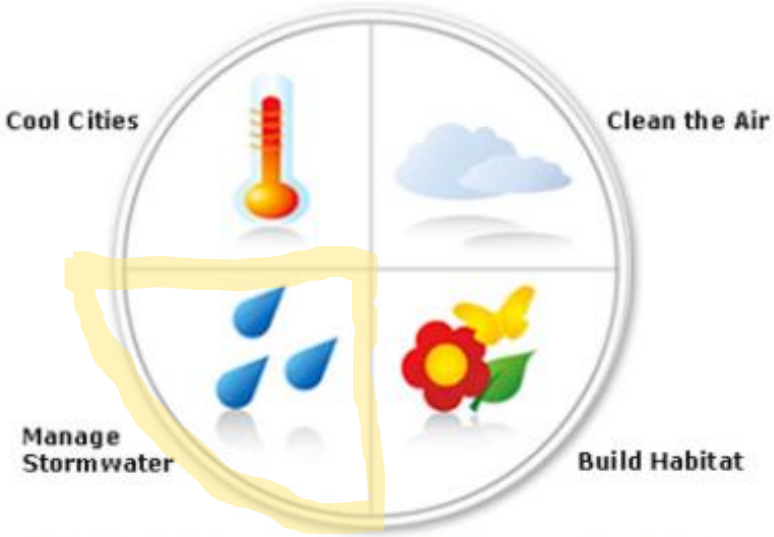
Part 3: PowerPoint Slides (10 minutes)[10]

- Play slides: How does Green Roof helps the city?
  - Cities are quite impervious, it disrupts natural water cycle
  - A green roof replaces traditional roofing with **lightweight soil, compost, and plants**. It creates a thin, green skin made out of plant and soil atop a building.
  - Green roofs cover roof surfaces that are built to keep water out with living, breathing, plant materials that absorb water and let it flow through. Green roofs are good for people and they are good for the environment. They provide natural spaces for people to enjoy. They help to **cool cities** in the summer. They **reduce stormwater runo**ff that flows into our watersheds. They help to **reduce air pollution**. And, they **create a place for wildlife in the city.**

- **2 Kinds of Green Roofs.**
  - **Extensive green roofs.** Extensive green roofs are light in weight and inexpensive to construct and maintain. An extensive green roof usually has a **thin (2 – 6 inch)** layer of lightweight, engineered soil.
  - **Intensive green roofs**. Intensive green roofs **are deeper** than the extensive roof. It holds the weight of more soil; therefore, it can grow a wider variety of plants, like a ground-level garden.

- **Green roof benefits** for the environments are:
  1. Make the cities (and the building) cooler
  2. Help clean the air
  3. Build habitat
  4. **Manage stormwater – we are focusing on this one!**

[10] https://www.asla.org/greenroofeducation/coolcities.html



Green Roofs help cool cities, clean the air, build habitat, and manage stormwater.

- Continue with PowerPoint Slides

Part 4 – Worksheet 3.1 (15 minutes)

- Distribute **Worksheet 3.1** (there are 2 options for the location).
- Describe to the students that what they see on Google Maps is a top view of the building, where you can only see the roof.
- Have the students identify potential roofs that can be turned into green roofs.
- Have the students identify the benefits of having many green roofs in Kansas City

Worksheet 3.1 Green Roofs in Kansas City

Name:_____ Class:_____ Date:_____

Directions:

There are some green roofs in the downtown of Kansas City, but there is potential for more. If you can add 4-5 green roofs in Kansas City, where would you put it? Things to consider:

- Roof with larger areas.
- Highly trafficked areas.
- Lower roofs so that people on the taller building can see, and it is easier to transport soil from the ground.
- The use of the building. Towers usually have a bigger base below the tower called a podium. The roof of this podium can be used as a roof deck for fun outdoor activities such as outdoor sport, swimming, etc. It is a perfect place to have a green roof!

Use these aerial maps to indicate where the new green roofs should be and explain why they should be there.

List 4 benefits of the new green roofs that you have added to Kansas City.

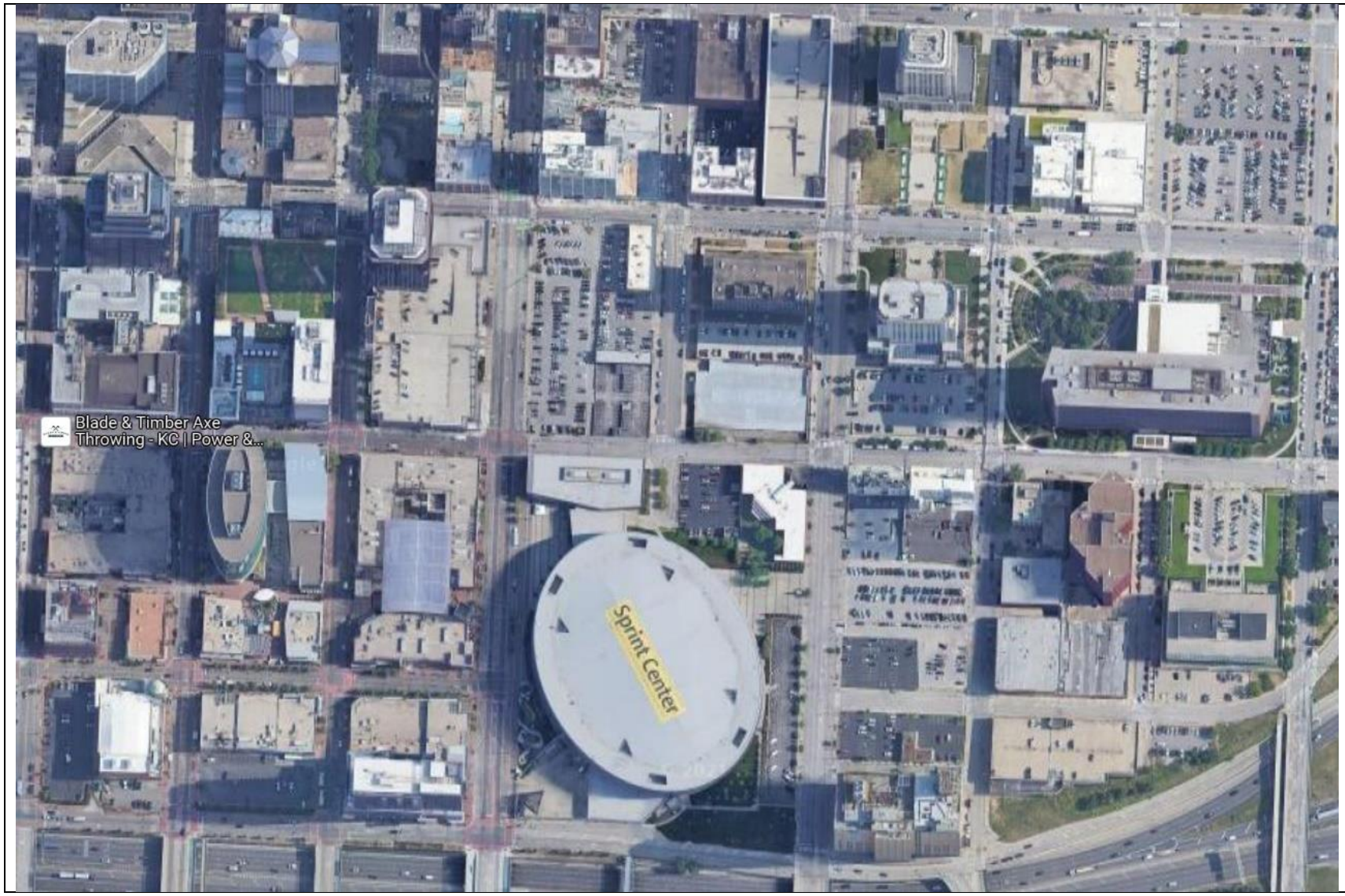
1. _____

2. _____

3. _____

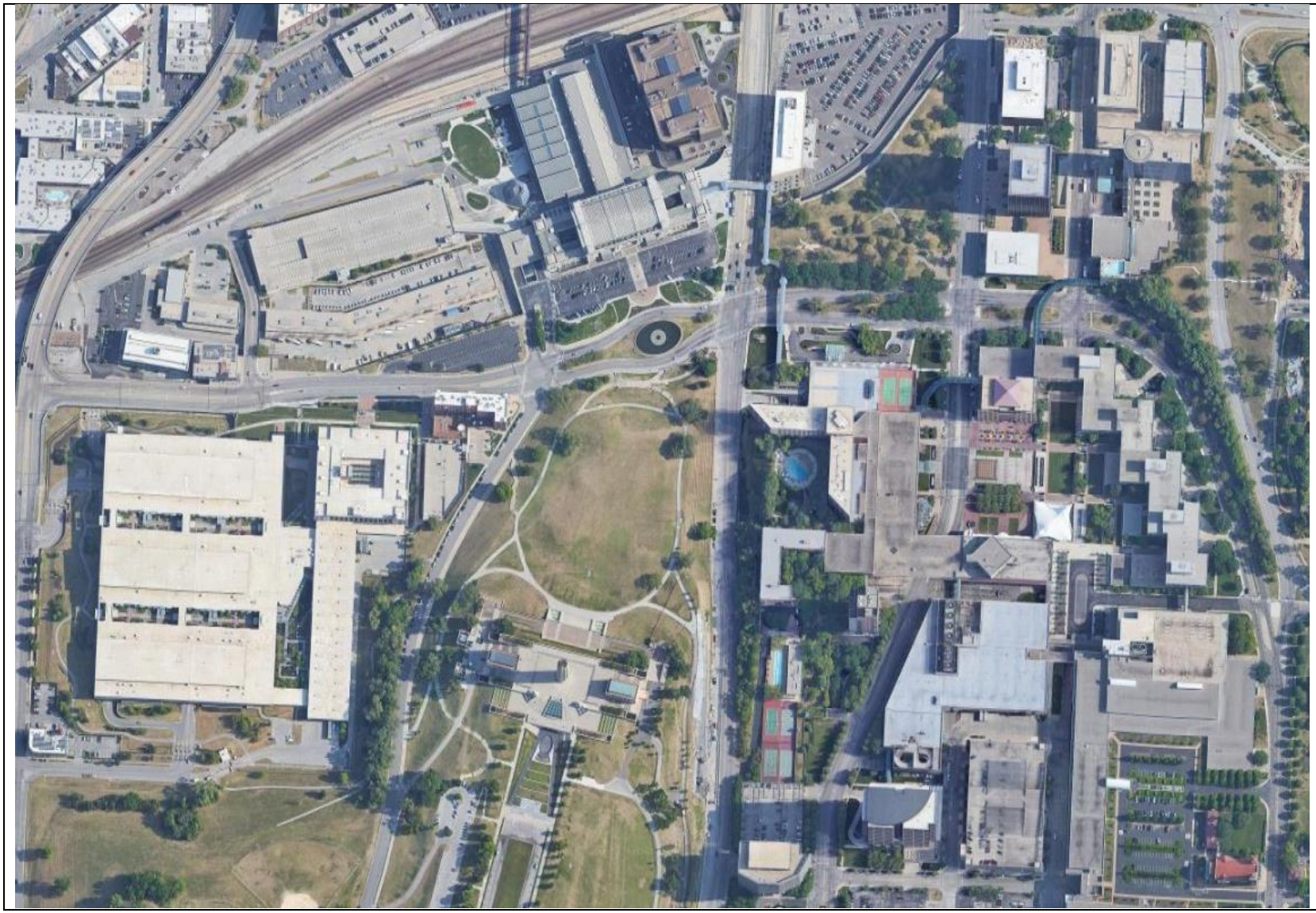
4. _____

Site – Option A (Near Sprint Center)



Google map image

Site – Option B (Union Station)



Google map image

Activity 3.2. Which Roof?

Lesson:	Green Roof	Day: 10 Time Frame: 45 mins	Grade level: 4
Desired Outcome from Lesson: Students will be able to identify different types of roof suitable for the climate, and roof shape affects the ability of the structure			
Topic of Lesson: Introduction to Roof types, material drawing roofs.			
Students' Goals of the Day: Students will understand which roof types are suitable for green roof			
Essential Vocabulary: ▪ Flat roof, gable roof, shed roof, hip roof (see graphics in ppt for description) ▪ ***2D drawing*** – Drawing an object by flattening the object in a view. ▪ ***3D drawing*** – Drawing an object three-dimensionally, with its height, width, and depth. ▪ ***Dead load*** – The weight of a building's structural elements such as beams, walls, and roof. ▪ ***Elevation drawing*** – 2D drawing that shows one side of a building. ▪ ***Floor Plan drawing*** – 2D drawing from the top view of a building without a roof. ▪ ***Live load*** – The weight of things on/in a building, such as people, goods, stormwater. ▪ ***Load*** – Any force that pushes or pulls. For example, the weight of snow pushes down on a building, and that's what we call a snow load. A wind load pushes on the sides of a building and the structures of a bridge. ▪ ***Model*** – A small object that represents another larger object ▪ ***Parapet*** – A low wall along the edge of a roof. ▪ ***Perspective drawing*** – 3D drawing that views a building/an object three-dimensionally. ▪ ***Roof Plan drawing*** – 2D drawing from the top view of a building. ▪ ***Section drawing*** – 2D drawing of a building as though it is cut along a vertical plane. ▪ ***Snow load*** - the weight of accumulated snow and ice on a roof. ▪ ***Structural load*** – The amount of weight a structure has to carry. -			

Teaching

Material

- 3 physical models with different types of roof (flat, gable, and shed)
- PowerPoint Presentation
- Worksheet 3.2.1

Instruction

- **What are the disadvantages of Green Roof?**
  - Cost is higher (30-50%) than traditional roof
  - Heavier than traditional roof
  - It will require maintenance
  - It cannot be built to all types of roof, only to roofs with minimal slopes
  - Only beneficial to urban areas, not so much to rural areas
- What are the **different types of roofs in the city?** (remind them of the green roof coloring activity). What about the roof of their house and in their neighborhood? What about the roof of the school? What about the roof of the Capitol?
- Now we will learn about roof shapes that are suitable to have a green roof.
- **Play PowerPoint presentation** of Basic Roof Shapes and Roof Material

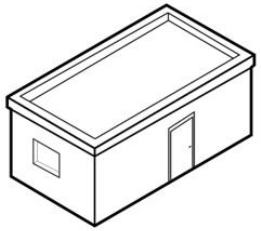
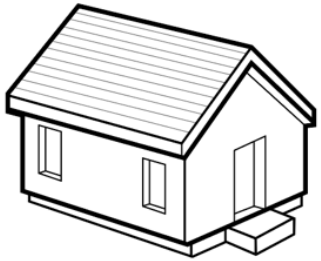
The ppt presentation will cover 4 common roof shapes suitable for a green roof, roof material, and how drawing can represent different roof types.

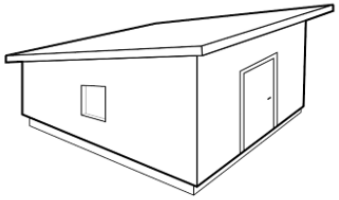
  - Emphasize that structure will need to be stronger to hold the extra weight of soil and plants
  - Emphasize the importance of the parapet (low wall on the roof) to hold the soil on the roof.
- **How do you draw different types of roofs?**
  - 2D drawing and 3D drawing
  - Have the students fill out **Worksheet 3.2.1**

Worksheet 3.2.1. Drawing Different Types of roofs

Name:_____ Class:_____ Date:_____

Direction: Look at the 4 types of roofs and try to draw them in plan, elevation, and section

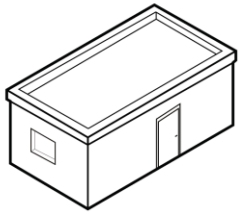
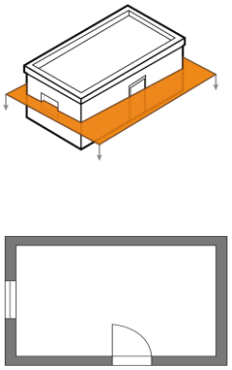
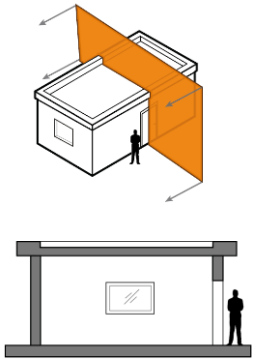
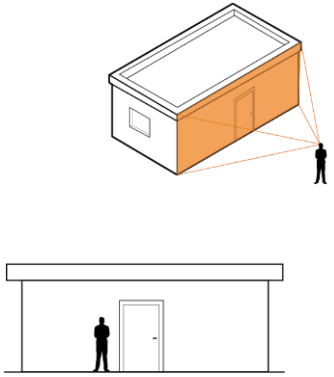
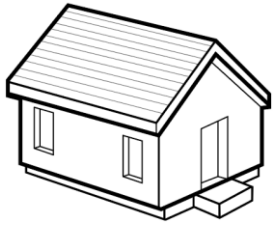
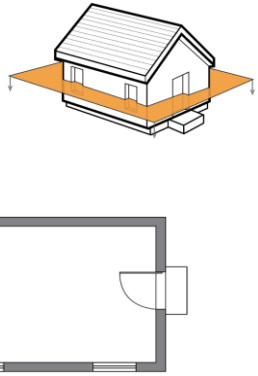
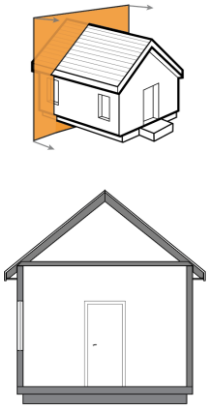
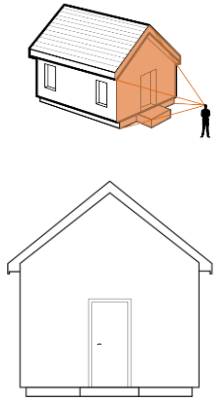
Perspective Drawing	**Roof Plan Drawing**	**Section Drawing** (dotted line indicates section cut)	**Elevation Drawing** (pick 1 elevation; front/side/back)
Flat Roof 			
Gable Roof 			

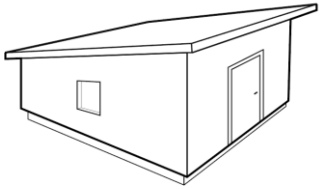
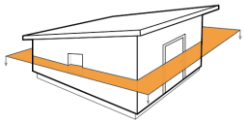
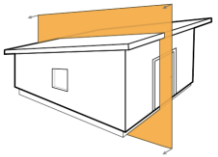
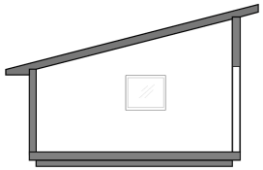
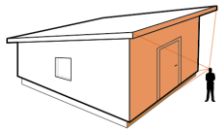
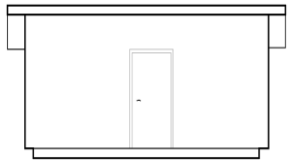
Perspective Drawing	**Roof Plan Drawing**	**Section Drawing** (dotted line indicates section cut)	**Elevation Drawing** (pick one elevation, front/side/back)
Shed Roof 			

Answer sheet 3.2.1. Drawing Different Types of Roofs

Name:_____ Class:_____ Date:_____

Direction: Look at the 4 types of roofs and try to draw them in plan, elevation, and section

Perspective Drawing	Plan Drawing	Section Drawing	Elevation Drawing
Flat Roof 			
Gable Roof 			

Shed Roof 	 	 	 

Demonstration: Testing the roofs[11]

Material (provided)

- 3 physical models with different types of roof (flat, gable, and shed)
- Roof substitutions (cardboard gable roof, cardboard flat roof, and aluminum foil)
- Worksheet 3.2.2
- A handful of pennies/little rocks
- Strainer
- Flour
- Ice cubes made with food coloring (to help with visibility)
- Masking tapes
- Small plastic lid, small enough to hold an ice cube inside of the physical house model

Material (by teacher)

- Digital Thermometer
- Blow dryer
- Stopwatch

Instruction

- Distribute **worksheet 3.2.2** to each student
- See instructional videos to help teachers prepare on Canvas and/or in the PowerPoint

Part 1 – Slope Test (how snow interact with roof slopes)

- What shape is the roof on your house? What is the climate where you live? Can you think of reasons **why the climate might influence the shape of your roof**? Architects and Engineers need to consider the climate of the area in which they plan to design and build structures. Imagine you live in an area that receives a lot of snow. Architects and engineers who design homes in regions that get a lot of snow think about how snow builds up on the roofs. If a roof is not strong enough, the weight of the snow (the "snow load") may cause the roof to cave in. The building roof and materials have to be chosen to be suitable for the climate. It needs to maintain the desired temperature within the building to provide a stable structure to protect against the local weather conditions. Architects and Engineers use models to test the shapes, materials, and functionality of their design.

[11] Adapted from: Construct and Test Roofs for Different Climates - Activity - TeachEngineering & Simple Snow Load Roof Model Demo: Which Roof Is Tops? - Activity - TeachEngineering


- **Show gable roof** and **shed roof models**. Explain that the Gable roof is steeper than the gable roof.
- Explain that the flour represents snow. Predict as to which roof would be best for a snowy climate.
- Slowly sprinkle "snow" onto the top of the roof with a strainer. As students watch the roof through the end of the roof.
- Have students make observations and record n their worksheets as the snow is applied to the roof and builds up to a weighty amount ("the snow load").
- Repeat the process with each model roof type.
- Conclude with a class discussion to share and compare observations and conclusions.

Part 2 – Snow Load test


- Pick the **cardboard gable roof house**
- Now let's test if the shape of the roof will be able to support snow.
- We will use pennies to simulate snow
- Does the roof withstand the weight of the snow?
- Change the cardboard roof to **foam core roof** on the building
- Redo the test
- Does the roof pass the test now?

Part 3 – Heat test

- Pick the cardboard flat roof house
- Now let's test if the house can pass the heat test
- Place an ice cube inside of the house (use a small lid to hold the water)
- We will test to see if this house can keep an ice cube from melting
- Hold blow dryer above the house for 2 minutes
- Measure the temperature inside of the house
- Is the ice cube melting? Does the house pass the test?
- Now change the roof with foam core & a sheet of aluminum foil
- Redo the test
- Measure the temperature inside of the house
- Is the ice cube melting? Does the roof pass the test now?

Worksheet 3.2.2. Testing roofs

Name:_____ Class:_____ Date:_____

As you are observing the Roof testing demonstrations, answer the questions below.

Slope Test (Roof Slope)

1. What happened to each model roof when the "snow" was applied? Does the "snow" pile-up or slide off?

   Gable Roof_____

   Shed Roof_____

2. Predict: Circle which roof type will cave into the snow load the easiest?

   Gable Roof / Shed Roof

   Why?_____

Snow Load Test (Pennies)

3. Circle which roof fell down when the "snow load" was applied?

   Cardboard roof / Foam core roof

   Do they fall slowly or all at once?_____

4. Which roof design is more suitable for snowy climates?

   _____

5. In addition to snow loads, what other forces should we plan for?

   _____

   _____

Heat Test (Roof Material)

Draw and Predict: In the space below, draw the two models with ice in each one. Predict what will happen in each model after heat is applied. Label your drawings with your prediction of what will happen to the ice.

	Cardboard Roof	Foam Core Roof
6. **Observe:** What happen to the ice?		
7. Did the roofs fail/pass the heat test? Why?		

Conclusion

8. After conducting all these tests, which roof shape would be suitable for Green Roof?

_____

_____

Why?

_____

_____

Answer sheet 3.2.2. Testing roofs

Name:_____ Class:_____ Date:_____

As you are observing the Roof testing demonstrations, answer the questions below.

Slope Test (Roof Slope)

1. What happened to each model roof when the "snow" was applied? Does the "snow" pile-up or slide off?

   Gable Roof snow slides off

   Shed Roof snow piles up and some slides off

   Predict: Circle which roof type will cave into the snow load the easiest?
2. Gable Roof / shed roof

   Why? Because the snow piles up and adds more weight to the roof.

Snow Load Test (Pennies)

3. Circle which roof fell down when the "snow load" was applied?

   Cardboard roof / Foam core roof

   Does it fall slowly or all at once? slowly

4. Which roof design is more suitable for snowy climates?

   Roof that has a stronger structure

5. In addition to snow loads, what other forces should we plan for?

   The forces of wind and rain and maybe even earthquake shaking; the weight of roof material (shingles, tiles or green roof soil and plants), gutters and walking people; falling tree branches.

Heat Test (Roof Material)

Draw and Predict: In the space below, draw the two models with ice in each one. Predict what will happen in each model after heat is applied. Label your drawings with your prediction of what will happen to the ice.

	Cardboard Roof	Foam Core Roof + aluminum foil
6. **Observe**: What happened to the ice?	The ice partially melted	The ice melted a little bit
7. Did the roofs fail/pass the heat test? Why?	Fail The cardboard transfers the heat into the inside of the house	Pass Because aluminum reflects most of the heat and does not let any air movement to transfer energy. The foam core acts as an insulation and absorbs the heat,

Conclusion

8. After conducting all these tests, which roof shape would be suitable for Green Roof?

The roof with the strong support and does not have a steep slope.

Why?

The roof needs to hold the additional weight of the soil, plants, people. A steep roof is dangerous to walk on, and it is hard to keep the soil & plant on

Activity 3.3. Green roof in Detail

Lesson:	Green Roof	Day: 11 Time Frame: 45 mins	Grade level: 4
Desired Outcome from Lesson: Students will understand the makeup of green roofs and how the soil can hold and filter the water.			
Topic of Lesson: Green roof layers;			
Students' Goals of the Day: Students will be able to identify the makeup of the roof, test and measure Green Roof's water retention and filtration.			
Essential Vocabulary: ▪ ***Drainage Layer*** – Move excess water to the roof drain. ▪ ***Filter Membrane*** – Filter rainwater and some of its pollutants but let the water through. ▪ ***Growing media*** – Special lightweight soil to grow the plants that drain water well. ▪ ***Roof Structural Support*** – Concrete or steel structure that supports the roof. ▪ ***Section drawing*** – 2D drawing of a building as though it is cut along a vertical plane. ▪ ***Thermal Insulation*** – Material that reduces heat transmission. ▪ ***Vegetation*** – Plants and trees. ▪ ***Waterproofing*** – Protective the roof that repels water from the green roof. ▪ ***Water retention*** – Ability to hold water.			

Teaching

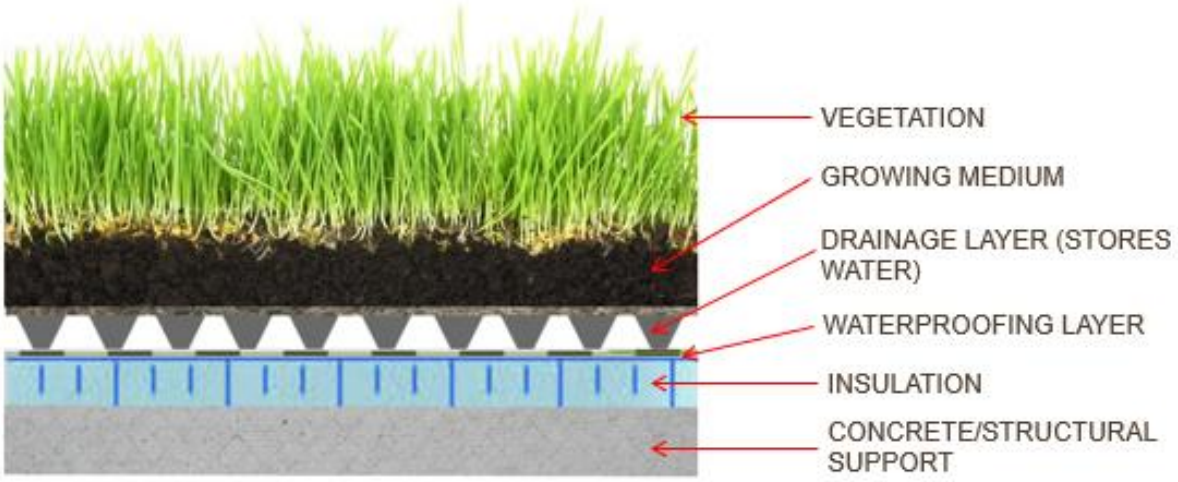
PLEASE RECORD THIS LESSON ON SWIVL

Material

- Worksheet 3.3.1
- Green Roof poster

Instruction

- Distribute Worksheet 3.3.1
- If we cut a section of the green roof, what would we see? Ask students to draw on their worksheet & collectively draw their ideas on the whiteboard
- Ask what the purpose or benefit of each component is



- Identify and explain the different layers of green roof (water retention and water filtration)
- Distribute **worksheet 3.3.1** and ask students to label the layers of green roof

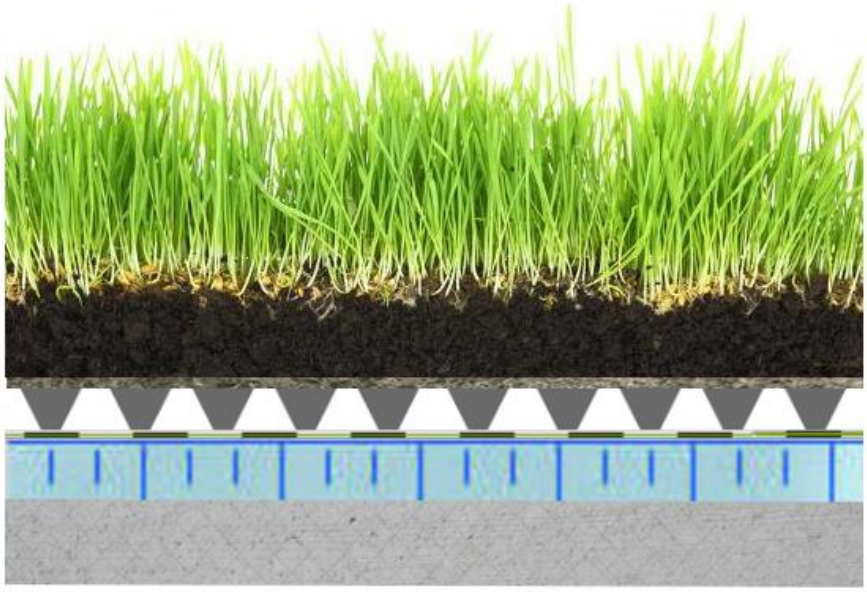
Worksheet 3.3.1 Green Roof Construction

Name:_____ Class:_____ Date:_____

Directions: Draw what do you think a section of the green roof and its material might look like

Directions:

After learning about the layers of Green roof material, label the layers that make up a green roof.



Demonstration 3.3.2: Water Retention

Material

- Worksheet 3.3.2
- Green Roof PVC tubes Kit from Dr. Burken. The PVC tubes consist of Kitty Litter (KL), Hydrogel (HG), and Green Roof media (GAF). Each of the PVC tubes is planted with Sedum (Green Roof vegetation)
- Scale
- Measuring cup
- Water (250ml for each tube/@750ml per group)
- Small cups to collect the water drainage, roughly 200 ml, 1 pint.
- Digital Thermometer (optional)

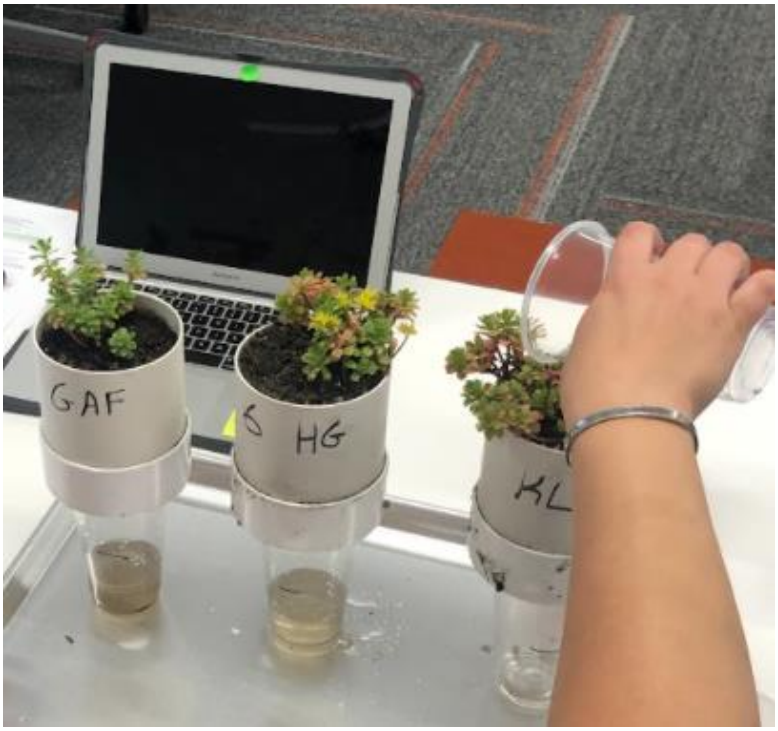
Preparation

- Divide the students into a group of 3-4
- Distribute Worksheet 3.3.2
- **Discussion**: What are everyday materials that can absorb water in your house? (sponge, cloth, towel, diaper, kitty litter, etc.).
- In this experiment, we will try to use kitty litter, diaper material (Hydrogel), and soil that is used in the green roof (Green Roof Media)
- **Explain:** Engineers are constantly finding a good composition of Green Roof media to effectively store rainwater that is lightweight.

Instruction

- **Weigh PVC tubes** before watering and record them in the worksheet
- **Water PVC tubes** with a known amount of water each, 250 ml or 1 Pint should be plenty.

  - Discuss the water retention and the 'slowing' of the water flow as well. The drainage water is looking 'dirty' and has nutrients from the soil. The particles and nutrients are typically only at the initial stages but can be detrimental to the receiving water, lake, or river.



- **Leave the PVC tubes to drai**n in a well-lighted window to drain (or outside) for 3 days.
- **Weigh the PVC tubes and record** the weights daily for 3 days and tally the water loss in the worksheet.

Expected findings:

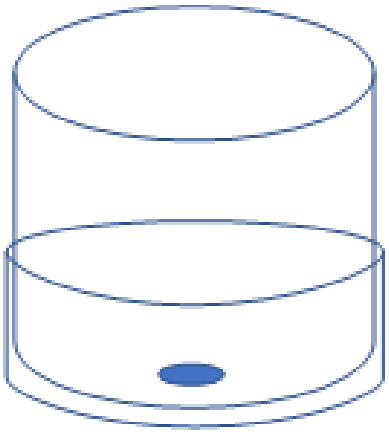
- Water retention returns water to the atmosphere as clean water.
- By altering, engineering the media, we/students can increase the benefits of the green roof and restore the urban water cycle.
- Discuss the benefits of vegetation, in addition to the water benefits.

Optional:

Students can make their own Green Roof Media PVC tubes. Below is the instruction:

- Distribute the 3 pre-made empty PVC tubes (see below)/group and other material listed above.
- Have students assemble the PVC tubes

- Fill with media: a) green roof media, b) green roof media with 6 ml of hydrogel (1%), c) green roof media with 30 ml of kitty litter (5%). Clay or limestone-based is the best Kitty Litter for this activity.
- Label each PVC to reflect each media
- Plant the PVC tubes with Green Roof vegetation (sedum)



Worksheet 3.3.2. Water Retention

Name:_____ Class:_____ Date:_____

Instruction:

1. Assemble 3 Green Roof Tubes
2. Add 3 different types of Green roof media and record them in the table below
3. Add Green Roof vegetation (Sedum)
4. Weigh the tubes and record them in the table
5. Water the tube with 250ml of water/tube
6. Measure their weight and record their weight in the table

Directions: List the two different media you used in each test kit in the first column. Then record the weight of each test kit every day for three days. Record the weight in the table below.

	Kitty Litter (KL)	**Hydrogel (HG)**	**Green Roof Media (GAF)**
Before Water	_____lbs	_____lbs	_____lbs
After Water	_____lbs	_____lbs	_____lbs
Day 1	_____lbs	_____lbs	_____lbs
Day 2	_____lbs	_____lbs	_____lbs
Day 3	_____lbs	_____lbs	_____lbs

Which media absorbed the most water?_____

What are some benefits of retaining the water on the roof?_____

_____

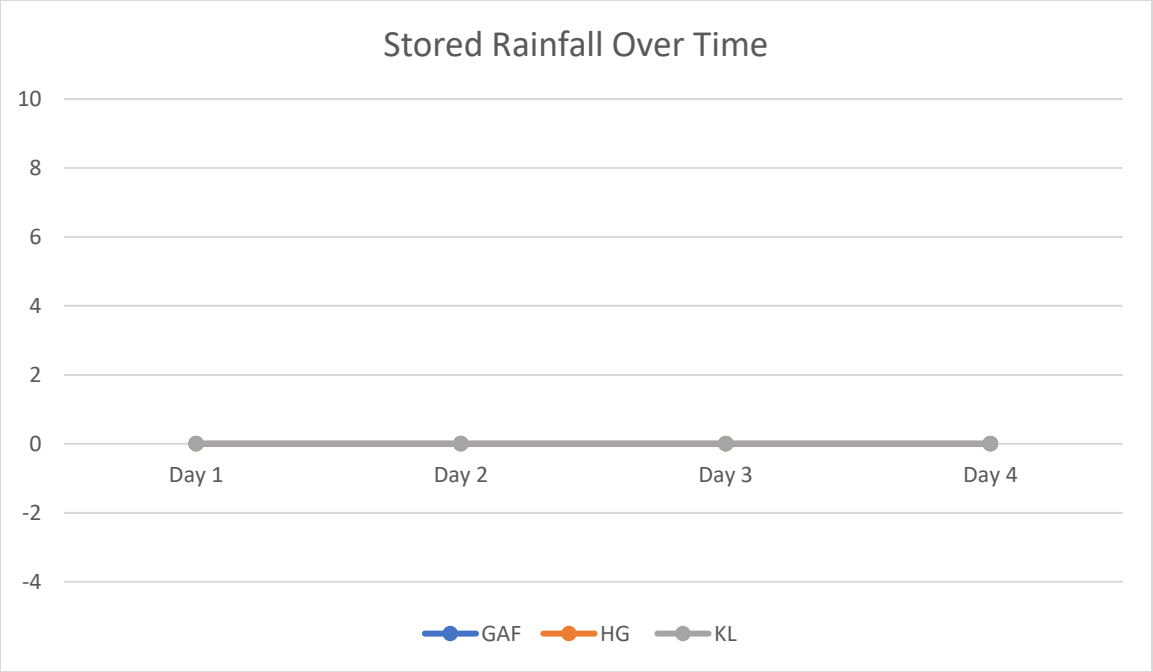
_____

What would you call our new 'invention' or holding water on the roof?_____

_____

Extension:

Create a graph of how much stormwater is stored in each of the PVC tubes over 3 days.



Answer sheet 3.3.2. Water Retention

Name:_____ Class:_____ Date:_____

Instruction:

1. Assemble 3 Green Roof Tubes
2. Add 3 different types of Green roof media and record them in the table below
3. Add Green Roof vegetation (Sedum)
4. Weigh the tubes and record them in the table
5. Water the tube with 250ml of water/tube
6. Measure their weight and record their weight in the table

Directions: List the two different media you used in each test kit in the first column. Then record the weight of each test kit every day for three days. Record the weight in the table below.

Trend: Hydrogel weighs the most when wet; GAF and Kitty Litter have a similar result

	Kitty Litter (KL)	**Hydrogel (HG)**	**Green Roof Media (GAF)**
Before Water	_____lbs	_____lbs	_____lbs
After Water	_____lbs	_____lbs	_____lbs
Day 1	_____lbs	_____lbs	_____lbs
Day 2	_____lbs	_____lbs	_____lbs
Day 3	_____lbs	_____lbs	_____lbs

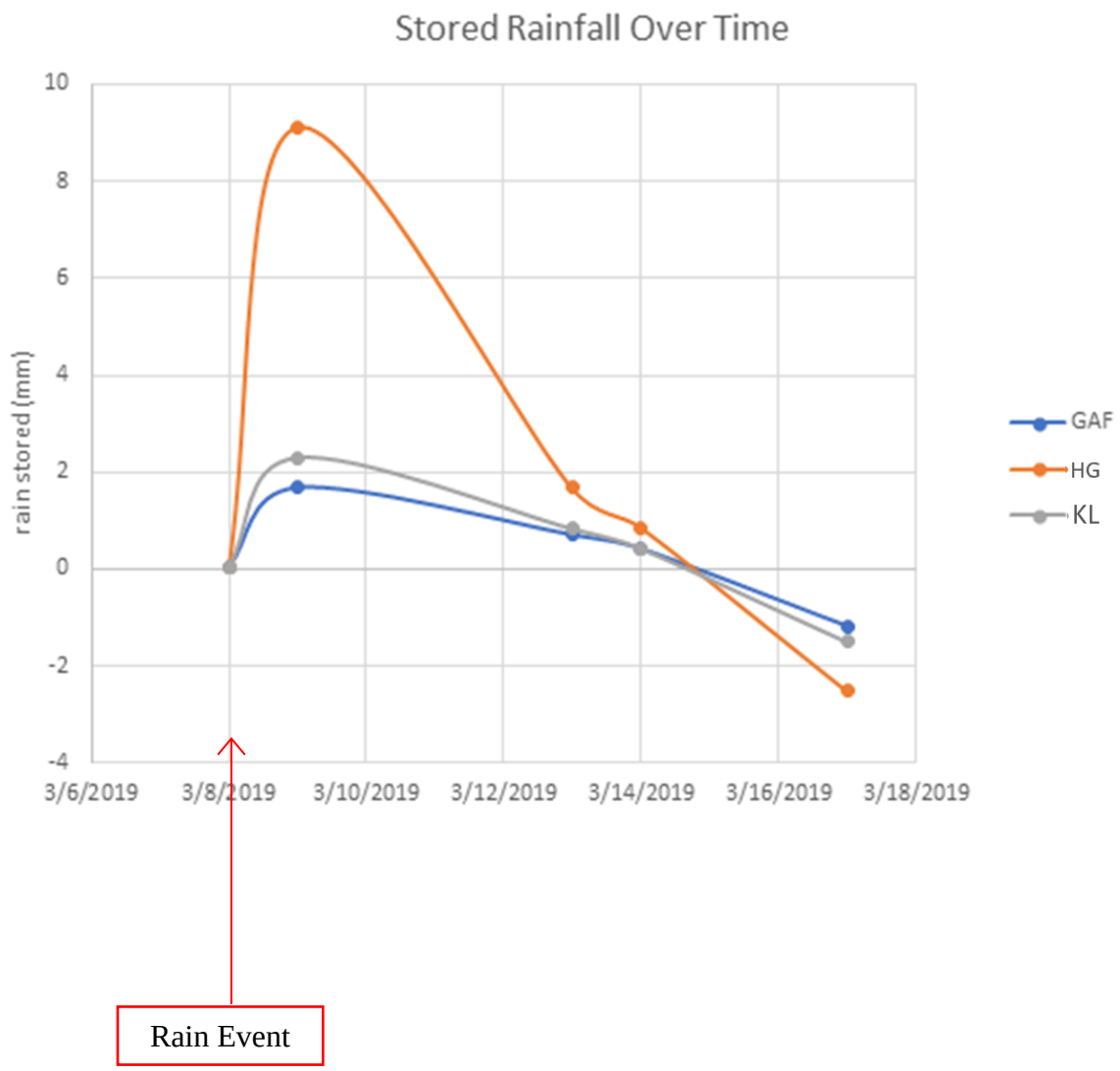
Which media absorbed the most water? Hydrogel

What are some benefits of retaining the water on the roof? It slows the rush of water downstream, preventing downstream flooding and erosion

What would you call our new 'invention' or holding water on the roof? Green roof

Extension:

Create a graph of how much stormwater is stored in each of the PVC tubes over 3 days.



Activity 3.4: Virtual Field Trip: Ask the Engineer

Lesson:	Green Roof	Day: 12 Time Frame: 45 mins	Grade level: 4
Desired Outcome from Lesson: Students will be able to see, experience, and explore a green roof project in a real-world			
Topic of Lesson: Explore Green Roof and ask an engineer about Green Roof			
Students Goals of the Day: Students will be able to ask questions live with the experts			
Essential Vocabulary:			

Material

- TV screen

Instruction

- Organize a day and time that will work for each school
- Confirm zoom details with the University of Missouri Research Team.
- Allow students to ask questions to the Engineers
- At the end of the zoom, ask: what are the new things the students learn about Green Roof.

Activity 3.5. How does Green Roof Help Water Cycle in the City?

Lesson:	Green Roof	Day: 13 Time Frame: 45 mins	Grade level: 4
Desired Outcome from Lesson: Students will be able to understand how Green Roof interacts with Water Cycle			
The topic of Lesson: How do green roofs help the water cycle in urban environments.			
Students' Goals of the Day: Students can draw connections between the green roof and the water cycle.			
Essential Vocabulary: ▪ ***Aggregate* –** Small stones used in building. ▪ ***Aquifer*** – Below ground natural reservoir water used for cooking, drinking, bathing, and irrigation. ▪ ***Bio retention (rain garden)*** – Swale/channel that absorbs, holds, and slowly releases excess water. ▪ ***Permeable surfaces*** – Surfaces where water can readily absorb into the ground. ▪ ***Storm sewer*** – A series of pipes that collects and transports only stormwater. ▪ ***Stormwater runoff*** – Rainfall that flows over the ground surface. ▪ ***Swale –*** *A* little valley on land that collects stormwater.			

Teaching

Material

- ASLA Video – Leveraging Landscape to manage water
- PowerPoint presentation

Instruction

- **Engage:** Now that you know about the water cycle, and green roofs let's learn more about how green roofs can improve the water cycle in cities.
- **Play ASLA Video** – Leveraging Landscape to manage water
- **Show PPT slides**
- Green roofs can **reduce stormwater volumes by up to 85%,** the rain is retained in the soil, and the plants soak up the water and release it as clean air (transpiration). Only the excess water flows to the city drain.

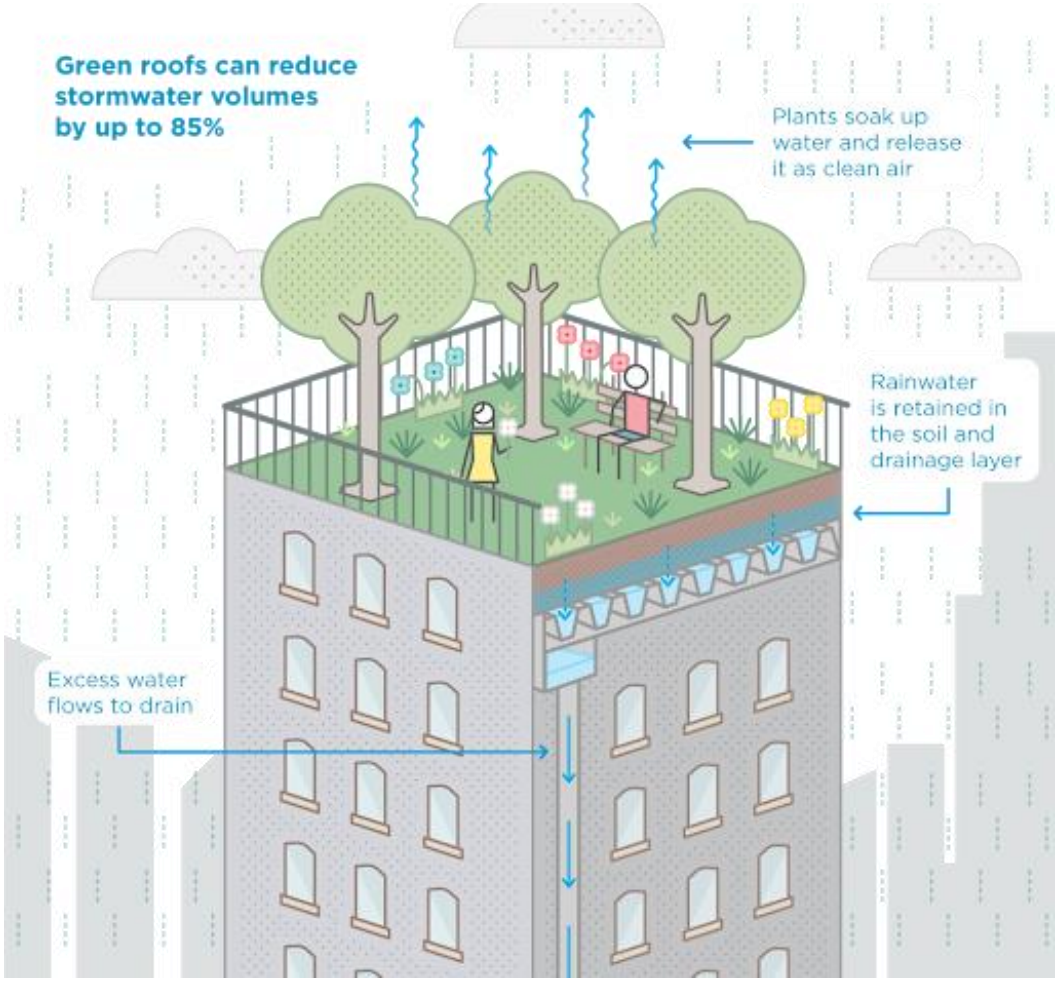


Image source: http://urbanwater.melbourne.vic.gov.au/industry/treatment-types/green-roofs/

- The image below shows that having a green roof reduces the stormwater drain compared to a traditional roof. The roof also repels the heat, making the building more energy-efficient.

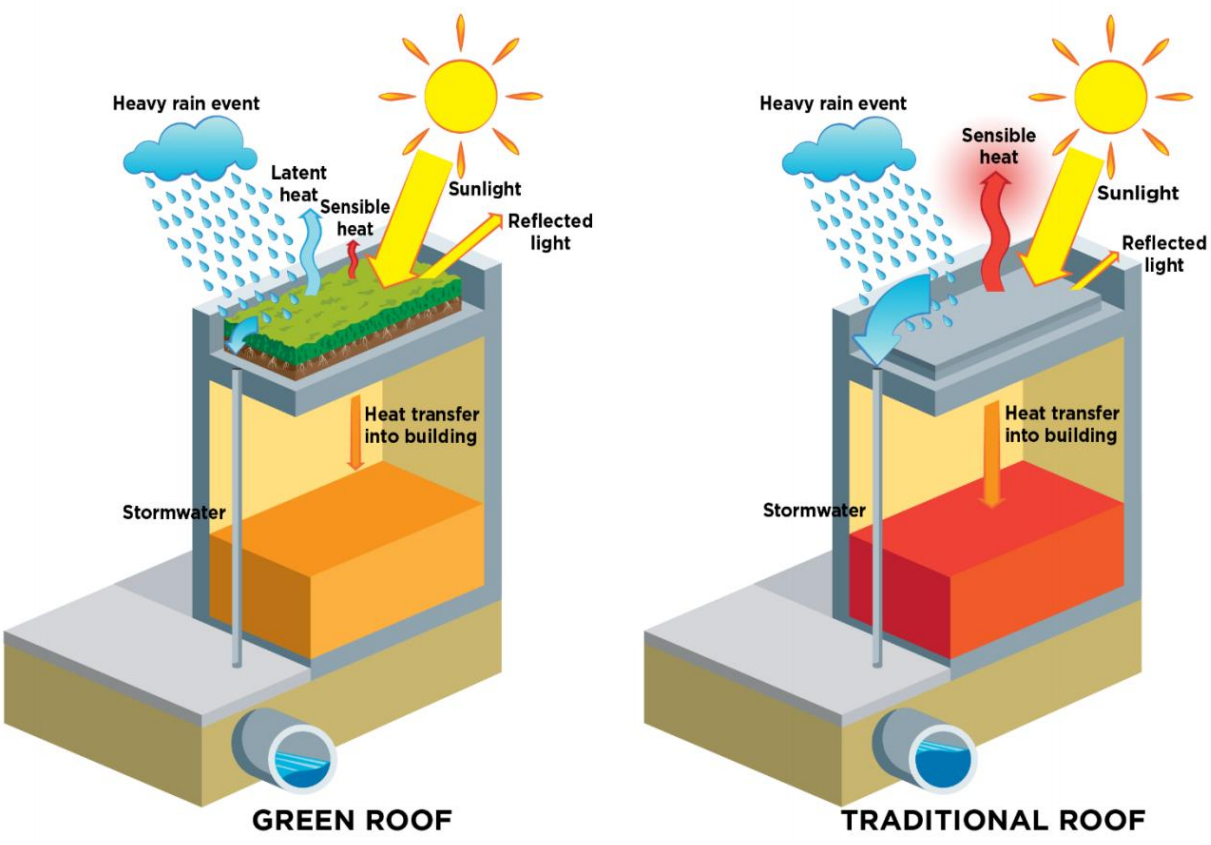


Image source: https://www.epa.gov/sites/production/files/2018-09/documents/greenroofs_casestudy_kansascity.pdf

Hands-on Activity 3.5. Shoe Box Green Roof

Students will build a green roof on a shoebox.
https://www.youtube.com/watch?v=jUh6R1hs2Tw

Material (provided):

- Have each student bring a shoebox to school
- Newspaper to cover tables
- Glue sticks or liquid glue
- Craft materials (foam shapes, cardboard, buttons, pipe cleaners, construction paper, tissue paper, popsicle sticks, felt, etc., for decoration).
- Markers
- Masking tape
- Aluminum foil sheets (sized to line each shoe box lid)
- Potting soil with fertilizer (enough to fill each shoe box lid)
- Different types of sedum or other types of seeds for plant variation (optional)
- Clay
- Small gravel and sand

2. Material (by teacher):

- 24 Forks (for each student)
- Trowels for scooping potting soil
- Plastic bags (to transport potting soil and grass seed if the green roof will be assembled at home)
- Scissors
- Hand washing supplies: water, soap, towels

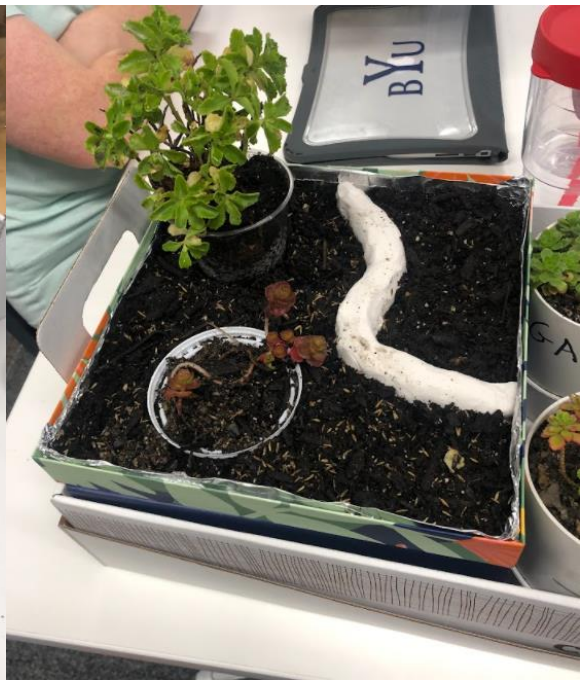
Instruction:

How to assemble your green roof

- Glue or tape the upside-down lid to the bottom of the box.



- Line the inside of the box lid with few layers of aluminum foil. Glue the foil in place to create a tight fit. Makes sure that the lid is 'watertight.'
- Decorate the outside of the box and lid to create a building (house, apartment building, grocery store, fire/police station, community center, church, etc.
- Bring the decorated box to the supply table for potting soil.
- Students can also design the landscape of the green roof by creating a path from clay, small gravel, and sand. Create different levels by placing big pots from plastic cups/lids; and add landscape features such as benches, fences from popsicle sticks, etc.
- Spread soil evenly on top of the aluminum foil
- Sprinkle grass seed from one cup onto roof soil. Use a fork as a hoe to evenly distribute the seeds in the soil. Students can use different types of plant seeds or sedum plants that may be available.
- Students can bring the green roof home.



How to care for your green roof

- Place it on a bright window so it can soak up plenty of sunlight
- Sprinkle ½ -3/4 cup of water over your roof when you get home and then a few days or when the soil is dry. Remember that your roof is made of cardboard, so be careful not to add too much water,
- Within 2—3 weeks, your grass should germinate (sprout).
- You may want to trip the grass with scissors if it gets too long

Model 3

Refer to Student Modeling Packet

30 minutes

Lesson 4: Design Project

Lesson Summary

Using design project to demonstrate understanding on how green roofs can positively affect the urban water cycle

Outline of Activities

Activity 4.1: We Have a Problem! Introduction to design problem and constraints; learn about the client (the dog and the owner) and the site (the backyard) and start designing. (Slides, design activity, worksheet)	10 minutes
- **Worksheet 4.1**	35 minutes
Activity 4.2: Mini Presentation. Mini Presentation & Consensus Design (Continue design, pin-up, group design presentation, collaborate and agree on 2 design options)	30 minutes
- **Worksheet 4.2**	15 minutes
Activity 4.3: Modeling & Testing. (Getting modeling material, model the selected design(s), conduct weight and slope tests)	35 minutes
- **Worksheet 4.3**	10 minutes
Activity 4.4: We Have a Solution! Improve the design as a group, refine the model and draw the final design (Design activity, remodel, draw, overlay water cycle diagram)	35 minutes
- **Worksheet 4.4**	10 minutes
Activity 4.5: Presentation Day. Finalize presentation pitch, present the design in the classroom, exhibit design, and evaluate other group's design	30 minutes
- **Worksheet 4.5**	15 minutes

**Please record the highlighted activities using Swivl*

Preparation Alert

Lesson	Materials need to be provided by	
	Teachers	**Students**
4.2-4.4	Home Improvement Store can be set up at the start of Lesson 4.2	-

Activity 4.1. We have a problem!

Lesson:	Design Project	Day: 14 Time Frame: 45 mins	Grade level: 4
Desired Outcome from Lesson: Understand the criteria of a design problem and generate multiple design solutions			
Topic of Lesson: Project Introduction, generate design solutions			
Students' Goals of the Day: Understand the project requirements and draw their design ideas on paper. Students work individually today.			
Essential Vocabulary: ▪ ***Client*** – A person, a couple, a family, or a group of people who hired an expert/professional (such as architects, landscape architects, and engineers) to design and build a project (such as a house, a garden, a building, and other structures). ▪ ***Design Criteria*** – The goals a project must achieve to be successful. ▪ ***Model*** – A small object that represents another larger object. ▪ ***Section drawing*** – 2D drawing of a building as though it is cut along a vertical plane. ▪ ***Site Plan drawing*** – A 2D drawing that sees the house/building in its context (on a larger scale).			

Teaching

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Material

- PowerPoint Presentation
- Worksheet 4.1

Instruction **(10 minutes)**

- Read the narrative below:

Imagine you are an architect, and you have a new client with a design problem for you to solve.

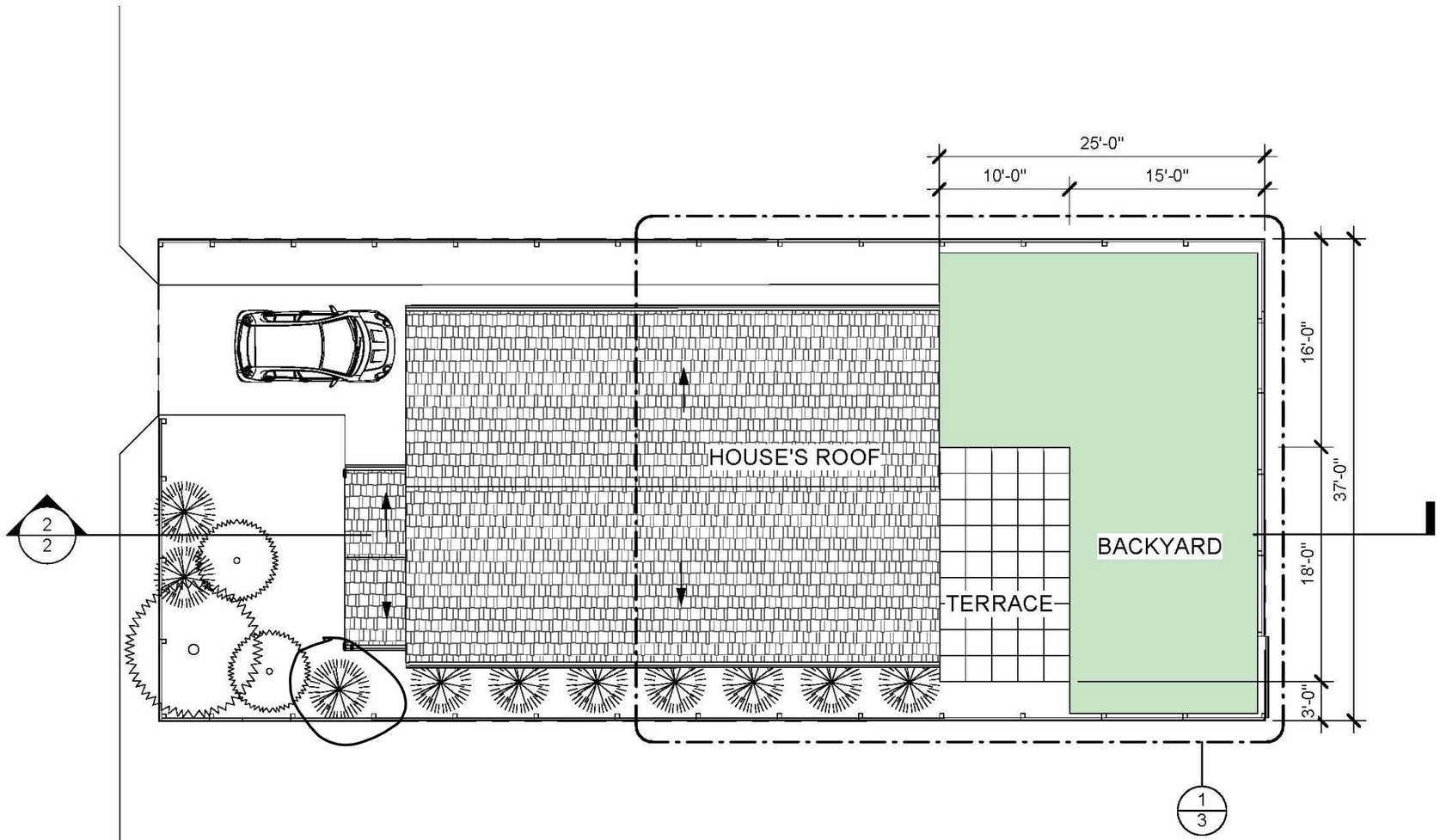
Meet Luna. She is a 2-year-old Siberian Husky. She loves to be outside and loves winter. During the summer months, she gets warm very quickly. Billy, her owner, wants to build a doghouse in his backyard. Billy has a small and barren backyard. Billy wants the doghouse to have **a green roof** to be a nice place for Luna to chill during warmer weather. He wants the green roof doggie house to be **aesthetically pleasing and improve the stormwater drainage** in his backyard. Can you help Billy and Luna to find a creative solution for the doggie house?

- Show **PowerPoint Slides** of green roof dog house examples
- Distribute the **worksheet 4.1** and Billy's house drawings
- Have each student **develop an individual design** for the green roof dog house
- Have students identify the materials of the dog house

Worksheet 4.1. Green Roof Dog House

Name:_____ Class:_____ Date:_____

Direction: Draw your dog house design with a green roof for Luna at Billy's back yard. You can draw a plan, elevations, a section, or a 3D drawing. You can draw in this worksheet or on the architectural drawings or extra paper if you need more space for your ideas.



1 Site Plan
1" = 10'-0"

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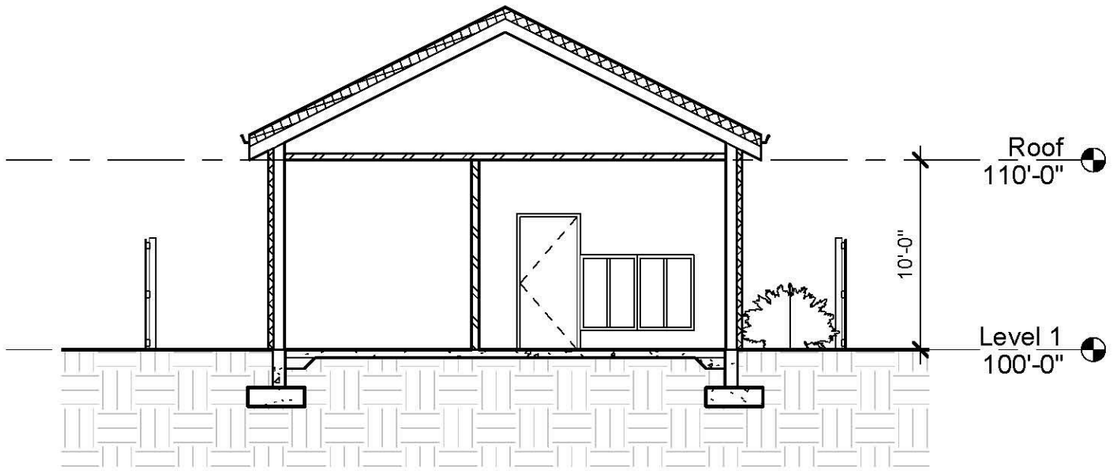
1 of

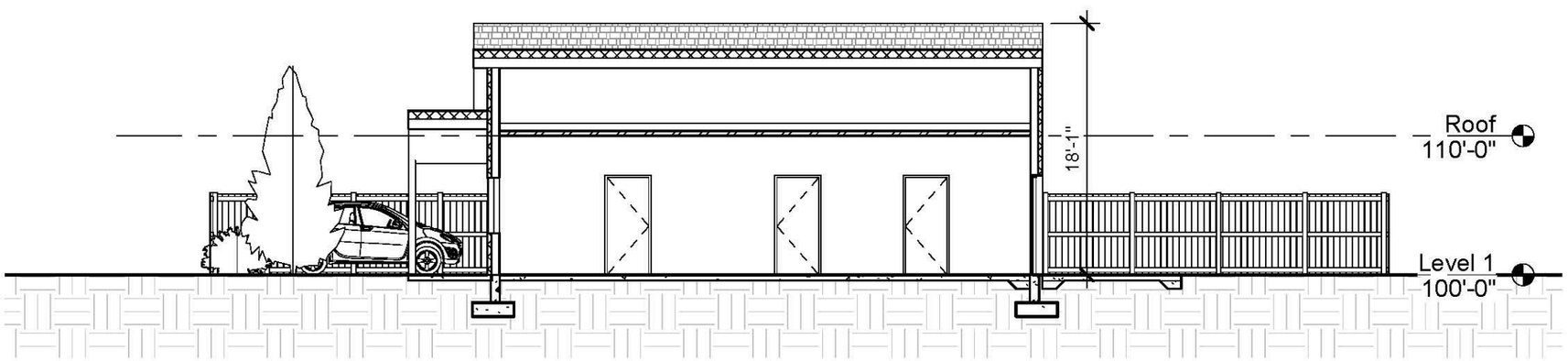
project # 202101
date 7/12/2021 10:48:08 PM

Doggie House
Kansas City



1 Section 1

1/8" = 1'-0"



2 Section 2

1" = 10'-0"

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Building Sections

2 of

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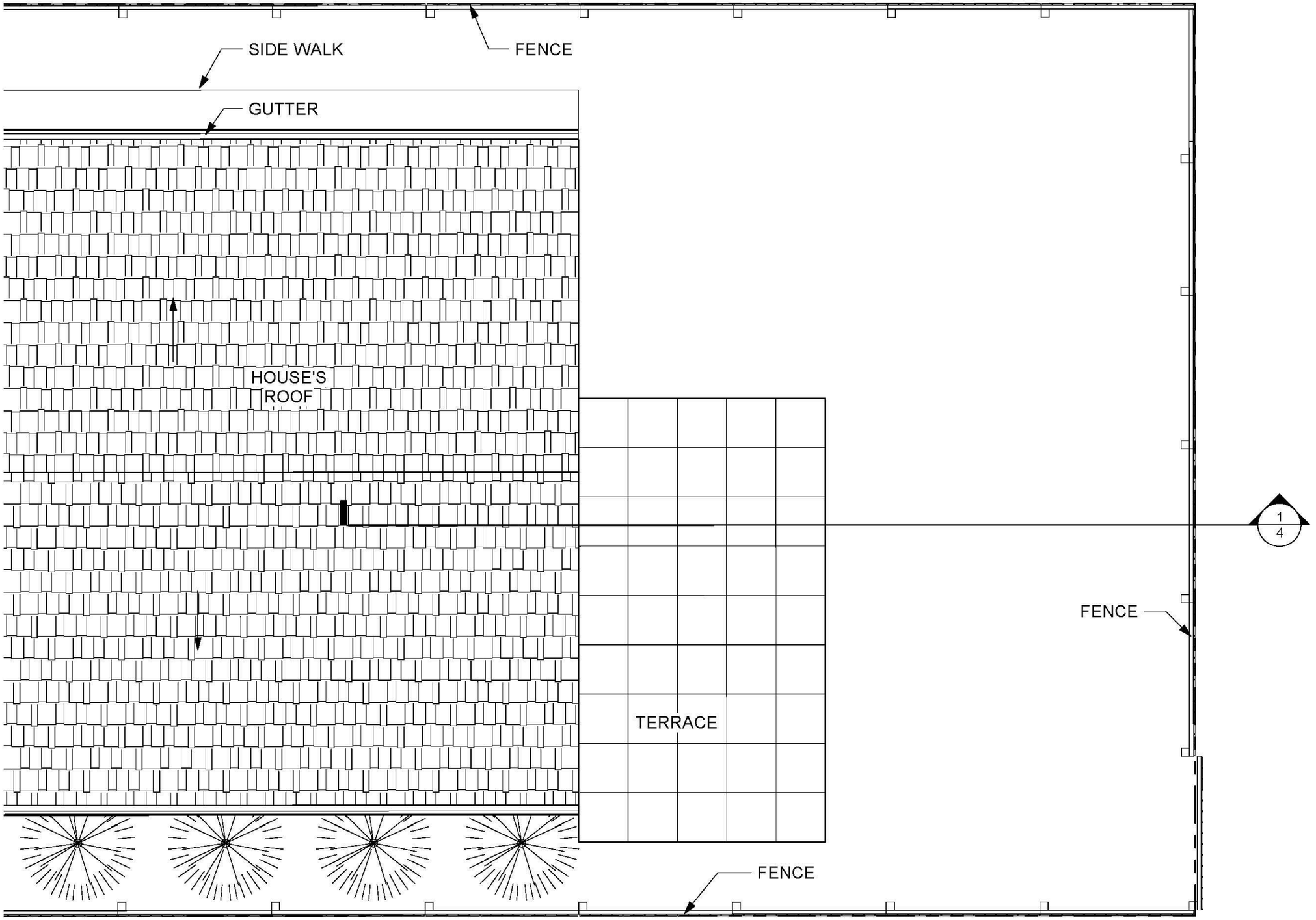
Doggie House

Kansas City



1 DOGGIE HOUSE SITE (BACKYARD)

1/4" = 1'-0"

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Doogie sHouse Site

3 of

project #_202101

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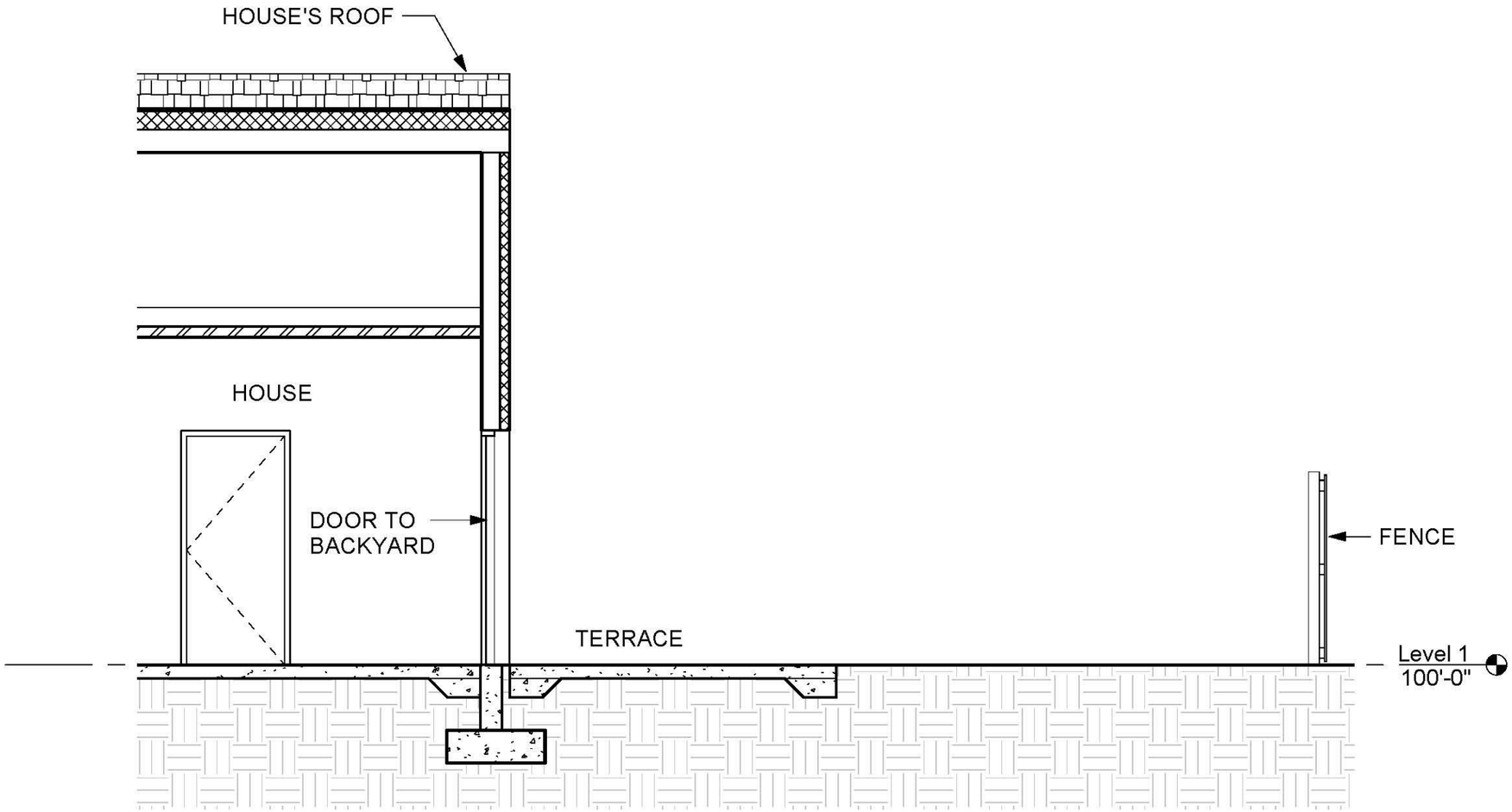
Doggie House

Kansas City



1 Doggie House Site (Backyard) Section

1/4" = 1'-0"

revision / issue

Site Section

sheet number

of

project # 202101

date 7/12/2021 10:48:32 PM

Doggie House

Kansas City

Activity 4.2. Mini Presentations & Consensus Design

Lesson:	Design Project	Day: 15 Time Frame: 45 mins	Grade level: 4
Desired Outcome from Lesson: Students will be able to present their design, analyze, evaluate and select design options by understanding design constraints; material, cost, and time			
Topic of Lesson: Practice presentation & design options			
Students Goals of the Day: Students will share their individual ideas and in groups of ~3 collaboratively agree on 2 final options based on design criteria, material, and budget.			
Essential Vocabulary: ▪ ***Collaborate*** – Working together to solve a problem. ▪ ***Client*** – A person, a couple, a family, or a group of people who hired an expert/professional (such as architects, landscape architects, and engineers) to design and build a project (such as a house, a garden, a building, and other structures). ▪ ***Design Criteria*** – The goals a project must achieve to be successful. ▪ ***Model*** – A small object that represents another larger object ▪ ***Section drawing*** – 2D drawing of a building as though it is cut along a vertical plane. ▪ ***Site Plan drawing*** – A 2D drawing that sees the house/building in its context (on a larger scale).			

Hands-on: Mini Presentations & Consensus Design

Material for drawing (by teacher)

- Worksheet 4.2
- Papers for drawing
- Pencil, pencil colors, eraser, etc.
- Pin-up board

Material for Physical Model

Allocate a desk where all the material can be laid out as the "Home Improvement Store." Students may not have time to start buying the material on this session.

- Popsicle sticks (provided)
- Various colored/ wrapping paper for decoration (provided)
- Aluminum foil (provided)
- Cardboard (by teacher)
- Stick glue or liquid glue or glue gun (by teacher)
- Scissors (by teacher)
- Magazine pages that have photos of grass, flowers, etc (by teacher)
- Fabrics, felt, and interior samples (by teacher)
- And other decorative materials (by teacher)

Instruction

Part 1 – Presentation (10 minutes)

- Have students sit with a group of 3 & distribute **Worksheet 4.2**
- Have students **pin up** their dog house designs and **present their individual designs** within the group (2 minutes for each student)

Part 2 – Discussion (15-20 minutes)

- Following the prompt in **Worksheet 4.2,** discuss the following;
  - How each design can **function** as a dog house. Does it have a roof and walls that enclose the space? Does it have a door so that the dog can enter?
  - How each design **meets the design criteria** (does it improve Billy's backyard, and does it improve the water cycle at Billy's backyard)
  - Discuss **creativity** and **aesthetics**. Is it a standard dog house, or is there a special feature in the design? How does the scale of the dog house compare to the big house? What are the materials that are being considered? Are there shape, color, texture considerations in the design?
  - Discuss if the students can **build a small model** of their design? **Compare** which are easier to build than others.
  - Discuss if some designs may **cost more or less** than others. Have the students rank each design

Part 3 – Evaluate & Design Consensus (15-20 minutes)

- Have students compare which design has the most positive values. The **design with the most positive values is possibly the best solution for the doghouse design**. Otherwise, students can select the best features of each design solution and design a new one as a group.
- Have student teams **collaboratively agree** on a design (consensus designs)
- Fill out **worksheet 4.2** on why the final design was selected.
    - If they can't decide on a design, they can keep 2 designs for further testings in the next activity
    - Or, they come up with another design that combine all the positive values from all three design options.

- Students can start collecting/buying building material if there is some extra time

Worksheet 4.2. Design Options

Name:_____ Class:_____ Date:_____

Directions: Answer the questions below.

	Design Criteria Will this design improve Billy's backyard and the water cycle? If so, how?	**Creativity** Do you think the design is creative? What do you like the most about it?	**Buildability** Can you make a small model for this design? What do you need to model this design?	**Cost** Rank do you think each design will cost. (1 is the cheapest and 3 is the most expensive)
Design 1				
Design 2				
Design 3				

Based on the above, is there one design that stands out compared to others? You can also combine the best of two or three design solutions and develop it further as a group. Write what you decide as a group below.

_____

_____

This extra paper is provided if the group decides to re-design the doghouse as a group based on their analysis.

Activity 4.3. Modeling and Testing Day

Lesson:	Design Project	Day: 16 Time Frame: 45 mins	Grade level: 4
Desired Outcome from Lesson: Students will be able to construct a prototype of their design and understand what can go wrong with the design by conducting testing			
Topic of Lesson: Modeling and testing design options			
Students Goals of the Day: Student groups will now construct models of their final design and carry out tests on the model. Students will plan how the doghouse design can be improved based on their tests.			
Essential Vocabulary: ▪ ***Client*** – a person, a couple, a family, or a group of people who hired an expert/professional (such as architects, landscape architects, and engineers) to design and build a project (such as a house, a garden, a building, and other structures) ▪ ***Design Criteria*** – the goals a project must achieve to be successful ▪ ***Section drawing*** - 2D drawing of a building as though it is cut along a vertical plane ▪ ***Site Plan drawing*** – a 2D drawing that sees the house/building in its context (on a larger scale) ▪ ***Model*** - a small object that represents another larger object			

Hands-on Activity – Modeling & Testing

Material :

- Material for Physical Model: (see lesson 4.2)
- Worksheet 4.3
- Weight Test: Books of various thickness
- Slope Test: Green foam/felt/oasis/moss for green roof

Instruction:

Part 1: Buying and Modeling (25 minutes)

- Allocate a desk as a "Home Improvement Store," where the modeling material will be located.
- Have students shop their building material from the "Home Improvement Store"
- Explain that the model can't be bigger than 8" tall.
- Have students build the models

Part 2: Testing (20 minutes)

- Distribute **Worksheet 4.3**. Ask students to conduct the tests by following the directions in the Worksheet.
- Weight Test
  - Have students test their model by placing weight on top of their model (books)
  - Observe if the model withstands the weight
- Slope Test
  - Place a green foam/felt/oasis/moss for the green roof
  - Have students analyze if the roof can hold the soil (place oasis/moss) on the roof. Is the roof too steep or too flat?
- Have students think about **how they can improve their design** based on the tests they conducted
- Have students improve their design and draw it on the worksheet
- If there is extra time, the students can keep improving on their physical model.

Worksheet 4.3 Modelling & Testing

Name:_____ Class:_____ Date:_____

Direction:

Draw your design in the left column and describe what happened to the models after the weight and slope test. Once you finish testing your models, how do you think you can improve your design? Draw the improved design in the last row.

1. **Weight Test**

   Carefully place a thin book on top of your doggie house design for few seconds. Can your model hold up the book without caving in?

   _____

   _____

   If it caved in, what are the changes to happen to improve the model?

   _____

   _____

2. **Slope Test**

   Carefully place a layer of green foam/felt/oasis/moss on the roof. Does it stay?

   _____

   _____

   If it falls off, what can you do to keep it on the roof?

   _____

   _____

3. Are there other changes that you would like to add in your model? If so, list them below.

   _____

   _____

4. Draw the improved model from the tests that you just have done. Alternatively, you can take a photo of the improved model and label the changes that improved the design.

Activity 4.4. We Have a Solution!

Lesson:	Design Project	Day: 17 Time Frame: 45 mins	Grade level: 4
Desired Outcome from Lesson: Students will understand how the roof will affect the water cycle in the built environment			
Topic of Lesson: Complete the final model			
Students Goals of the Day: Complete the final model and have each student draw the doghouse with a water cycle diagram			
Essential Vocabulary: ▪ ***2D drawing*** – Drawing an object by flattening the object in a view. ▪ ***3D drawing*** – Drawing an object with its height, width, and depth. ▪ ***Aerial view*** – 3D drawing that views a building/an object from above. ▪ ***Elevation drawing*** – 2D drawing that shows one side of a building. ▪ ***Floor Plan drawing*** – 2D drawing looking down on a building. ▪ ***Sales pitch*** – A sales presentation to persuade someone about their product. ▪ ***Section drawing*** – 2D drawing of a building as though it is cut along a vertical plane. ▪ ***Vegetation*** – Plants and trees.			

Hands-on Activity: Improve, Finalize, and getting ready to Present the Model

Material

- Material for Physical Model: (see lesson 4.2)
- Worksheet 4.4.1 (print for each student)
- Worksheet 4.4.2 (print for each group)
- Reprint 11x17 house drawings sheet no 3-4.

Instruction:

Part 1: Improve your model (10-15 minutes)

- Have students buy new material if required
- Have students improve their model

Part 2: Final drawing & Water Cycle (15-20 minutes)

- Distribute Worksheet 4.4.1
- Have each student draw a section of the doggie house and add water cycle diagram. Ask yourself: how does your design improve the water cycle in Billy's backyard.

Part 3: Presentation preparation (20-30 minutes)

- Distribute Worksheet 4.4.2
- **Explain:** Now that the design is completed, it is now time to present it to the client (Billy and Luna)
- The presentation should explain how their doggie house design with a green roof can improve the water cycle process in Billy and Luna's backyard.
- The presentation should have a **'sales pitch**' to convince Billy that your design is the best solution to their problem.
- The presentation should not be longer than 1 minute.
- Give students a couple of options on the presentation format;
  - Stand up oral presentation
  - Commercial
  - Flip Grid (this can be an extension)
- Have students discuss within their group which presentation format they would like to choose.
- Prepare your sales pitch

Worksheet 4.4.1 Design Solution & Water Cycle

Name:_____ Class:_____ Date: _____

Direction: Draw a section of your doggie house. Add water cycle diagram in your drawing to explain how your design improve water cycle in Billy's backyard. (water cycle diagram use pictures/symbols or vocabulary words)

Worksheet 4.4.2 Presentation

Name:_____ Class:_____ Date: _____

Direction: Explain how their doggie house design with the green roof can improve the water cycle process in Billy and Luna's backyard.

Activity 4.5. Presentation day

Lesson:	Design Project	Day: 18 Time Frame: 45 mins	Grade level: 4
Desired Outcome from Lesson: Students will display an understanding of the relationship between Green Roof and Water Cycle in a built environment			
Topic of Lesson: Presentation Day			
Students Goals of the Day: Students will be able to present their design in an engaging way & able to provide positive feedback to their peers			

Hands-on Activity: Presentation & Evaluation

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Material & Preparation

- Worksheet 4.5 (print for each group)
- Allocate space for students' work display. Space should allow for a model to sit on and a peer's evaluation sheet adjacent.

Instruction:

Part 1: Presentation (30 minutes, including questions and answers)

- Have each group present to the whole class
- Allow space for drawings pin-up and model display
- Allow some time for questions and answers
- At the end of the presentation, have each group display their model
- Place Peer's evaluation sheet (Worksheet 4.5) adjacent to each model

Part 2: Peer's work evaluation (15 minutes)

- Have students provide positive comments/feedback on the peer's work on the evaluation sheet (Worksheet 4.5)
- This activity can take place throughout the following week after the presentation.

Worksheet 4.5 Peer's evaluation sheet

Name: _____ Date: _____

_____ Class: _____

_____

List positive feedback for your friend's doggie doghouse design

Evaluator Name:	Feedback

Evaluator Name:	Feedback

Evaluator Name:	Feedback

Rubric

Use this rubric to grade your student's the Doggie House design project

Activity Title: Design and Construct Dog House						
Name:			Class:		Grade:	
Criteria	**Beginning**	**Developing**	**Proficient**	**Advanced**	**Weight (X-Factor)**	**Subtotal**
Design	Design does not address the design criteria and does not pass the weight test.	Design meets the design criteria, pass the weight test, but did not consider the context and aesthetics	Design meets all the design criteria, pass the weight test, address the aesthetics and the context	Design meets the design criteria, pass the weight test, considered the context and aesthetics; highly creative (out of the box); well developed and included high level of details	30%	
Model Construction	Construction are incomplete	Dog house shows evidence of hasty construction	Dog house shows evidene of careful craftmanship and appropriate use of materials and tools	Dog house shows evidence of very careful craftmanshipand, with a lot of details and considers the scale.	20%	
Demonstrates Understanding of how green roof can improve water cycle in the built enviornment	Does not use terms correctly, unable to answer questions on green roof and/or water cylce	Can answer questions about green roof and/or water cycle, but uses terms incorrectly	Can elaborate & answer questions about green roof and/or water cylce, uses the terms correctly, can explain how they apply to the doggie house design	Can elaborate on green roof & answer questions about green roof and/or water cycle, uses the terms correctly, can explain how they relate to their doggie house design and offers suggestions for other doggie house designs	50%	
					Total	
Teacher comments:						