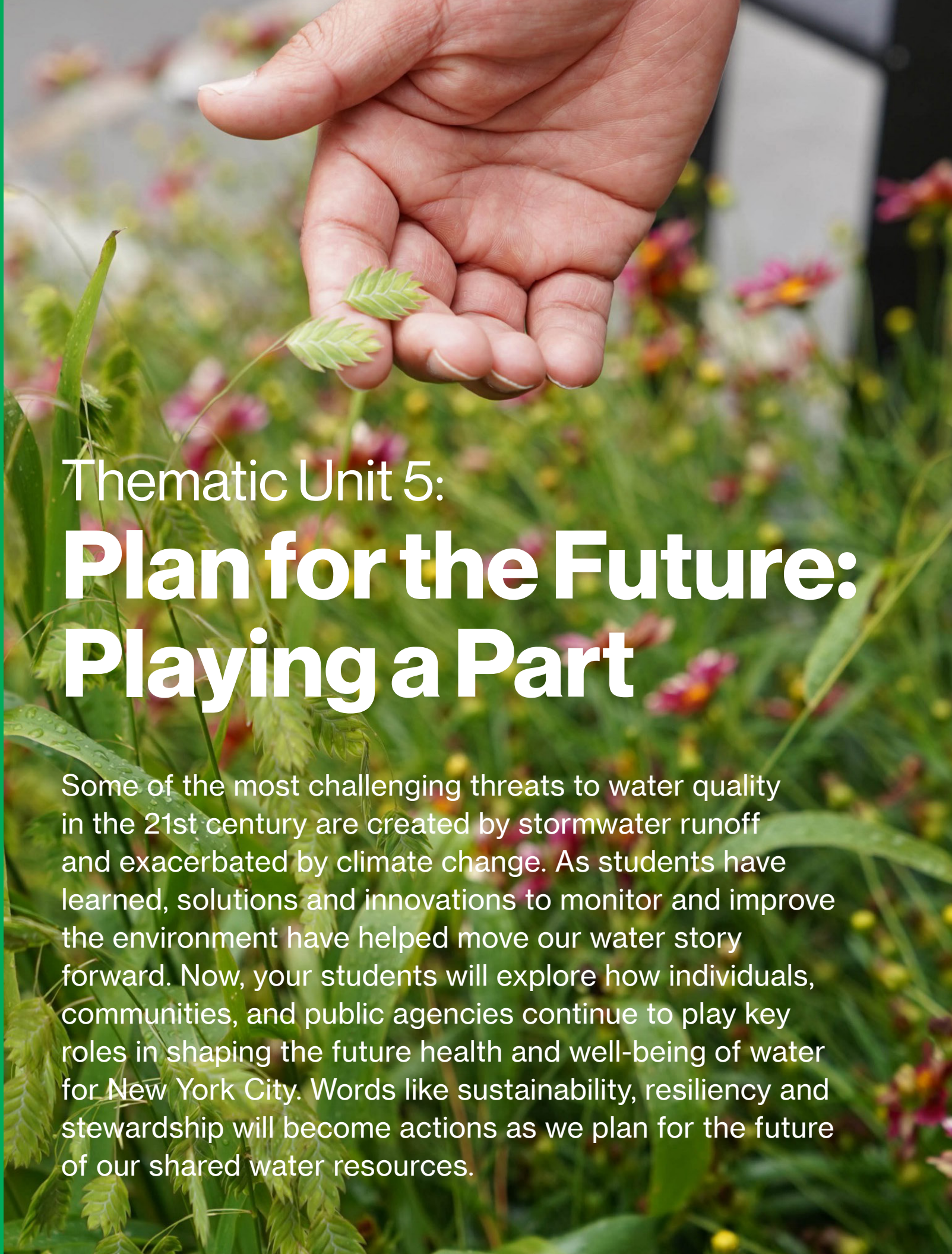


Thematic Unit 5:

Plan for the Future: Playing a Part

Some of the most challenging threats to water quality in the 21st century are created by stormwater runoff and exacerbated by climate change. As students have learned, solutions and innovations to monitor and improve the environment have helped move our water story forward. Now, your students will explore how individuals, communities, and public agencies continue to play key roles in shaping the future health and well-being of water for New York City. Words like sustainability, resiliency and stewardship will become actions as we plan for the future of our shared water resources.

What you should know:

STORMWATER RUNOFF

The Earth has a very efficient method of cycling water through the atmosphere and the land. As precipitation falls from the sky, it infiltrates and replenishes the groundwater, gets absorbed by plants, and runs into waterways refreshing surface water. The heat from the sun warms the water and turns it into a gas that rises back into the atmosphere through the process of evaporation. Transpiration also releases water from plants as a gas into the atmosphere. Unfortunately, in an urban environment, many of these natural processes can be thwarted by our developed landscape.

Modern towns and cities are full of **impervious** surfaces, like roads, sidewalks, and parking lots, which cannot absorb rainwater. New York City's ultra urban landscape is approximately 72% impervious. Because infiltration is not possible, this stormwater will flow downhill until it reaches a waterway or a catch basin where it will enter the sewer system. The water that does not infiltrate but instead runs off the land is called **stormwater runoff.** As it flows over impervious surfaces, stormwater runoff picks up pollutants like litter, pesticides, fertilizers, animal waste, and motor oil.

When polluted stormwater runoff reaches our waterways the ecological balance suffers. Trash creates a risk for wildlife when it is mistaken for food. Chemicals, such as motor oil and pesticides, can be toxic to those same animals. Fertilizers can cause algae to grow out of control and deplete the oxygen levels in the water. Too much animal waste can introduce unhealthy levels of bacteria into the waterways. Stormwater runoff, and the pollutants it carries, remains a challenge for New York City's combined and separate sewer systems, and ultimately, harbor water quality. With 520 miles of waterfront, most New Yorkers are connected in one way or another with New York Harbor and its rivers, creeks, and bays. Remedying the problems caused by stormwater runoff will improve the quality of life for all New Yorkers, visitors, and marine ecosystems.

GREY AND GREEN INFRASTRUCTURE

One way to improve water quality is to upgrade existing infrastructure to help reduce discharges and pollutants from contaminating our waterways. **Grey infrastructure** includes system improvements that manage stormwater, such as the installation of underground stormwater retention tanks or large-scale tunnels, and construction of new separate sewers where none existed. While grey infrastructure can be effective at diverting or retaining large amounts of water during wet weather, these techniques tend to be costly and are only "working" when it's raining.

Another approach to improve water quality includes more natural, land-based solutions to manage stormwater runoff. Since 2010, New York City has invested in **green infrastructure** that uses innovative and sustainable tools engineered and constructed to absorb or hold water in place during a rainstorm, which reduces flow into catch basins. Green infrastructure techniques increase green space in our urban environment, mimicking the water cycle to reduce the impact of stormwater pollution. Trees, flowers, and grasses planted in special engineered soil maximize the capture and slow release of water as it infiltrates into the ground and promote evapotranspiration. **Rain gardens, green roofs, blue roofs, permeable pavement,** and **rain barrels** are all common types of green infrastructure found throughout New York City.

Such projects also provide many community benefits, including improving air quality, creating habitats for pollinators and animals, offering shade and cooler air temperatures from planted trees, and beautifying neighborhoods.

Staten Island's **Bluebelt** system is another unique stormwater management program. Bluebelts provide an engineered solution to stormwater that relies on streams, ponds, and wetlands to convey, store, and filter water in an environmentally responsible manner. Wetlands and waterways naturally help control street flooding, something that has become increasingly critical as we experience more intense rain events. While these projects are aesthetically pleasing, engineered weirs, and rocks and riffle ponds also naturally promote aeration and maintain flow to prevent stream bank erosion and sedimentation.

WATER SYSTEMS AND CLIMATE CHANGE

The most recent and pressing challenge to water management is our changing climate. Protecting New York City's water systems means developing a clear understanding of the impact of sea level rise and creating tools to adapt to new weather and climate conditions. The average annual rainfall in New York City has increased by nearly 20% or more than 8" over the last century. This may not seem like much, but it manifests in rainstorms of increased intensity and frequency that lead to flooding.

Improved stormwater management practices are part of New York City's long-term resiliency plan. The City's OneNYC 2050 plan is a strategy to secure our future against the challenges of today and tomorrow by taking bold actions to confront our climate crisis, achieve equity, and strengthen our democracy. Within the plan, DEP's goals include building green infrastructure on City-owned property like sidewalks, parks, and schools as well as creating incentives to encourage private property to build green infrastructure on their own. Data proves that as more green infrastructure projects are constructed on land, the healthier our waterways become. Investing in these sustainable solutions is essential to protecting New York City's water quality and marine ecosystems.

Systemic and collective understanding along with action will help us meet these new challenges together. Encouraging your students to understand the problems as well as the solutions will inspire them to act as responsible citizens *for the love of water*.

Sequence of Lessons

1. Green Infrastructure: Following Nature's Lead
2. Calculating Rainwater
3. Restoring Urban Waterways
4. A "Model" Schoolyard
5. Climate Change: Engaging in Action


NYC
RAIN GARDEN

L1 Green Infrastructure: Following Nature's Lead

New York City is helping transform its urban environment into a greener, healthier place to live, work, and play. By understanding and adapting to water quality challenges, together we can sustain not only the ecological health of our waterways, but also the public health, economy, and quality of life for all New Yorkers.

ESSENTIAL QUESTION

What are the benefits of constructing green infrastructure in our community?

VOCABULARY

Rain Garden *(noun)*
A planted area with engineered soils designed to collect and manage stormwater runoff from streets and sidewalks.

Mitigate *(verb)*
To cause a situation to become less harsh or severe.

SUGGESTED IDEAS AND ACTIVITIES

a. Working in small groups, have students look at different materials and consider how each item interacts with water (e.g., tin tray, cardboard, paper towel, coffee filter, sponges, rocks, straws, plastic sheet). Ask students to share out their observations and then define terms like absorb, convey, infiltrate, filter, and runoff. Look at images of New York City's rain gardens and consider how the different design components interact with water in similar ways. (Refer to DEP's Green Infrastructure Education Module).

b. Walk outside along the block directly across from your school entrance. Take a series of photos (or make individual drawings) to capture a panoramic of the entire block when "stitched" together. In the classroom, create a streetscape mural using the photos and drawings of the block. Highlight any green practices on the street (e.g., street trees, window boxes, rain barrels) and include additional practices that you think could benefit the area.

c. Use the DEP Green Infrastructure Program Map to find an existing project (or one under construction) in your neighborhood. Organize a tour (when accessible) to a green roof or community garden. Plan a self-guided tour to a rain garden in your neighborhood. Observe plants and wildlife, and sketch the project including how stormwater might flow through it. Find out how you and your students can help maintain these sites through DEP's Harbor Protectors program.

d. Compare historic maps of your neighborhood or borough to the DEP's Green Infrastructure Program Map. Research historic maps online using the Public Library or Historical Society digital collections. Investigate the natural landscape of your neighborhood through these maps; how has it changed over time? Identify the nearby waterway(s) where water drains. Then compare to DEP's map; discuss the placement of green infrastructure and its role in our city's landscape today.

e. Define and identify native (and common non-native) plants and trees in parks or on the streets around your school, and catalogue these using photographs or drawings. Discuss the environmental benefits of green infrastructure, including how rain gardens and green roofs provide habitat for native and migratory animal species. Study the wildlife that these plants attract, including monarch butterflies.

f. Visit Brooklyn Grange Rooftop Farms to explore a large-scale rooftop farm and green infrastructure project. Meet with educators from City Growers to learn about the many benefits of urban farming and to find out how the farm was constructed as a green infrastructure project. Research other large-scale green infrastructure projects that are open for visits in your neighborhood or borough, such as Kingsland Wildflowers.

g. In groups, build small-scale cityscapes using Lego blocks in paint trays. Create a rainstorm, spraying water on top. Monitor stormwater runoff and measure how much is collected

after watering 1-cup of "rainwater" atop the city. Add in different size and color sponges to represent types of green infrastructure; measure stormwater runoff collected after a second rainstorm. (Refer to CUSP's Extreme Events activity kit).

CONSIDER AND DISCUSS

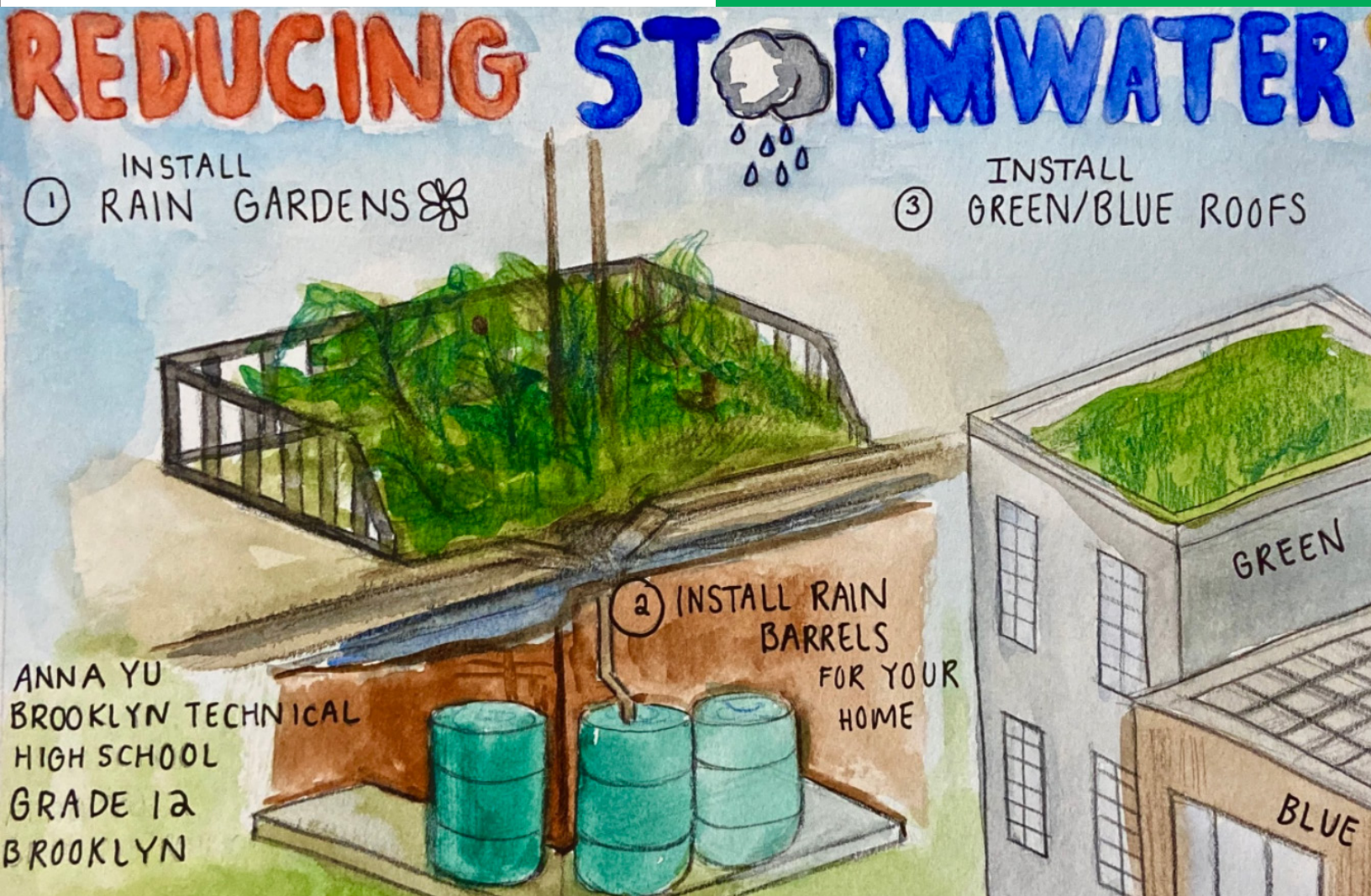
- Explore DEP's Harbor Water Quality Virtual Tour for video interviews, maps, and more activities on green infrastructure. What are the different types of green infrastructure? Where have you seen these techniques in your community?
- What are the benefits that green infrastructure can have in my community? Consider how green infrastructure can help mitigate the local impacts of climate change, including increases in stormwater and air temperature.

ASK THE EXPERT

Horticulturist – a specialized agriculturist who manages the art, science, technology, and business of plants.

GREEN INFRASTRUCTURE

Green infrastructure collects rainfall which would normally flow along street gutters and into catch basins, entering the sewer system. These vegetated features (e.g., engineered soils, rocks, plants, and trees) manage rain where it hits the ground similar to the way a natural system such as a forest or a meadow would handle runoff. DEP works with other city agencies to design, construct, and maintain all types of green infrastructure across New York City. More than 10,000 curbside rain gardens have been constructed and more are on the way. These rain gardens help prevent flooding and reduce Combined Sewer Overflows into surrounding waterways.



L2 Calculating Rainwater

Rainwater landing on city streets and rooftops is often measured in volume. Help students visualize just how much water falls on the roof of a single home or apartment building by calculating gallons of rain. There are different categories of storms, some which will precipitate more than others. Students will be able to understand that if this water is not being absorbed by the land, many gallons of water may end up as stormwater runoff, flowing into our waterways.

ESSENTIAL QUESTION

Why is capturing rainfall where it lands important for water quality?

VOCABULARY

Absorb *(verb)*
To soak up or take up a liquid or another substance (such as in plants).

Infiltration *(noun)*
The action of passing into or through a substance by filtering or permeating its pores (such as in soil).

Transpiration *(noun)*
The passage of water vapor from a living body (as of a plant) through its membrane or pores.

SUGGESTED IDEAS AND ACTIVITIES

a. Use the chart below to help students understand how to calculate the volume of stormwater. Explain that storms of different intensities can generate large quantities of runoff on impervious surfaces. Discuss how this would increase per building, block, or neighborhood.
b. Go outside and select various sites around the schoolyard that feature different slopes. In small groups, have students measure the slope and learn about different rates of stormwater runoff at each site. What types of land surfaces can be found at each of these sites? (Refer to DEP's Green Infrastructure Education Module).
c. Working in small groups, have students play the part of city planners tasked with managing stormwater runoff. Map out and investigate your school community to determine where constructing green infrastructure could improve stormwater conditions. Explain why you chose these sites, and the types of green infrastructure you would like to use. Explore the Gowanus Canal Conservancy's Blue Schools curriculum for activity ideas on site analysis and design development.
d. Install a rain gauge at your school to collect data on rainfall levels. Students can take turns each week recording data for the class. Compare and analyze seasonally and/or annually.
e. Collect and graph rainfall data with students using available online data from the National Oceanic and Atmospheric Administration (NOAA). Discuss trends in the data, including seasons, locations, and large wet weather events. Look at yearly rainfall data over the last decade or more and have students discuss what trends they can infer. Have students share their hypotheses.
f. Explore the Climate and Urban Systems Partnership (CUSP) NYC interactive map; add map layers to display city infrastructure and flooding. Discuss how climate change plays a role, and relate back to your activities on calculating rainfall. Zoom in on your borough and then your school neighborhood. Research or take a walk to nearby sites to see "What's being done?" and record what you see. Follow up in your classroom by adding to the "Impacts & Observations" map layer.

Volume of Rain Calculations:

Rain Event (in)	Square Footage (ft2)	Rain (ft)	Cubic Feet (ft3)	Conversion (ft3/gal)	Gallons
1/10	1000	0.008	8	7.5	60
1/4	1000	0.021	21	7.5	157.5
1/2	1000	0.042	42	7.5	315
1	1000	0.083	83	7.5	622.5
2	1000	0.166	166	7.5	1245

CONSIDER AND DISCUSS

- Did you ever envision rain as a volume of water?
- Consider the impacts of climate change on New York City. How are these changes affecting different communities and the surrounding waterways?

ASK THE EXPERT

Geographic Information Service (GIS) Mapping Specialist – a professional who uses computer-based methods to collect, manage, analyze, model, and present geographic or spatial data.

L3 Restoring Urban Waterways

Urbanization is responsible for many of the sources that contribute to ecological degradation in our waterways. Increases in impervious surface area and stormwater runoff have negative effects on stream flow. If the health of a waterway is compromised by pollution or excessive runoff, it sets off a chain of degradation from erosion to water temperature changes to habitat loss.

One example of an innovative and cost-effective stormwater management approach is the Bluebelt system on Staten Island. The Bluebelts are an engineered solution that take advantage of the natural drainage properties of waterways. These designed streams, ponds, and wetlands effectively prevent street flooding by slowing the flow of stormwater runoff. Wetlands provide native habitats for local wildlife and plant species which help filter stormwater and absorb nitrogen and phosphorous.

ESSENTIAL QUESTION

What are the long-term benefits of restoring urban streams, for people and wildlife?

VOCABULARY

Erode *(verb)*
To wear away by the actions of water, wind, or glacial ice.

Flood *(noun)*
An overflow of water, caused by either a large body of water or heavy rainfall, onto normally dry land.

SUGGESTED IDEAS AND ACTIVITIES

a. Create a very simple stream by filling a plastic storage container with sand or potting soil and creating a light rain shower; students can "make it rain" using a spray bottle or other gentle methods. At first, they will see how channels naturally form. Next, introduce heavier rain conditions by more aggressive pouring and see how that erodes the "banks" of your stream. Discuss what could be done to keep the stream from eroding (e.g., add rocks and plants to simulate a real riparian buffer); adapt your models and try again.
b. Take a field trip to the nearest waterfront, observe and record conditions of the waterway and surrounding area before and after a rain event. Hypothesize on what changes they expect to notice; what would cause these changes? Consider and discuss student observations of the flow, water temperature, available habitat, evidence of erosion, and types of pollution.
c. Refer back to lessons in Unit 1 to discuss the benefits of maintaining the riparian buffer around waterways. While visiting a nearby waterway, have students fold their paper in half and sketch what they see above on the surface of the riparian buffer and then illustrate what they think it looks like below the surface (e.g., layers of soil, roots, rocks, animals). Discuss important terms, such as erosion, filter, intercept, and infiltrate. Ask students to identify the different parts of their image that are working to help protect water quality.
d. Meet with a community organization in your borough to conduct water sampling and monitoring along the Bronx River, Gowanus Canal, Newtown Creek, or other accessible waterbody. Plan an education program with Solar One at Stuyvesant Cove Park along the East River or Hudson River Park Trust on the Hudson River.
e. Connect with DEP to visit the Staten Island Bluebelts. Identify native plants and wildlife that you observe (e.g., pickerelweed and its properties). Organize volunteer efforts to clean up a Bluebelt and develop a plan for long-term stewardship.
f. Create a story, a photographic essay, or a documentary video about life in and around a local waterway. Consider the outside impacts that have shaped or altered the waterway's history and landscape, such as pollution, development, industry, or climate change. Have students share and present their projects to classmates, the entire school, or their families and the school community.

CONSIDER AND DISCUSS

- Review the riparian buffer activity and discuss the function as well as the beauty of the bank of a river. Do most of New York City's waterways have riparian buffers? Examine different waterways as examples. How has New York City's waterfront changed over time?
- Review again why these green tools are considered "infrastructure." Bluebelts are constructed in areas with separate sewer systems, and are considered an ecological extension of the city's infrastructure.

ASK THE EXPERT

Ecologist – a scientist who surveys ecosystems to study the relationship between plants, animals, and the environment.

L4 A "Model" Schoolyard

Using your own building, schoolyard, and surrounding community, you can begin connecting all that your students have learned to becoming active environmental stewards. The goal of this lesson is to engage students with opportunities to be creative, get involved in their school community, and make sustainable decisions. The next Thematic Unit will share additional activities and resources for moving these ideas forward to create a real project, fund it, monitor its benefits, and ensure its long-term care.

ESSENTIAL QUESTION

How would you like to change your schoolyard or school community?

VOCABULARY

Stewardship (*adjective)*
Taking personal responsibility to help protect your environment.

SUGGESTED IDEAS AND ACTIVITIES

a. Form a green team in your school to get students more involved in stewardship and sustainability projects. Connect with the New York City Department of Education's Office of Sustainability to hear about resources and programs to help you get started. Have a Sustainability Specialist visit your school and meet with your green team.
b. Measure and draw a plan of your schoolyard. Use your own body or the entire class as units of measure. Use your own feet and relative units of measure and proportion. Find a scale drawing of the school and have students duplicate it. Transfer measurements to a base, like cardboard or poster paper. First with a pencil, label the base with all prominent features, including the school building, the play area, surrounding sidewalks and streets. Make this three-dimensional using different building materials (e.g. shoeboxes, foam board, cardboard, blocks). Use crumpled tissue paper, straws, pipe cleaners, sponges, to make your green areas. Consider where students would want to add new green features.
c. Research schoolyards in your borough that have been redesigned to manage stormwater by the Trust for Public Land and DEP. Plan a visit to one of these schoolyards, which open up to the community during after-school hours and on weekends. Explore, make observations, and discuss some initial smaller-scale changes that can be implemented in your own schoolyard. Present and propose student plans to school administrators.
d. Connect with DEP to receive a free rain barrel for your schoolyard. Work with your custodial engineer to determine the best location for connecting the rain barrel to the gutter system. If your school does not have gutters, consider building a small lean-to to demonstrate where water collects. What can you do with this water (e.g., watering plants, starting a garden)?
e. If you were to build a school, or community, garden, where would it be located? What would you need to get started? What types of plants would you include? Have students plan their ideal school garden, then work with your school administration to make your garden a reality. Begin growing plants in the classroom, and then move them to raised plant beds in the schoolyard. Connect with GrowNYC educators to learn more about how to get started.
f. Survey your school community to create a sustainable plan that addresses the needs of school stakeholders. Research the City's OneNYC 2050 plan to learn how community input was incorporated into the goals to create a stronger and more fair city. Have students identify the stakeholders in your school community and strategize methods for disseminating their survey. (Refer to DEP's Breaking Down OneNYC lesson).

CONSIDER AND DISCUSS

- How will changes to the schoolyard change your feelings toward the outside space of your school?
- Consider how much of New York City's landscape is made up of school properties. How will greening your schoolyard help water quality and our local environment?

ASK THE EXPERT

Environmental Educator – a professional who teaches students, adults, and the general public about nature, and how to be a good steward of our environment.

L5 Climate Change: Engaging in Action

Concentrations of greenhouse gases trapped in our planet's atmosphere are causing an overall change in the Earth's temperature at an ever-increasing rate. As a coastal city, New York is experiencing higher ocean and atmospheric temperatures, which lead to more intense and frequent rainfalls, flooding, and sea level rise that affects our harbor and surrounding waterways. A changing climate will also impact New York City's water supply and wastewater treatment system. In an effort to strengthen climate resiliency, New York City is taking action to mitigate the effects and adapt to these changes. Young people are already engaging in action in their schools and communities, both independently and in partnership with community leaders, city agencies, and environmental advocacy organizations, to create the change needed to prepare our city for the impacts of climate change.

ESSENTIAL QUESTION

How is climate change affecting New York City?

VOCABULARY

Weather *(noun)*
The state of the atmosphere with respect to temperature, wind, humidity, precipitation, and cloudiness.

Climate *(noun)*
The long-term average of conditions of weather at a place as exhibited by temperature, wind velocity and precipitation.

Adaptation *(noun)*
The actions taken to modify or remodel a situation to fit new conditions.

Resiliency *(noun)*
The ability to withstand or swiftly recover from changing conditions as a result of preparation and adaptation measures.

SUGGESTED IDEAS AND ACTIVITIES

a. Look at photographs of different weather and discuss what characterizes weather. Add in images that depict climate, and discuss the differences between weather and climate. Group students in teams for a game of weather versus climate trivia. Discuss how weather and climate are forecasted differently. (Refer to DEP's Distinguishing between Weather and Climate lesson).
b. Record daily weather reports for a given period (a few weeks or months); set up your own temperature station outside the classroom to collect and compare local data if possible. Discuss patterns and compare the results from different sources (e.g., NOAA's National Weather Service or The Weather Channel). Consider how this weather data could be used as a snapshot of our current climate in the future. (Refer to DEP's Recording Weather and Climate lesson).
c. Introduce the greenhouse effect by modeling the Earth's atmosphere using shoe boxes. Add a layer of soil to the bottom and place a thermometer in the center of the soil. Cover each box with a different material (e.g., plastic wrap, tin foil, cardboard, Plexiglas). Place boxes in a sunny area and measure the temperature twice a day for a week. Discuss which covers trapped more heat and how these warmer boxes represent our changing atmosphere. (Refer to DEP's Modeling the Earth's Atmosphere lesson).
d. Ask students to think about whether they have ever been affected by climate change. Explain how New York City has already seen shifts in temperature, precipitation, and local sea level. Introduce each of these climate impacts. In their journals, ask students to reflect on their own experiences related to extreme heat, increased wet weather, and flooding. (Refer to DEP's Placing Climate Change in New York City lesson).

e. Introduce the term "resiliency" and ask students to brainstorm what they think it means for New York City to be a resilient city. Research major climate-related events that have challenged New York City's resiliency (e.g., Hurricane Sandy). Survey classmates, friends, and family members about their experience with the event.

f. Explore what New York City has done to build more resiliency using the NYC Mitigation Actions Map. Refer back to students' experiences with the impacts of climate change. Discuss other ideas for building resiliency in your neighborhood; allow students to get creative by illustrating and designing their own strategies.

g. Refer back to lessons in Units 2 and 3 that introduce the different components of the New York City water supply and wastewater treatment systems. Define the term "system." Discuss how climate change can impact these interconnected systems. In groups, brainstorm some strategies for helping protect our water resources and how it relates back to climate change (e.g., water conservation helps during wet weather and during a drought).

CONSIDER AND DISCUSS

- How do overall rising atmospheric and ocean temperatures impact our water supply, wastewater treatment, and stormwater management systems?
- Review the water cycle and discuss how temperature rise and sea level rise may alter this cycle.
- Research OneNYC 2050. Discuss what New York City is doing to increase climate resiliency and sustainable practices.

ASK THE EXPERT

Climate Scientist – a scientist who studies weather and climate data over long periods of time, using computerized climate models and projections based on Earth's systems.