Grade 7-8

Save the Bay

Problem How can we engineer a device to monitor and clean-up our Chesapeake Bay Watershed?

Lesson Summary Student teams will engage in a problem-based learning experience in order to explain the importance of a healthy Chesapeake Bay and define their roles as stewards. Activities will help connect students with the watershed while nurturing an ethic of responsible citizenship. As an entry event, students will kayak the Back Creek River to recognize sources of pollutants and perform water quality tests to recognize consequences (alternative is to complete the Gizmo simulation called Coral Reef1 which demonstrates the effects of changing conditions on the Coral Reefs). Teams will then embark as environmental engineers and city planners to design, build, and test models of urban landscapes, which utilize green roofs and permeable pavement to reduce pollutant-carrying surface run-off. After a unit on computer engineering, robotics and programming, teams will use the engineering design process to incorporate Hummingbird Robot kits in the prototype of a device that will *monitor* bay pollutants, have *clean-up* capabilities, can be *placed* in areas of properties where run-off is likely to carry pollutants, and is *affordable* for the township. Media presentations of devices will be shared with the local Chesapeake Bay Foundation, EPA, and NOAA representatives.

Major Topic and SOL

Math SOL

8.7 investigate and solve practical problems involving surface area

Science SOLs

LS.11 investigate and understand the relationships between ecosystem dynamics and human activity.

6.7 a,f,g investigate and understand the natural processes and human interactions that affect watershed systems

PS 1 m construct models and simulations to illustrate and explain phenomenon; perform scientific investigations

Language Arts SOL

writing informative and concise

History SOL

CE.4 demonstrate knowledge of personal character traits that facilitate thoughtful and effective participation in civic life

Technology

C/T 6-8.10 practice reasoning skills when gathering and evaluating data. Use a variety of resources when gathering and evaluating data.

Length of Time 12 90-minute blocks

Lesson Contributed by: Theresa Guthrie

Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Student Objectives

- The student will investigate and understand relationships between ecosystem dynamics and human activity as is related to environmental issues.
- The student will investigate and understand the natural processes and human interactions that affect watershed systems. Including:
  - the health of ecosystems and the abiotic factors of a watershed;
  - major conservation, health, and safety issues associated with watersheds; and
  - water monitoring and analysis using field equipment including hand-held technology.
- The student will demonstrate an understanding of scientific reasoning, logic and the nature of science by planning and conducting investigations in which models and simulations are constructed and used to illustrate and explain phenomena;

21st Century Skills

- Critical-Thinking and Problem Solving
- Communication
- Creativity and Innovation
- Collaboration
- Information and Media Literacy
- Contextual Learning

Assessment Evidence (attached)

- *Rubric includes media presentation of device with visual and written description*
- *Environmental Engineering Quiz*
- *Computer Engineering Quiz*

Supplies/Materials/Technology

- **Craft materials, computers, Hummingbird Robot Kits**

Product(s) Group:

- Evaluate water quality data from testing done in watershed streams or rivers.
- Design and build an urban landscape with green roof and permeable pavement.
- Build and program a working pseudo-model of a robotic device capable of monitoring pollutant data and removing pollutants.
- Create a media presentation to the Chesapeake Bay Foundation describing which indicators their device measures, why they chose those indicators, and where in the watershed region their unit should be located.

Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Lesson Plan

	Essential Knowledge, Skills, and Processes & Success Skills Content and Success Skills needed by students to successfully complete products	**Instructional Procedures** Strategies for ALL learners, provided by teacher, other staff, experts: includes scaffolds, differentiation strategies, materials and lessons aligned with EKS and assessments	**Formative & Summative Assessments** To check for learning and ensure students are on track; support instructional decisions with the use of data	**Deliverable(s)** Clearly defined in order to hold students accountable for their daily learning
Day 1	Engineering career investigation • locate and critique a media article or editorial (print or electronic) concerning water use or water quality. Analyze and evaluate the science concepts involved. • propose ways to maintain water quality within a watershed.	Hook: Summer Olympic water contamination concern watch video clips and read articles group members each read/watch different articles about water issues. http://www.usatoday.com/story/sports/olympics/2015/08/12/rio-de-janeiro-2016-summer-olympics-water-quality-pollution-sweage/31509243/ Show a success story video of river clean-up	http://discovere.org/discover-engineering/engineering-careers Informal group and whole class discussions. Daily warm ups	Describe the role of an environmental engineer as it relates to Chesapeake Bay Conservation efforts. Engineer Career Query worksheet
Day 2-3	• explain the factors that affect water quality in a watershed and how those factors can affect an ecosystem.	Read State of the Bay report, focus on how data from report can help us understand relationships. Complete Coral Reef and Water Pollution research using Simulation websites Concord.org & http://www.explorelearning.com Recall water testing from 7th grade *Scaffolded worksheets and extra-time provided as needed*	Informal group and whole class discussions. Daily warm ups Water Pollution and Coral Reef Gizmo Worksheets	Find commonalities amongst data. Make charts to compare concerns. Worksheet questions Most helpful findings

Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

	Essential Knowledge, Skills, and Processes & Success Skills Content and Success Skills needed by students to successfully complete products	**Instructional Procedures** Strategies for ALL learners, provided by teacher, other staff, experts: includes scaffolds, differentiation strategies, materials and lessons aligned with EKS and assessments	**Formative & Summative Assessments** To check for learning and ensure students are on track; support instructional decisions with the use of data	**Deliverable(s)** Clearly defined in order to hold students accountable for their daily learning
Day 3	• measure, record, and analyze a variety of water quality indicators and describe what they mean to the health of an ecosystem.	Field trip to kayak in Back Creek to observe factors affecting water quality (coal plant, oil refinery, water treatment facility) agricultural run-off, residential run-off…). Perform water quality tests .	Informal group and whole class discussions. Daily warm ups	Complete summary of findings
Day 4-5	• propose ways to maintain water quality within a watershed.	Design an Urban Landscape – http://www.eie.org/engineering-everywhere/curriculum-units/dont-runoff Students will be given a building and a parcel of "land" to develop. Their building must have a green roof with a parking lot of permeable pavement. The urban landscapes will be covered in a pollutant and tested to see how much pollutant filled surface run-off is collected. *Student roles are dependent on ability and/or choice. Option to complete written reflections /reports as needed.*	Students use the engineering design process and make hypothesis, complete research, and present findings. Environmental Engineering Quiz - Taken after the Urban Landscape Challenge	Rubric for team report on product
Day 6-8	• Understand the relevance for using technology to solve real-world problems. • Careers in technology explorations.	Whole class lessons on computer engineering, programming, and robots. Hook up a Raspberry Pi microprocessor and use it to learn the Scratch Language. *Alternative: Complete Hour of Code on-line with Scratch. Offer pair programming and video tutorials.*	Student products are the completed programs. Students define computer vocabulary. Computer Engineering Quiz	

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

	Essential Knowledge, Skills, and Processes & Success Skills Content and Success Skills needed by students to successfully complete products	**Instructional Procedures** Strategies for ALL learners, provided by teacher, other staff, experts: includes scaffolds, differentiation strategies, materials and lessons aligned with EKS and assessments	**Formative & Summative Assessments** To check for learning and ensure students are on track; support instructional decisions with the use of data	**Deliverable(s)** Clearly defined in order to hold students accountable for their daily learning
Day 9-11	• forecast potential water-related issues that may become important in the future. • develop possible solutions • identify constraints and conditions.	Build and program a water quality data collection and/or pollutant clean-up device using the Hummingbird robotics kit. The robotic device must have 3 functions such as collect at two types of data, have 1 moving part for clean up. Group roles to include lead programmer, lead builder, publicist, team manager. *Student roles are dependent on ability and/or choice.*	Students use the engineering design process and make hypothesis, complete research, and present findings.	Rubric for products and team roles
Day 12		Group presentations Media Presentations to the Chesapeake Bay Foundation describing which pollutants their device measures or removes, why they chose those indicators, where in the watershed area their unit should be located, and the estimated cost of the device. *All students present in groups*	Media presentations	Rubric for presentations

Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

2014 STATE OF THE BAY

HEALTH INDEX: 32/D+
WATER QUALITY: IMPROVING
FISHERIES: A CONCERN

SAVE THE BAY • SAVE THE BAY • SAVE THE BAY • SAVE THE BAY®

CHESAPEAKE BAY FOUNDATION
Saving a National Treasure

PRESIDENT'S MESSAGE

The Chesapeake Bay Foundation's *2014 State of the Bay* report presents a mix of good and bad news.

The great news: Water quality indicator scores have improved significantly over the 2010 and 2008 scores.

The worrisome news: Blue crabs and striped bass are not doing well. The declines in these metrics and in the phosphorus indicator offset the improvements in water quality. Overall, the 2014 score is unchanged from 2012.

We can celebrate the water-quality improvements. However, the Bay and its rivers and streams still constitute a system dangerously out of balance. We continue to have polluted water, risks to human health, and lost jobs—at huge societal costs.

The future is just around the corner; 2017—the year when 60 percent of programs to achieve the Chesapeake Clean Water Blueprint pollution-reduction targets are to be in place—is in our sights.

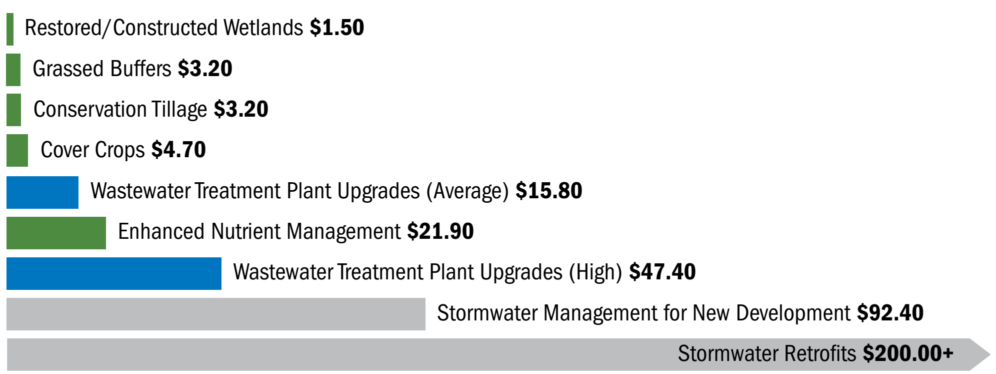
We must accelerate pollution reduction, particularly from agriculture. Runoff from farm fields remains the largest source of pollution to the Bay and its rivers and streams (see page 13). Ironically, this pollution is the least expensive to reduce and has the most generous federal and state cost-share funding available.

In some jurisdictions, polluted runoff from urban and suburban areas is the only source of pollution continuing to grow. Investments in reducing this source of pollution must be increased as well.

The Clean Water Blueprint is working so far, but there are danger signs ahead. States must expedite required implementation of agricultural and urban pollution reduction. If they do not, EPA must impose sanctions.

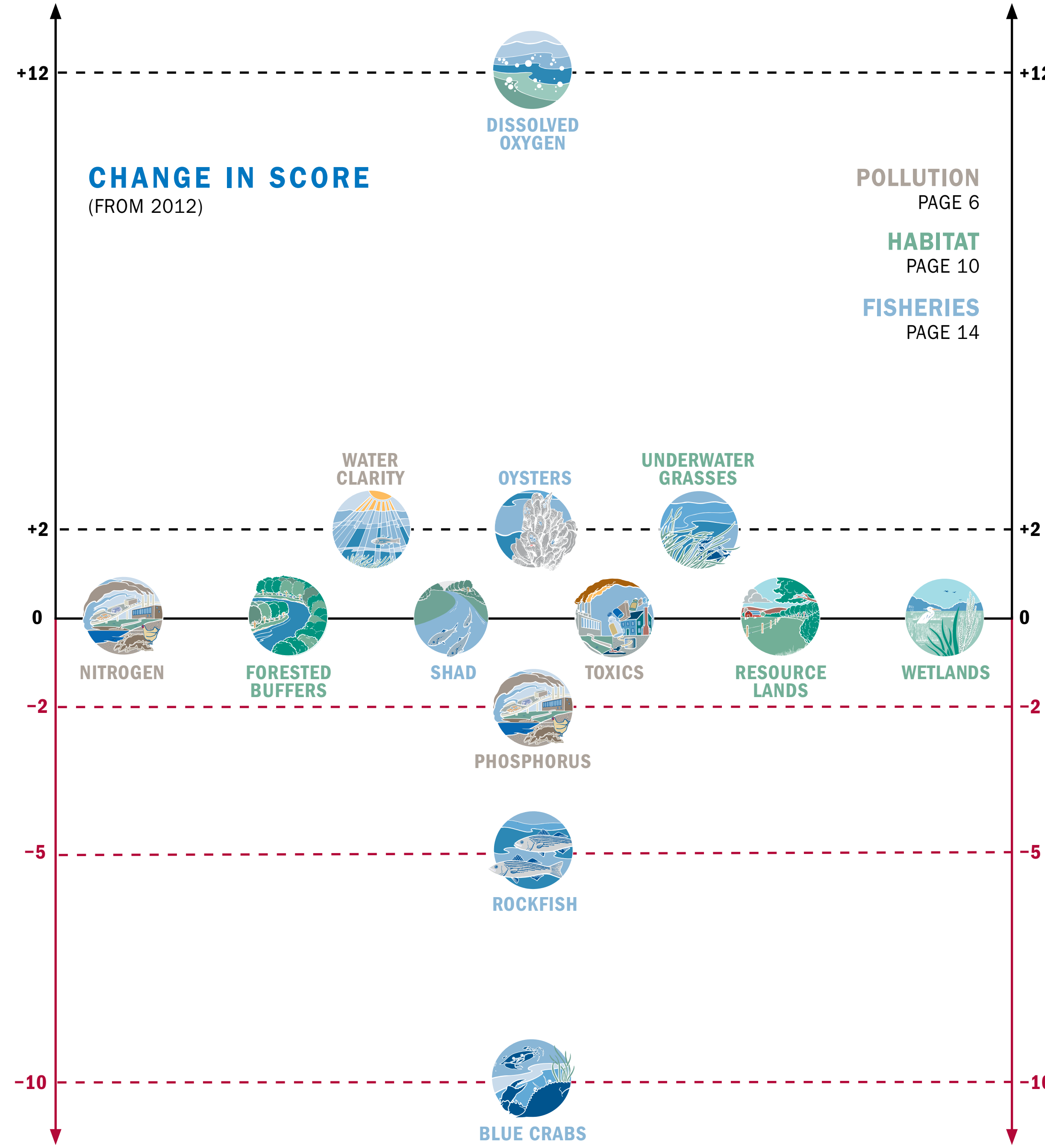
William C. Baker, President

Cost of Nitrogen Pollution Reduction by Sector and Practice (per pound)

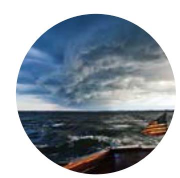


Agriculture | Wastewater Treatment Plants | Stormwater

Source: World Resources Institute, 2011



ECONOMY
PAGE 4



BLUEPRINT
PAGE 8

AGRICULTURE
PAGE 12

EDUCATION
PAGE 16

Saving the Bay Makes Economic Sense

In 2010, the six Bay states, the District of Columbia, and the federal government launched a renewed, mandatory effort to restore the health of the Bay and its vast network of rivers and streams. That effort—the Chesapeake Clean Water Blueprint—is designed to reduce substantially the amount of nitrogen, phosphorus, and sediment pollution degrading local waters and the Bay. The Blueprint's goal: Restore the Bay system to good health. Fully implementing the Blueprint will reduce risks to our health, provide a legacy of clean water for our children and grandchildren, and increase economic benefits to the region.

Fully implementing the Blueprint will be a big job. It will require the commitment, time, and resources of all sectors of society.

Opponents suggest the juice may not be worth the squeeze. So, CBF followed the science to determine what the economic return would actually be. In October, we released *The Economic Benefits of Cleaning Up the Chesapeake*, a peer-reviewed report. The numbers are staggering.

In 2009 (before the Blueprint), the lands and waters of the Chesapeake Bay region provided economic benefits totaling $107.2 billion annually. This served as the baseline for our study. These benefits include air and water filtration, better agricultural and seafood production, higher property values, and improved flood and hurricane protection.

The value of these same benefits will increase by $22.5 billion annually to $129.7 billion if the Blueprint is fully implemented. Once realized, those benefits would be enjoyed year after year.

If, however, nothing more is done to implement the Blueprint, pollution will increase, and the value of the Bay system's natural benefits will decline by $5.6 billion annually to $101.5 billion.

Now we know with certainty what we have long suspected: The environment and the economy are two sides of the same coin. Read our report at cbf.org/economicbenefits.

Nitrogen: 16
(no change from 2012)

Phosphorus: 25
(–2 from 2012)

Excess nitrogen and phosphorus, which fuels algal blooms that ultimately cause the Bay's dead zone, is still largely driven by precipitation. Rain and snowmelt wash these and other contaminants off farmland, lawns, and city streets into local streams, rivers, and ultimately the Bay. The 2014 phosphorus score dropped because annual phosphorus loads were higher in 2014 compared to 2012, particularly in the Potomac and James Rivers and on Maryland's Eastern Shore. There is evidence, however, that we are making progress.

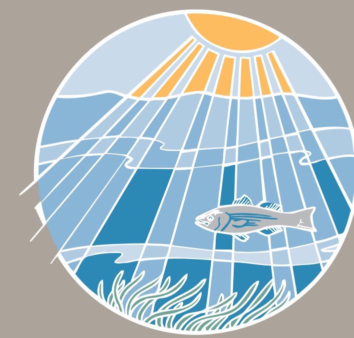
Observed decreases in nitrogen in mostly forested headwater streams in the Appalachian Mountains of Maryland, Pennsylvania, and Virginia have been attributed to regulatory reductions in air pollution from coal-fired power plants. Upgrades to sewage treatment plants continue to reap benefits as evidenced by the return of underwater grasses to the Potomac and Patuxent Rivers.[1] Reducing pollution from agriculture remains the region's biggest challenge, but the Chesapeake Clean Water Blueprint provides the way forward—implementation of this plan is the key to success.

1 Lyerly, C.M., A.L. Hernández Cordero, K.L. Foreman, S.W. Phillips, W.C. Dennison (eds.). 2013. *Lessons from Chesapeake Bay Restoration Efforts: Understanding the role of nutrient reduction activities in improving water quality.*

Dissolved Oxygen: 37
(+12 from 2012)

In a typical year, the amount of nitrogen and phosphorus pollution that flows into the Bay during the spring largely influences the size of the summer dead zone. This pollution feeds algal blooms that eventually die, sink to the bottom, and are decomposed by bacteria, which uses up oxygen in the process. This year, due to high spring pollution loads, scientists predicted a larger than average dead zone for the Chesapeake Bay.

June monitoring results were in line with this prediction. However, weather conditions in early July changed this trajectory. Hurricane Arthur produced strong winds as it passed the coast and mixed the oxygenated surface waters into the deep waters of the Bay causing a large reduction in the dead zone. Sustained, below-average temperatures throughout the rest of July resulted in the dead zone remaining the smallest it has been in thirty years of sampling—cooler water holds more oxygen. Towards the end of the summer, as temperatures increased, the dead zone returned to "above average" size. In this case, "above average" is not desirable, because it means large parts of the Bay and its tidal rivers are off-limits to aquatic life.



Water Clarity: 18
(+2 from 2012)

Water clarity decreased between 2012 and 2013 then improved through 2014, resulting in an increase in this indicator score. Water clarity is measured as the depth in the water column to which sunlight is able to penetrate. Sunlight is vital to the growth and reproduction of underwater grasses. Underwater grasses are critical to the Bay ecosystem as they trap sediment, provide habitat for fish and crabs, and food for waterfowl. Water clarity is negatively affected by algal blooms fueled by phosphorus and nitrogen pollution and suspended sediment in the water from runoff from agricultural and urban lands. These pollutants also negatively affect local streams and rivers.

Implementation of the Chesapeake Clean Water Blueprint will reduce the amount of nitrogen, phosphorus, and sediment that runs off the land resulting in clean, healthy streams and ultimately leading to better water clarity in the Bay. Practices, such as streamside forest buffers and conservation tillage on farmland, and creating more open spaces in urban areas, are particularly effective at preventing runoff of soil and nutrients.

Toxics: 28
(no change from 2012)

Toxic chemicals from air deposition, urban runoff, and industrial sources continue to degrade the health of the Bay and its tributaries. Over 70 percent of the Bay and its tidal rivers remain impaired due to chemical contaminants. Improvement is slow due to the persistent nature of many chemicals, especially PCBs and mercury, which cause most of the region's fish consumption advisories. Two new initiatives, however, give us hope.

First, after much urging from CBF and other environmental groups, the new Chesapeake Watershed Agreement includes a goal to "Ensure that the Bay and its rivers are free of effects of toxic contaminants on living resources and human health." One outcome associated with this goal calls for improvements to practices, controls, and existing programs to reduce and prevent the detrimental effects of toxic contaminants.

Second, the Anacostia River Toxics Remediation Act of 2014 passed by the District of Columbia City Council established a June 2018 deadline for establishing a clean-up plan for removing toxic chemicals from the Anacostia River, one of the region's toxic hotspots. We commend the District for this action.

Implementing the Blueprint

The Chesapeake Clean Water Blueprint is in place. Our *2014 State of the Bay* report confirms it’s working. Comparing only the scores for pollution indicators—nitrogen, phosphorus, dissolved oxygen, water clarity, and toxics—we see an almost 11 percent improvement over the 2012 pollution indicators’ scores and a 21.5 percent improvement over the 2010 scores.

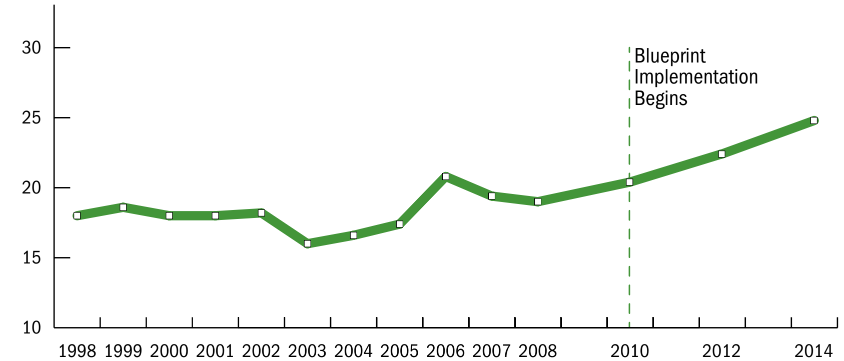
This water-quality improvement and the recent Milestone reports indicate that we are on track to achieve a restored Bay system if we fully implement the Blueprint. The benefits will be many—a significantly cleaner environment, fewer risks to human health, impressive economic gains, a proud legacy, and a model for the world.

But, digging deep into the data, we find there is reason for concern. Bay-wide, agriculture is not on pace to meet its 2017 mid-term goal, and urban and suburban polluted runoff (stormwater) is heading in the wrong direction.

Our concern is real; the price we all pay for pollution is expensive. We call on governments, businesses, and individuals; right now, starting in 2015, let’s roll up our sleeves a little further, work together, follow the science-based plans for restoration, and accelerate pollution reduction.

It would be a shame to snatch defeat from the jaws of victory.

***State of the Bay* Average Pollution Indicator Scores** (see page 6-7)



Forested Buffers: 58

(no change from 2012)

Streamside forested buffers provide numerous natural benefits. They serve as filters to prevent nutrient and sediment pollution from reaching waterways, enhance a stream's ability to process and remove nitrogen, and reduce air pollution. Accelerating forested buffer implementation is a key component of the Chesapeake Clean Water Blueprint and the federal Chesapeake Executive Order Strategy (EO13508). Yet despite these benefits and commitments, the rate of annual implementation of this vital practice continues to decline. In recent years, the average acres of forested buffers planted was roughly 4,000 acres per year. To achieve Blueprint commitments watershed-wide, an average of 14,000 acres per year is needed between now and 2025.

In June 2014, the Alliance for the Chesapeake Bay convened a "Forest Buffer Summit" attended by leaders from federal and state governments and nonprofit organizations to highlight the implementation gap and kick off an effort to accelerate implementation. One outcome was the establishment of state task forces, led by the U.S. Department of Agriculture (USDA), to develop recommendations for how to overcome current obstacles to greater implementation. We urge federal and state agencies, particularly USDA, which plays a lead role in providing financial and technical assistance for buffers, to embrace and implement these recommendations expeditiously in 2015.

Wetlands: 42

(no change from 2012)

Water-saturated lands like marshes or swamps—commonly known as wetlands—are a vital link to Bay health. They provide valuable habitat and act as natural filters that improve water quality by trapping and treating polluted runoff. For example, marshes in the tidal Patuxent River in Maryland are estimated to remove about 46 percent and 74 percent of the total nitrogen and phosphorus inputs, respectively.[1] Wetlands can also help mitigate sea level rise and provide natural protection from storm surges. Recent efforts to restore and protect wetlands have languished, but efforts are being made to change that.

In 2014, the new Chesapeake Watershed Agreement set a goal of restoring 85,000 acres of wetlands by 2025. For context, between 2010 and 2013, some 6,000 acres of wetlands were restored on farmland—about seven percent of this new goal.

Also in 2014, the Environmental Protection Agency released a draft regulation that attempts to clarify what types of water bodies are protected under the Clean Water Act. The rule responded to two Supreme Court decisions that had caused great confusion among regulators, the regulated community, and other stakeholders. This rule, clarifying wetland definitions and boundaries, will ensure vital wetland habitat remains protected.

1 Boynton, W.R., et al. 2008. *Nutrient Budgets and Management Actions in the Patuxent River Estuary, Maryland.* Coastal and Estuarine Research Federation.

Underwater Grasses: 22

(+2 from 2012)

Underwater grasses are an essential component of the Chesapeake Bay ecosystem. They provide crucial habitat and nursery grounds for fish and crabs and provide food for waterfowl. They also remove pollutants from the water and help reduce shoreline erosion by softening wave action. Grasses are a good indicator of the state of the Bay because their health and abundance is very closely linked to water quality.

From 2012 to 2013, underwater grasses increased roughly 24 percent, a strong recovery from the previous years of decline. Each of the four salinity zones of the Bay saw improvement. This recovery appears to have continued into 2014. In addition, many of the observed beds are dense and healthy, also a positive sign for Bay recovery. The huge, dense grass bed on the Susquehanna Flats, which was able to survive Hurricane Irene and Tropical Storm Lee in 2011, increased in acreage in 2013 and remained robust in 2014.

Resource Lands: 32

(no change from 2012)

The state of resource lands—forests, farms, wetlands, and stream valleys—is a mixed bag. Forestland increased statewide in Pennsylvania and Virginia over the past five years, yet there is still a net loss of a half million acres over the last 15 years in the three major Bay states.

Pennsylvania, Maryland, and Virginia continue to permanently protect resource land. Statewide, Pennsylvania's farmland protection program added 15,000 acres in 2013, as the Commonwealth neared the 500,000 acre preserved farmland mark. Maryland's preservation of resource lands slowed to just 9,000 acres in 2013, down from its previous low in 2011. Virginia added about 45,000 acres in 2013, which was more than occurred in 2011.

At the same time, land development has increased. In the Maryland and Virginia counties studied, the number of building permits has generally risen over the past several years. National statistics and growth in these locations suggest that damaging, spread-out development may be on the rise, absent good state and local policies to shape and manage it. Failure to effectively plan, account for and offset growth, and manage polluted runoff from new development with strong state stormwater programs, could endanger water-quality improvements.

Farming for Clean Water

Agriculture is the largest source of nitrogen, phosphorus, and sediment pollution damaging local rivers, streams, and the Chesapeake Bay. This is not because agriculture is more polluting than other land use, but because agriculture is the second-largest land use in the region, behind forests.

Farmers have made progress, but not enough. Science has identified the practices necessary to reduce pollution from all sources. And the states have developed plans to achieve those reductions. Those plans expect to get 75 percent of their pollution reduction from agriculture.

However, the region is not on track to meet the 2017 Chesapeake Clean Water Blueprint interim goals from agriculture. Meeting the interim and final 2025 goals requires accelerating agricultural pollution reduction.

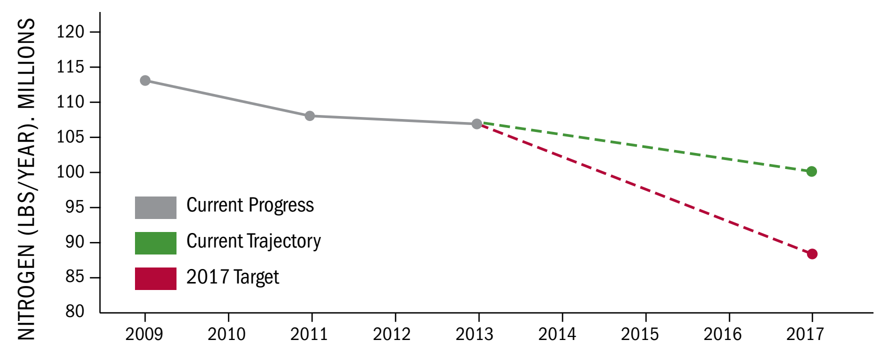
Fortunately, reducing pollution from agriculture is the most cost-effective way to reduce pollution.

The Clean Water Act allows the federal Environmental Protection Agency to regulate the largest animal raising operations, but gives the states the option to regulate the large majority of smaller farms.

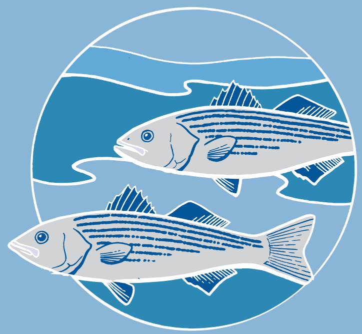
Because we need to significantly increase efforts to reduce farm pollution, it is primarily up to the states to implement programs and policies to achieve those reductions. Business as usual will not get the job done.

With budget shortfalls throughout the region, the prospects for significant additional cost-share funding for agriculture may not be bright. We will continue to advocate for cost-share funding, however, and we will also consider enforcement, litigation, better use of existing public funds, and bringing more private money to the table. If the states fail to meet agricultural reduction goals, EPA must look elsewhere—at point sources, for example—for pollution reduction.

Watershed Modeled Nitrogen Pollution from Agriculture



FISHERIES



Rockfish: 64

(–5 from 2012)

A new scientific assessment[1] documents a ten-year decline in the rockfish (striped bass) population since 2003, to the level that triggers conservation action. Catches coastwide will be cut back beginning in 2015 in an effort to bring numbers up. While down substantially from an all-time high in 2003, the current population level is still fully capable of reproducing. In fact, spawning in 2014 was about average, and the 2011 hatch was very good and will help bring adult numbers up in the next few years.

Rockfish spend the first four to eight years of their life year-round in the Bay. Once Bay rockfish have matured, they migrate up the East Coast in summer. During the resident period, they are exposed to conditions in the Bay including the summer dead zone. Scientists have found that they are dying at higher rates in recent years, probably because of *Mycobacteriosis*, a disease triggered by stress from low oxygen levels and poor nutrition from lack of preferred forage species like menhaden. Improvements in both will help the 2011 year class survive in numbers that will bolster future rockfish populations.

1 Atlantic States Marine Fisheries Commission, Atlantic Striped Bass Benchmark Assessment, 2013.

Blue Crabs: 45

(–10 from 2012)

The Bay's blue crab population dropped dramatically to less than half its 2012 level (from 765 to 297 million). Most noteworthy, the number of adult female crabs (the spawning stock) dropped below the level considered depleted, forcing the states to cut back on catches to improve the chances of good reproduction. Crabbers suffered poor catches in both 2013 and 2014. The science-based management approach put in place in 2008 provides important guidelines for the fishery, but has not been able to stabilize the fishery at sustainable levels. Consideration should be given to a quota-based system for managing total catch as a way to improve the quality of the fishery.

Factors other than harvest are evidently also limiting the crab population. The large numbers of juvenile crabs produced in 2011 did not mature into large numbers of adults as expected. Continued low levels of underwater grass habitat probably exposed small crabs to high predation by striped bass and other predatory fish. Clearly the management of the crab catch needs to be supplemented by further efforts to reduce nitrogen and phosphorous pollution and restore crab habitat.

Oysters: 8

(+2 from 2012)

Oysters continue to rebound. Roughly a billion oysters are now planted annually in the Bay and its tributaries. Surveys show they are surviving better than they have in decades. Over 90 percent have survived in Maryland waters in each of the last three years, indicating reduced losses from disease. In addition, a good spat set (the number of baby oysters attaching to hard surfaces) in recent years is boosting restoration efforts and watermen's catches. The total Baywide catch nearly hit one million bushels in the 2013-14 season, the first time that benchmark has been approached since 1987. Most importantly, a thriving aquaculture industry has taken root, producing five times what it did just five years ago.

Collaboration between state and federal agencies has never been better. A new approach that targets individual river systems with a goal of restoring ten tributaries by 2025 is showing great promise. Still, there are major challenges. The increased catches are improving the availability of shell, the preferred material for restoring reefs, but quantities are still well below what is needed. Alternative materials are being tried successfully and will be essential for rebuilding the once-common, three-dimensional reefs. Most importantly, continued dedicated funding will be essential to maintain momentum and recover the essential role that oysters play in the Bay ecosystem.

Shad: 9

(no change from 2012)

American shad numbers in the Chesapeake Bay and along the Atlantic coast remain low. Most traditional fisheries are closed. Rebuilding the formerly bountiful spring shad migrations up Bay rivers faces several challenges. Dams that block those migrations are the most direct impediment to restoring the fishery. The unintentional catch of shad in large-scale ocean fisheries also undermines recovery and must be a top priority for the agencies that manage fisheries in federal waters.

The spring 2014 shad run was relatively good in Virginia rivers, and the Potomac River remains a bright spot. But the Susquehanna River, the site of enormous historical shad runs, had its lowest number of returns since the Conowingo Dam fish lift began operations in 1997. The dam is currently undergoing relicensing. Improving upstream and downstream fish passage is a critical element in the relicensing.

State and federal efforts to re-stock shad juveniles have met their targets in recent years.

Once the most valuable fishery in the Chesapeake, shad are now in danger of being the forgotten fishery and will only recover with a formula that includes restocking of juveniles, protecting adult fish in the ocean and the Bay, and restoring access to historic spawning grounds.

Investing in the Future

Key to the success of any long-term plan to save the Chesapeake Bay and its rivers and streams is the environmental literacy of future generations of watershed residents. As our region's population continues to grow, it is critical that today's young people develop the knowledge and skills they need to make informed decisions and act as responsible clean-water stewards.

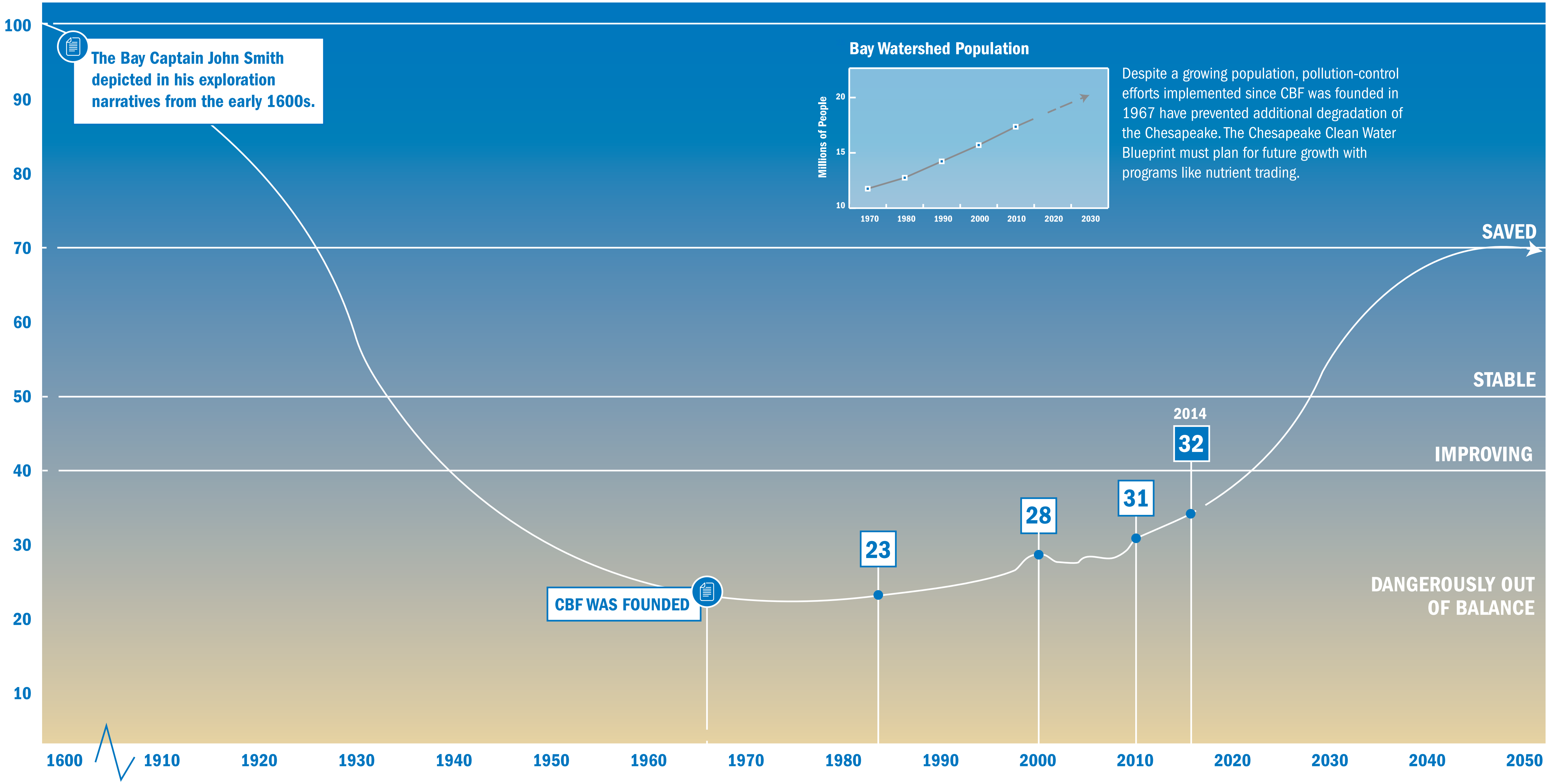
There are many building blocks needed to establish a solid foundation for environmental literacy. Reaching all students requires a systemic approach to environmental education. Teachers need tools and resources to teach about our watershed—in and out of the classroom. School leaders need to understand how environmental education can support overall achievement and help meet educational goals. Students need opportunities to explore and learn outside. And once they've been inspired to do more, they need meaningful ways to take action to protect and restore their local waterways.

The good news is that parents, teachers, and school administrators increasingly recognize the value of environmental education to student engagement and citizenship. Education agencies at the state and local levels have developed plans for increasing environmental literacy through programs, partnerships, and policies. Teacher and principal professional development programs provide much needed training in using the outdoors as a context for teaching and learning. Non-profit environmental organizations and natural resource agencies are partnering with schools to provide meaningful outdoor educational experiences for students of all ages. And students across the watershed are taking action at school and in the community—installing rain gardens, monitoring stream health, raising oysters, educating others, and much more.

Building on this momentum, the six Chesapeake Bay states and the District of Columbia have signed a Chesapeake Bay Agreement that includes a first-ever goal for environmental literacy. This plan commits leaders from around the Bay watershed to increase outdoor learning experiences for students, encourage environmental education during the school day, and support the "greening" of schools and schoolyards. If these commitments are met, the benefits will be long-lasting and far-reaching.

When schools and community partners collaborate to educate and inspire students, we make a sound investment in a clean and vibrant Chesapeake Bay for generations to come.

STATE OF THE BAY 2014



The State of the Chesapeake Bay is improving. Slowly, but improving. What we can control—pollution entering our waterways—is getting better. But, the Bay is far from saved. Our 2014 report confirms that the Chesapeake and its rivers and streams remain a system dangerously out of balance, a system in crisis. If we don't keep making progress—even accelerate progress—we will continue to have polluted water, human health risks, and declining economic benefits—at huge societal costs.

The good news is that we are on the right path. A Clean Water Blueprint is in place and working. All of us, including our elected officials, need to stay focused on the Blueprint, push harder, and keep moving forward. Saving the Bay and restoring local water quality will not just benefit us; clean water will benefit our children and all future generations.

Please contact your local, state, and federal officials and urge their unwavering support for the Chesapeake's Clean Water Blueprint. You can find information on how to do this at cbf.org/getinvolved.

How We Create Our Report

The *State of the Bay* report is based on the best available information about the Chesapeake for indicators representing three major categories: pollution, habitat, and fisheries. Monitoring data serve as the primary foundation for the report, supplemented by in-the-field observations.

We measure the current state of the Bay against the healthiest Chesapeake we can describe—the Bay Captain John Smith depicted in his exploration narratives from the early 1600s, a theoretical 100.

We assign each indicator a score and then average the scores in the three categories to determine the overall state of the Chesapeake Bay. Our number scores correlate with letter grades as follows:

70 or better	A+
60–69	A
50–59	B+
45–49	B
40–44	C+
35–39	C
30–34	D+
25–29	D
20–25	D-
Below 20	F

The Chesapeake Bay's 64,000-square-mile watershed covers parts of six states and is home to more than 17 million people.

Map:
Lucidity Information Design

PHOTO CREDITS
Cover: Octavio Aburto/ILCP
Page 4: iStock
Page 8: Michael Redmond
Page 12: USDA Natural Resources Conservation Service
Page 16: Bill Portlock/CBF Staff

CHESAPEAKE BAY FOUNDATION

Saving a National Treasure

Maryland
Philip Merrill
Environmental Center
6 Herndon Avenue
Annapolis, MD 21403
410/268-8816

Eastern Shore
102 East Dover Street
Easton, MD 21601
410/543-1999

Virginia
Capitol Place
1108 East Main Street
Suite 1600
Richmond, VA 23219
804/780-1392

Hampton Roads
Brock Environmental Center
3663 Marlin Bay Drive
Virginia Beach, VA 23455
757/622-1964

Pennsylvania
1426 North Third Street
Suite 220
Harrisburg, PA 17102
717/234-5550

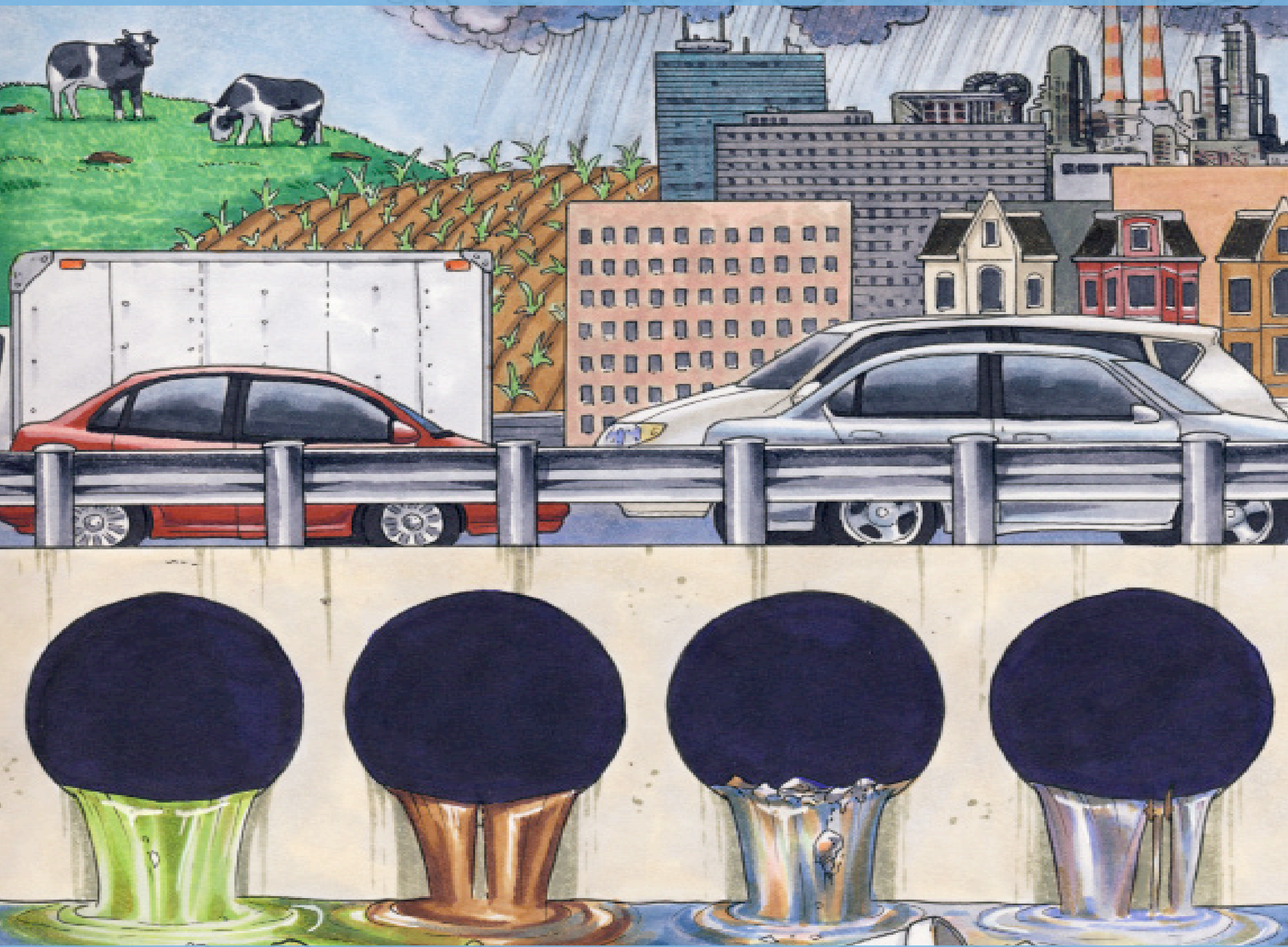
Washington, D.C.
1615 M Street, NW
Washington, DC 20036
202/544-2232

cbf.org

Engineering
Everywhere

Don't Runoff: Engineering An Urban Landscape

Environmental Engineering for Out-of-School Time • Grades 6–8



Written by the Engineering is Elementary® Team
Illustrated by Ross Sullivan-Wiley
and the Engineering is Elementary® Team

EiE Engineering is Elementary | Engineering Everywhere
Developed by the Museum of Science, Boston

Engineering is Elementary
Museum of Science
1 Science Park
Boston, MA 02114

Written by the Engineering is Elementary Team

Project Director:
Christine Cunningham

Research and Evaluation:
Christine Gentry
Jonathan Hertel
Cathy Lachapelle
Quinn Sallee
Christopher San Antonio-Tunis
Muhammed Shams
Stephen Sullivan
Richard Sutton

Multimedia:
Kristina Blanchflower
Ellen Daoust
Elizabeth Mantey
Michelle Mizner
Jean Towns

Curriculum Development:
Owen Berliner
Ian Burnette
Martha Davis
Michelle DiIeso
Melissa Higgins
Katy Laguzza
Natacha Meyer
Tania Tauer
iea toner

Professional Development:
Chantal Balesdent
Jason Brewer
Erin Fitzgerald
Martha Hass
Elissa Jordan
Shannon McManus
Elise Morgan
Corey Niemann
Kristin Sargianis
Max Siegel
Roger Skophammer
Sharlene Yang

Operations:
Valerie Costa
Emily Eppler
Laura Higgins
Kate Sokol

Outreach:
Cynthia Berger

Interns and Consultants:
Amy Hachigian

Support for this project has been generously provided by i2 Camp.

Pilot Sites:

This unit would not be possible without the valuable feedback from our pilot sites!

A.E. Burdick School, Milwaukee, WI
BASIS DC, Washington DC
Boys and Girls Club of the South Coast Area, San Clemente, CA
Child First Authority, Baltimore, MD
City Gate, Inc., Washington D.C.
Downtown Urban Community Kids, Phoenix, AZ
Fort Belvoir Elementary School, Fort Belvoir, VA
Girls, Inc. of Lynn, Lynn, MA
Hopkins North Junior High, Minnetonka, MN
Seabrook Adventure Zone, Seabrook, NH
South Boston Boys and Girls Club, Boston, MA
South Brooklyn Youth Consortium, Brooklyn, NY
Willamalane Park and Recreation District, Springfield, OR

Unit Map

Here's an overview of the activities in this unit and how they all fit together.

Prep Activity 1: What is Engineering?
Youths engineer a tower and are introduced to the Engineering Design Process as a problem solving tool.

Prep Activity 2: Technologies at Work
Youths will complete multiple activities to figure out the definition of technology and how engineers brainstorm improvements to technologies.

Activity 1: The Pollution Solution
Youths learn about their engineering challenge and use a model city to explore what happens to polluted runoff.

Activity 2: Green Possibilities
Youths *create* their own green roofs and *investigate* the properties of natural materials.

Activity 3: Passing Through
Youths *investigate* permeable pavement technology by engineering pavement that will meet certain criteria.

Activity 4: Creating an Urban Landscape
In groups, youths *plan, create,* and *test* a solution to their environmental engineering challenge.

Activity 5: Improving an Urban Landscape
Groups *improve* their designs to better meet the criteria.

Activity 6: Engineering Showcase
Youths *communicate* their work to visitors.

Table of Contents

Introduction

Activities

About Engineering is Elementary

Engineering is Elementary® (EiE) fosters engineering and technological literacy among children. Most humans spend over 95% of their time interacting with technology. Pencils, chairs, water filters, cell phones, and buildings are all technologies—solutions designed by engineers to fulfill human needs or wants. To understand the world we live in, it is vital that we foster engineering and technological literacy among all people, even young children! Fortunately, children are born engineers. They are fascinated with building, taking things apart, and how things work. EiE harnesses children's natural curiosity to promote the learning of engineering and technology concepts.

The EiE program has four primary goals:
Goal 1: Increase children's technological literacy.
Goal 2: Increase educators' abilities to teach engineering and technology to elementary students.
Goal 3: Increase the number of schools and out-of-school time programs in the U.S. that include engineering at the elementary level.
Goal 4: Conduct research and assessment to further the first three goals and contribute knowledge about engineering teaching and learning at the elementary level.

The first product developed by the EiE program was the Engineering is Elementary curriculum series. This curriculum, designed specifically for use in elementary school classrooms, is research-based, standards-driven, and classroom-tested. For more information about EiE, visit: eie.org.

In 2011, EiE began development of Engineering Adventures (EA), a curriculum specifically for use in out-of-school time settings. EA is tailored to kids in 3rd through 5th grade. More information about EA can be found online at: engineeringadventures.org.

In 2012, EiE began development of Engineering Everywhere (EE). Like EA, this curriculum is also designed for use in out-of-school time settings, but targets 6th through 8th graders. More information about EE can be found on the next page.

Engineering is Elementary is a part of The National Center for Technological Literacy (NCTL) at the Museum of Science, Boston. The NCTL aims to enhance knowledge of technology and inspire the next generation of engineers, inventors, and innovators. Unique in recognizing that a 21st century curriculum must include today's human-made world, the NCTL's goal is to introduce engineering as early as elementary school and continue it through high school, college, and beyond. For more information about the NCTL, visit: nctl.org.

About Engineering Everywhere

The mission of Engineering Everywhere is to create exciting out-of-school time activities and experiences that allow *all* learners to act as engineers and engage in the engineering design process. Our goal is to positively impact learner's attitudes about their abilities to engineer by providing materials uniquely appropriate for the varied landscapes of out-of-school time settings.

The main ideas that guide the developers of EE are listed below.

We believe youths will best learn engineering when they:

- engage in activities that are fun, exciting, and connect to the world in which they live.
- choose their path through open-ended challenges that have multiple solutions.
- have the opportunity to succeed in engineering challenges.
- communicate and collaborate in innovative, active, problem solving.

Through EE units, youths will learn that:

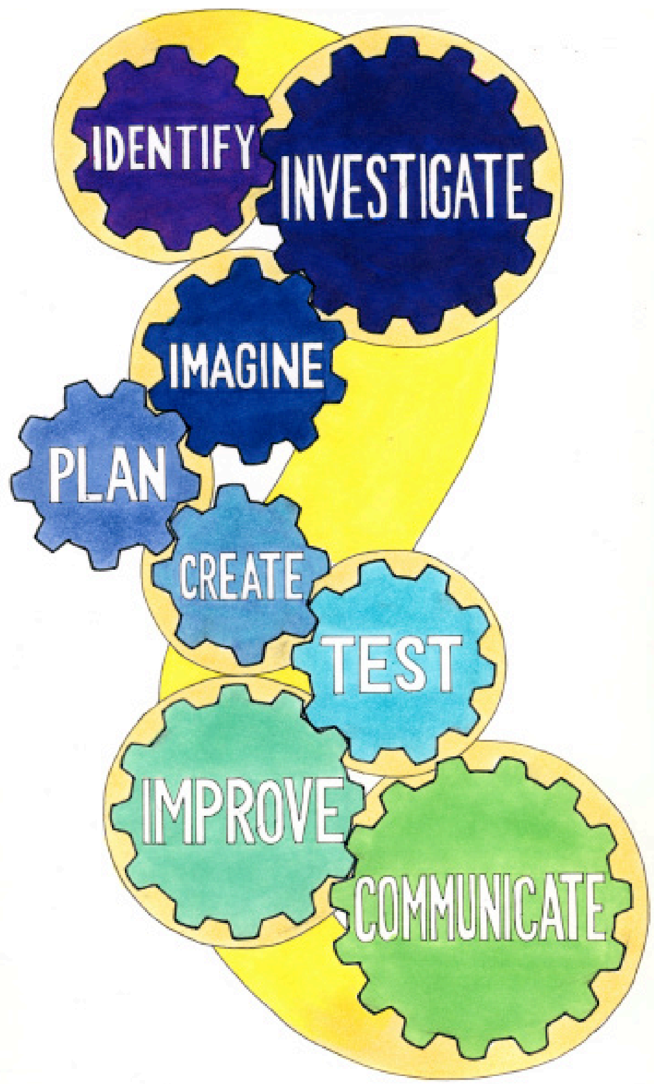
- they can use the Engineering Design Process to help solve problems.
- engineers design technologies to help people and solve problems.
- they have talent and potential for designing and improving technologies.
- they, too, are engineers.

As youths work through their engineering design challenges, they will have the opportunity to build their problem solving, teamwork, communication, and creative thinking skills. Most importantly, this curriculum is designed to provide a fun learning opportunity!

The Engineering Design Process

The Engineering Design Process (EDP) is the backbone of each Engineering Everywhere (EE) unit. It is an eight step process that guides youths in solving engineering challenges. Our goal for each EE unit is for youths to understand that the EDP can help them solve problems not only in engineering, but also in other areas of their lives.

While there are many versions of the EDP used in academic and professional fields of engineering, we developed an eight step process that builds on our five step process used in the elementary curriculum. There are guiding questions throughout the activities for the educator to ask to promote discussion about the EDP. There are also sections in the Engineering Notebook to encourage youths to engage in the process.



The Engineering Design Process begins with *identifying* a problem that needs to be solved and *investigating* what has already been done. Next, engineers *imagine* different solutions and *plan* their designs. Then, they *create* and *test* their design and make *improvements* based on the test results. Finally, engineers *communicate* their findings to others. While the process is shown as linear, youths may jump around to steps as they are engineering. For example, they may need to *imagine* and *plan* new designs in order to *improve*.

To further highlight the EDP throughout the unit, the steps are italicized in this guide. Youths are also provided with an explanation of each step, which can be seen in their Engineering Notebooks. To the right is the EDP used in the EE units.

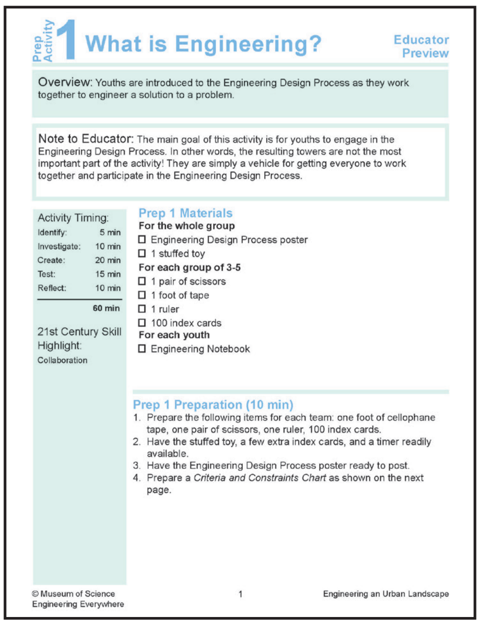
Unit Goals

Through this unit, youths will be introduced to engineering and the Engineering Design Process as they work together to engineer a solution to an environmental engineering challenge. Youths will learn about stormwater runoff, and explore what technologies and methods are used to reduce polluted runoff. Youths will collaborate to design ways to reduce stormwater runoff in a city model. Working with models is an important sub-goal for this unit.

By the end of the unit, youths will be ready to present what they learned about designing urban landscapes and the engineering design process by sharing the engineering work they have done.

Teacher Guide Components:

An **Educator Preview** with background information, activity timing, key concepts, materials list, and preparation.



Prep Activity 1 **What is Engineering?** Educator Preview

Overview: Youths are introduced to the Engineering Design Process as they work together to engineer a solution to a problem.

Note to Educator: The main goal of this activity is for youths to engage in the Engineering Design Process. In other words, the resulting towers are not the most important part of the activity! They are simply a vehicle for getting everyone to work together and participate in the Engineering Design Process.

Activity Timing:

Identify:	5 min
Investigate:	10 min
Create:	20 min
Test:	15 min
Reflect:	10 min
	60 min

21st Century Skill Highlight:
Collaboration

Prep 1 Materials

For the whole group
- ☐ Engineering Design Process poster
- ☐ 1 stuffed toy

For each group of 3-5
- ☐ 1 pair of scissors
- ☐ 1 foot of tape
- ☐ 1 ruler
- ☐ 100 index cards

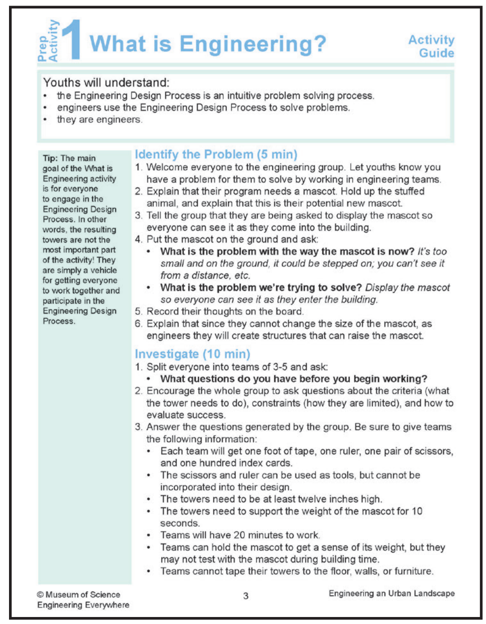
For each youth
- ☐ Engineering Notebook

Prep 1 Preparation (10 min)

1. Prepare the following items for each team: one foot of cellophane tape, one pair of scissors, one ruler, 100 index cards.
2. Have the stuffed toy, a few extra index cards, and a timer readily available.
3. Have the Engineering Design Process poster ready to post.
4. Prepare a *Criteria and Constraints Chart* as shown on the next page.

© Museum of Science
Engineering Everywhere 1 Engineering an Urban Landscape

An **Activity Guide** with step-by-step instructions, including discussion questions, extension ideas, and tips.



Prep Activity 1 **What is Engineering?** Activity Guide

Youths will understand:
- the Engineering Design Process is an intuitive problem solving process.
- engineers use the Engineering Design Process to solve problems.
- they are engineers.

Tip: The main goal of the What is Engineering activity is for everyone to engage in the Engineering Design Process. In other words, the resulting towers are not the most important part of the activity! They are simply a vehicle for getting everyone to work together and participate in the Engineering Design Process.

Identify the Problem (5 min)

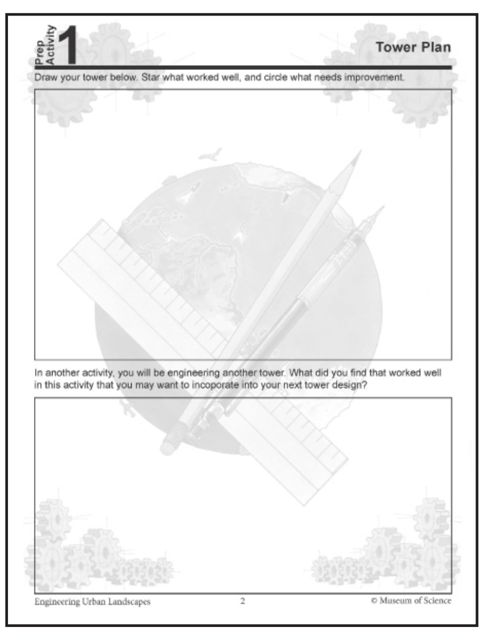
1. Welcome everyone to the engineering group. Let youths know you have a problem for them to solve by working in engineering teams.
2. Explain that their program needs a mascot. Hold up the stuffed animal, and explain that this is their potential new mascot.
3. Tell the group that they are being asked to display the mascot so everyone can see it as they come into the building.
4. Put the mascot on the ground and ask:
   - **What is the problem with the way the mascot is now?** *It's too small and on the ground, it could be stepped on; you can't see it from a distance, etc.*
   - **What is the problem we're trying to solve?** *Display the mascot so everyone can see it as they enter the building.*
5. Record their thoughts on the board.
6. Explain that since they cannot change the size of the mascot, as engineers they will create structures that can raise the mascot.

Investigate (10 min)

1. Split everyone into teams of 3-5 and ask:
   - **What questions do you have before you begin working?**
2. Encourage the whole group to ask questions about the criteria (what the tower needs to do), constraints (how they are limited), and how to evaluate success.
3. Answer the questions generated by the group. Be sure to give teams the following information:
   - Each team will get one foot of tape, one ruler, one pair of scissors, and one hundred index cards.
   - The scissors and ruler can be used as tools, but cannot be incorporated into their design.
   - The towers need to be at least twelve inches high.
   - The towers need to support the weight of the mascot for 10 seconds.
   - Teams will have 20 minutes to work.
   - Teams can hold the mascot to get a sense of its weight, but they may not test with the mascot during building time.
   - Teams cannot tape their towers to the floor, walls, or furniture.

© Museum of Science
Engineering Everywhere 3 Engineering an Urban Landscape

Engineering Notebook pages that allow youths to record findings and reflect on their learning.



Prep Activity 1 **Tower Plan**

Draw your tower below. Star what worked well, and circle what needs improvement.

In another activity, you will be engineering another tower. What did you find that worked well in this activity that you may want to incoporate into your next tower design?

Engineering Urban Landscapes 2 © Museum of Science

What You Need to Know **Before** Teaching an EE Unit

Engineering is fun.

The EE team hears this from many OST educators and youths alike. Engineering is really a way of problem solving—a way of thinking about the world—that is often very fun and creative. Any time you need to solve a problem in order to reach a goal, you are engineering.

There are no right or wrong answers.

There are often many great ways to solve the same problem. Not only is this a good engineering lesson for the youths in your program, it's a good life lesson.

You are a guide.

As the educator, it is your role to guide youths through these activities by encouraging them to pursue and communicate their own ideas, even if you think they might not work. Every problem has many possible solutions and multiple ways to reach them.

Ask questions!

Throughout the activities, you can ask questions prompting youths to share their prior knowledge, predict what they might find, or remind them of criteria that will help them as they engineer. Asking questions like these sets your youths up to succeed and feel confident in their ability to engineer.

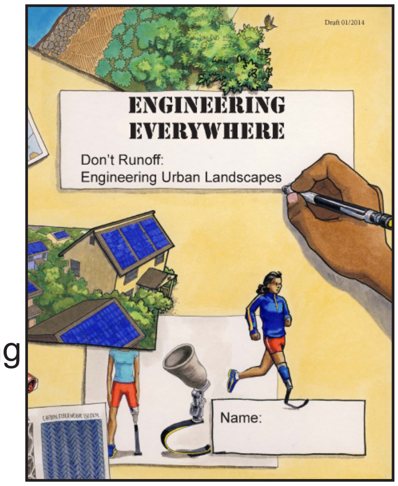
It's okay to try it out!

It can be very helpful to try out the engineering challenge yourself—either beforehand or right alongside the youths in your program as they work through the adventures. This can help you understand the challenges they might face.

Support reflection

Each activity includes five to ten minutes at the end for youths to communicate with their peers by sharing their work. This gives youths the chance to discuss new ideas, think about their own work and the work of others, and reflect on what was learned. Group reflection can help reduce competition by encouraging youths to support each other as they move through the Engineering Design Process.

Engineering Notebooks



Make a copy an Engineering Notebook for each youth before you begin working through this EE unit. Youths will use them as directed in the Activity Guide during every activity.

The Engineering Notebook is a central location for youths to record their thoughts and ideas as they move through the unit. Its pages guide youths through the Engineering Design Process, pose questions, and prompts youths to reflect on their engineering work. The time youths spend with their Notebooks during each activity will allow them to create a personalized record of their engineering learning.

There are a few ways you can use the Engineering Journal. You may want to have groups share one Engineering Journal as a central recording spot for all group data and findings. This allows group members who enjoy writing and recording to do so. You may also encourage groups to share the responsibility by having group members rotate who records

Alternate Prep Activities

The two prep activities, "*What is Engineering?*" and "*What is Technology?,*" introduce youths to engineering and technology. "*What is Engineering?*" gives youths the chance to collaborate, experience a mini hands-on engineering challenge, share out their designs, and learn about the Engineering Design Process. This activity sets the stage for what they can expect in the rest of the unit.

"What is Technology?" has youths interact with technologies, working with the definition that a technology is any thing designed by humans to help solve a problem or meet a need. Most youths think of technology as things that can be plugged into the wall. They do not realize the items that they interact with everyday, including pencils, paper, and water bottles, are also technologies. This activity introduces the definition of technology they will refer to as they engineer their own technologies to solve the problem presented in the unit.

While most prep activities for Engineering Everywhere are unit specific, there are a couple of versions that are repeated in multiple units. To avoid redundancy, you can find alternate activities online at www.engineeringeverywhere.org. If you have questions about these activities, please email www.engineeringeverywhere@mos.org.

Tips and Tricks for Teaching the Unit

Post a Daily Agenda

Giving youths a sense of the day’s activity will help them to plan ahead and manage their time.

Facilitate Teamwork

Being able to work well in teams is an important skill for any engineer. You may want to assign team roles to help youths if they struggle with teamwork. Possible roles include: the note taker, the materials gatherer, the tester, and the presenter.

This unit requires a collaborative workspace. Tables, desks, and chairs should be movable depending on the youths needs. It is a good idea to establish a materials table where you can set up materials for the day. Then groups can be in charge of gathering their own materials when they are ready

Invite Others to the Engineering Showcase

The Engineering Showcase, always the last activity in the unit, is a big deal! This is a chance for youths to highlight the engineering they’ve done and share their accomplishments with others. Consider inviting families, program staff, and other youth to come to the showcase.

Scheduling the Activities

Each activity requires 50-60 minutes of teaching time. We recommend that you budget at least 8 or 9 hours in order to complete this unit, as some activities may run longer than expected. You can schedule this unit in several ways: once a week, several times a week, or daily. It is also possible to group certain activities together. The chart below shows which activities are easily taught together. Use this chart to help you plan your schedule.

Prep Activity 1: What is Engineering? Prep Activity 2: Technologies at Work	2-3 hours
Activity 1: The Pollution Solution	1-2 hours
Activity 2: Green Possibilities Activity 3: Passing Through	2-3 hours
Activity 4: Creating an Urban Landscape Activity 5: Improving an Urban Landscape	2-3 hours
Activity 6: Engineering Showcase	1-2 hours

Background

Environmental Engineering

Environmental engineers focus on removing pollution from the environment, minimizing the harmful impacts of pollution already in the environment, and preventing pollution from entering the environment in the first place.

Every time pollution enters an ecosystem, regardless of the type or the quantity, it has an impact on that ecosystem. Some of these impacts are direct and easily observable, while others are indirect, and appear slowly over time.

Environmental engineers often work alongside city planners and civil engineers to ensure that new structures, such as roads and buildings, are constructed with minimal impact and are designed to minimize transfer of pollutants into the environment.

Urban Runoff

Runoff is a term used to describe water that flows over the surface of the landscape during and after a rainstorm. In rural landscapes, most rainwater is absorbed directly into the landscape, with runoff occurring only when the ground is over-saturated. In urban areas, however, the majority of rainwater becomes runoff, because it is not able to soak into the impervious paved surfaces that are so prevalent in cities. Regardless of location, runoff typically flows directly into local water bodies, such as creeks, rivers, bays, and, ultimately, the oceans.

Runoff in cities can be particularly harmful to the environment. As the water flows over the surface of the city, it picks up pollutants such as garbage, oils, detergents, and animal waste. These pollutants travel with the runoff into nearby bodies of water. Often the runoff of an entire city will end up in the same body of water, resulting in a highly concentrated area of pollutants. This is harmful not only to the organisms living in the water, but also to organisms relying on the water for drinking or even recreation.

Reducing runoff in cities requires being creative about how to absorb rainwater into the city landscape. When polluted stormwater runoff is absorbed into the ground, there are microbes that eat some of the pollution. Plants also can absorb and filter some pollutants, which reduces the amount and pace of polluted runoff entering a body of water. In this unit, youths explore permeable pavement technology (an absorbent pavement) and ways to incorporate absorbent natural materials into a city landscape (through parks, green roofs) to reduce polluted runoff from entering a river at the base of a model city.

Vocabulary

Constraint: A limitation or restriction on a design.

Criterion: A requirement for a design.

Environmental engineer: Someone who uses his or her creativity and knowledge of math, science, and natural systems to design technologies to solve problems relating to reducing pollution in the environment.

Engineer: Someone who uses his or her creativity and knowledge of math and science to design technologies that solve problems.

Engineering Design Process: The steps that engineers use to design technologies to solve a problem.

Green roof: A roof that is partially or fully covered with vegetation over layers of material to absorb water, with a waterproof membrane on the bottom to prevent leaking.

Runoff: The water that flows over the surface of a landscape during and after a rainstorm.

Permeable pavement: An absorbent pavement allowing water to pass through it.

Pollutant: Something that contaminates the air, water, or soil of an environment.

Pollution: The introduction of pollutants into the environment.

Technology: Anything designed by humans to help solve a problem.

Materials List

This kit is prepared for 8 groups of 3.

Quantity	Item
	Non-Consumable Items
1	*Engineering Everywhere Special Report* DVD or use the link: http://www.eie.org/engineering-everywhere/curriculum-units/dont-runoff
1	Engineering Design Process Poster
1	stuffed toy, approx. 6”
2	wind-up toys, walking
4	measuring cups, 1 cup
4	spray bottles
4	permanent marker
8	rubber duckies, small
8	ruler, 12”
8	scissors
	Consumable Items
1	cheesecloth (1 yard)
1	dish soap, liquid, 12 oz.
1	food coloring, liquid, pack of 4
1	gravel, aquarium, 10 lbs
1	potting soil (8 quart bag)
1	screen, nylon (1 yard)
1	sprinkles, 5-10 oz
1	vegetable oil, 1 cup
2	duct tape, roll
2	sticky notes, pads
4	sphagnum moss (100 cup in bag)
5	aluminum foil, roll, 75 ft.
6	sand (2.2 lb bag)
8	masking tape, roll
8	tray, foil (5” x 1.4” x 7.5”)
9	cardboard (11” x 17”)
9	trays, foil (10” x 18” x 3”)
20	chipboard (or cardboard), sheets
20	craft foam
20	cups, paper (3 oz)
20	sponges (plain, no scrub)
25	felt

Materials List (cont.)

30	box (4.5” x 3.25” x 2.5”)
50	cups, paper (8 oz)
100	cotton balls
100	craft sticks
100	straws
500	bingo chips (around 3/4” to 1” diameter) or plastic discs
500	coffee stirrers
500	paperclips, size 1
500	plastic sequins, small
1200	index cards, 3” x 5”
	NOT INCLUDED IN KIT
1	device to play online videos
1	chart paper
1	timer
1	paper towel roll

National Education Standards

This unit is written with the primary goal of teaching engineering practices and critical thinking skills. The engineering challenge in the unit also requires that a variety of science topics and principles are touched upon. The engineering standards taught in this unit and the science topics links in this unit are noted below.

		Prep Activity 1: What is Engineering?	Prep Activity 2: Technologies at Work	Activity 1: The Pollution Solution	Activity 2: Green Possibilities	Activity 3: Passing Through	Activity 4: Creating an Urban Landscape	Activity 5: Improving an Urban Landscape	Activity 6: Engineering Showcase
National Science Education Standards	Science as Inquiry	✓		✓	✓	✓	✓	✓	
	Physical Science								
	Life Science								
	Earth and Space Science			✓	✓	✓	✓	✓	✓
	Science and Technology	✓	✓	✓	✓	✓	✓	✓	✓
	Science in Personal and Social Perspectives			✓	✓	✓	✓	✓	✓
	History and Nature of Science								
ITEEA	The Nature of Technology		✓	✓	✓	✓	✓	✓	✓
	Technology and Society			✓	✓	✓	✓	✓	✓
	Design	✓		✓	✓	✓	✓	✓	✓
	Abilities for a Technological World	✓		✓	✓	✓	✓	✓	✓
	The Designed World								

		Prep Activity 1: What is Engineering?	Prep Activity 2: Technologies at Work	Activity 1: The Pollution Solution	Activity 2: Green Possibilities	Activity 3: Passing Through	Activity 4:Creating an Urban Landscape	Activity 5: Improving an Urban Landscape	Activity 6: Engineering Showcase
Next Generation Science Standards	MS-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.			✓			✓	✓	✓
	MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.						✓	✓	✓
	MS-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services.			✓	✓	✓	✓	✓	
	MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.			✓	✓	✓	✓	✓	✓
	MS-ESS3-4 Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.			✓			✓	✓	✓
	MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.	✓			✓	✓	✓	✓	
	MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	✓			✓	✓	✓	✓	
	MS-ETS1-3 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.	✓			✓	✓	✓	✓	✓
	MS-ETS1-4 Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.			✓	✓	✓	✓	✓	

Self-Assessment Rubric

How do you know if you are leading these activities successfully? This tool will help you keep track of successful moments and will ask you to identify how your own actions enabled youths to succeed.

Date: Activity:

Elements of success	Evidence: Where did I see this during the activity?	What was my role in making this happen?
Youths were engaged and challenged by the activity. They persisted through difficulties.		
Youths did most of the talking, sharing their ideas with each other during the entire activity.		
Youths value their engineering work as a process, not just as the end result.		

Self-Assessment Rubric

How do you know if you are leading these activities successfully? This tool will help you keep track of successful moments and will ask you to identify how your own actions enabled youths to succeed.

Elements of success	What does this look like?	How does the guide help me facilitate this?
Youths were engaged and challenged by the activity. They persisted through difficulties.	• Youths are on-task. • Youths are trying out their ideas. • Youths identify what is working well in their designs. • Youths troubleshoot their own work. • Youths improve their designs.	• Use the bold prompts to **ask open-ended questions** to help youths troubleshoot their work. • Use the bold prompts to **ask youths about what they think is working well** in their designs and what they would like to improve. This will help youths feel more confident about their problem-solving abilities.
Youths did most of the talking, sharing their ideas with each other during the entire activity.	• Youths bring their own ideas to the activity and are comfortable sharing them. • Youths brainstorm and debate within their groups. • Youths share their designs with others. • Youths talk about how their ideas are changing over time.	• Use the bold prompts in the guide to **encourage youths to share and explain their thinking**. • Have youths **collaborate in groups** so they can brainstorm and create a design together. • Use the bold prompts in the Reflect section to **help youths share their new ideas about designs.**
Youths value their engineering work as a process, not just as the end result.	• Youths go beyond talking about their design to talking about how they thought of it and why they designed it. • Youths use the Engineering Design Process to describe their actions.	• Use the bold prompts in the guide to **ask youths how they use the Engineering Design Process.** Spending time talking and thinking about their process will help youths see the value in it. • Use the bold prompts to **ask all youths about Improving** their designs, even if their designs are working well. • **Encourage youths to reflect individually** in their Engineering Notebooks to give them time for their experiences to sink in and be remembered.

Dear Family, Date: ________________

We are beginning an engineering unit called *Don't Runoff: Engineering an Urban Landscape*, which is part of the Engineering Everywhere curriculum developed by the Museum of Science, Boston. Through this unit, youths will be introduced to engineering and the engineering design process as they work together to engineer a solution to an environmental engineering challenge. This unit is set in a real-world context: throughout the unit, youths will work with teammates to engineer ways to reduce polluted runoff in a model city.

There are many reasons to introduce youths to engineering:

- **Engineering projects reinforce topics youths are learning in school.** Engaging youths in hands-on, real-world engineering experiences can enliven math, science, and other content areas.
- **Engineering fosters problem-solving skills**, including problem formulation, creativity, planning, and testing of alternative solutions.
- **Youths are fascinated with building and with taking things apart to see how they work.** By encouraging these explorations, we can keep these interests alive. Describing their activities as "engineering" when children are engaged in the natural design process can help them develop positive associations with engineering, and increase their desire to pursue such activities in the future.
- **Engineering and technological literacy are necessary for the 21st century.** As our society increasingly depends on engineering and technology, our citizens need to understand these fields.

Because engineering projects are hands-on, materials are often required. Several materials necessary to this unit are listed below. If you have any of these materials available, please consider donating them to us.

If you have expertise in environmental engineering or urban planning, or have any general questions or comments about the engineering unit we are about to begin, please let me know.

Sincerely,

If you have any of the following materials available and would like to donate them, I would greatly appreciate having them by the following date: ______________________ . Thank you!

____________________________ ____________________________
____________________________ ____________________________
____________________________ ____________________________

Prep Activity 1 What is Engineering?

Educator Preview

Overview: Youths are introduced to the Engineering Design Process as they work together to engineer a solution to a problem.

Note to Educator: The main goal of this activity is for youths to engage in the Engineering Design Process. In other words, the resulting towers are not the most important part of the activity! They are simply a vehicle for getting everyone to work together and participate in the Engineering Design Process.

Activity Timing:

Identify:	5 min
Investigate:	10 min
Create:	20 min
Test:	15 min
Reflect:	10 min
	60 min

21st Century Skill Highlight:

Collaboration

Prep 1 Materials

For the whole group

- ☐ Engineering Design Process poster
- ☐ 1 stuffed toy

For each group of 3-5

- ☐ 1 foot of tape
- ☐ 1 pair of scissors
- ☐ 1 ruler
- ☐ 100 index cards

For each youth

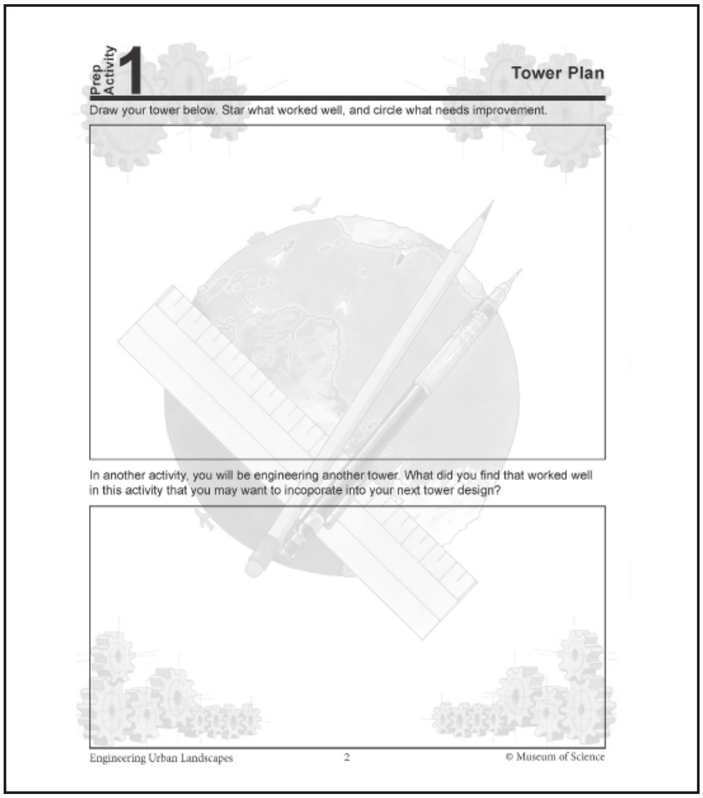
- ☐ Engineering Notebook

Prep 1 Preparation (10 min)

1. Prepare the following items for each team: one foot of cellophane tape, one pair of scissors, one ruler, 100 index cards.
2. Have the stuffed toy, a few extra index cards, and a timer readily available.
3. Have the Engineering Design Process poster ready to post.
4. Prepare a *Criteria and Constraints Chart* as shown on the next page.

Notebook Pages for Prep Activity 1

Tower Plan, p. 2



Prep Activity 1

Tower Plan

Draw your tower below. Star what worked well, and circle what needs improvement.

In another activity, you will be engineering another tower. What did you find that worked well in this activity that you may want to incoporate into your next tower design?

Engineering Urban Landscapes 2 © Museum of Science

Chart for Prep Activity 1

Criteria and Constraints Chart

Criteria (what you or your tower must do)	**Constraints (limitations of the challenge)**
• The tower must be at least twelve inches high. • The tower must support the mascot.	• You are limited to one hundred index cards and 1 foot of tape. • You have 20 minutes.

What is Engineering?

Youths will understand:
- the Engineering Design Process is an intuitive problem solving process.
- engineers use the Engineering Design Process to solve problems.
- they are engineers.

Tip: The main goal of the What is Engineering activity is for everyone to engage in the Engineering Design Process. In other words, the resulting towers are not the most important part of the activity! They are simply a vehicle for getting everyone to work together and participate in the Engineering Design Process.

Identify the Problem (5 min)

1. Welcome everyone to the engineering group. Let youths know you have a problem for them to solve by working in engineering teams.
2. Explain that their program needs a mascot. Hold up the stuffed animal, and explain that this is their potential new mascot.
3. Tell the group that they are being asked to display the mascot so everyone can see it as they come into the building.
4. Put the mascot on the ground and ask:
   - **What is the problem with the way the mascot is now?** *It's too small and on the ground, it could be stepped on; you can't see it from a distance, etc.*
   - **What is the problem we're trying to solve?** *Display the mascot so everyone can see it as they enter the building.*
5. Record their thoughts on the board.
6. Explain that since they cannot change the size of the mascot, as engineers they will create structures, or towers, that can raise the mascot.

Investigate (10 min)

1. Split everyone into teams of 3-5 and ask:
   - **What questions do you have before you begin working?**
2. Encourage the whole group to ask questions about the criteria (what the tower needs to do), constraints (how they are limited), and how to evaluate success.
3. Answer the questions generated by the group. Be sure to give teams the following information:
   - Each team will get one foot of tape, one ruler, one pair of scissors, and one hundred index cards.
   - The scissors and ruler can be used as tools, but cannot be incorporated into their design.
   - The towers need to be at least twelve inches high.
   - The towers need to support the weight of the mascot for 10 seconds.
   - Teams will have 20 minutes to work.
   - Teams can hold the mascot to get a sense of its weight, but they may not test with the mascot during building time.
   - Teams cannot tape their towers to the floor, walls, or furniture.

4. Post the *Criteria and Constraints Chart.*
5. Give each team a pair of scissors and 5 index cards. Give them 3 minutes to test some ideas for how they may want to use the index cards in their structures. They may want to roll, fold, or cut the cards.

Create (20 min)

1. Pass out index cards, tape, a ruler, and scissors to each team.
2. Set the timer for 20 minutes and have teams begin building.
3. As teams work, pass around the mascot so everyone can hold it and get a sense of its mass, but remind them they cannot test with it yet.
4. As you visit each team, ask questions like:
   - **How did your team come up with this design?**
   - **Why do you think your design will work well?**
   - **What are you doing to the cards to make them stronger?**
5. Every five minutes, let groups know how much time they have left.

Test and Communicate (15 min)

1. When time is up, have teams step away from their own work and observe the structures other teams created. Ask:
   - **What do you observe is the same about all of the designs?** *Materials, shapes, etc.*
   - **What do you observe is different about them?** *Different ways of using the index cards, different heights, etc.*
2. Point out that every team engineered a different solution to the same problem. In engineering, there are always many solutions to the same problem.
3. Have the teams watch as each team tests. Before testing, ask:
   - **Tell us about your design. What are its parts?**
   - **What do you predict will happen during testing?**
4. Allow a team member to place the mascot on top to see if it will hold for at least 10 seconds.
5. Whether or not their design met the criteria, ask each team:
   - **How would you improve your design if you had more time?**

Reflect (10 min)

Tip: Let teams know that they will be engineering towers later in the unit, and they should think back to what worked well and what didn't work well in this activity to help them get started.

1. Gather everyone around the Engineering Design Process poster.
2. Explain that engineers use a process called the Engineering Design Process to help them solve problems. Ask:
   - **How did your team use these steps as you engineered your tower?** *Encourage teams to link specific actions to specific steps, for example: we used the* imagine *step when we brainstormed.*
   - **Which, if any, steps did you use more than once?**
   - **What do you think would happen if you skipped a step?**
3. Explain that they will continue to use the Engineering Design Process to guide their engineering work throughout the unit.
4. Have youths fill out *Tower Plan,* p. 2 in their Engineering Notebooks, which they will refer back to in another activity.

Prep Activity 2 Technologies at Work

Educator Preview

Overview: Youths will complete multiple activities to helpt them define the word technology and understand how engineers brainstorm improvements to technologies.

Note to Educator: Many people think of technologies as things that are electronic or "high-tech." In actuality, technologies are anything designed by humans to solve a problem or meet a need.

Activity Timing:

Technology Activities:	50 min
Reflect:	10 min
	60 min

21st Century Skill Highlight:

Critical thinking

Prep 2 Materials

For the whole group

- ☐ Engineering Design Process poster
- ☐ *Is It Technology?*, this guide p. 9

For each group of 3-5

- ☐ small box or container
- ☐ Answer card (see preparation below)
- ☐ Optional: buzzer

For each youth

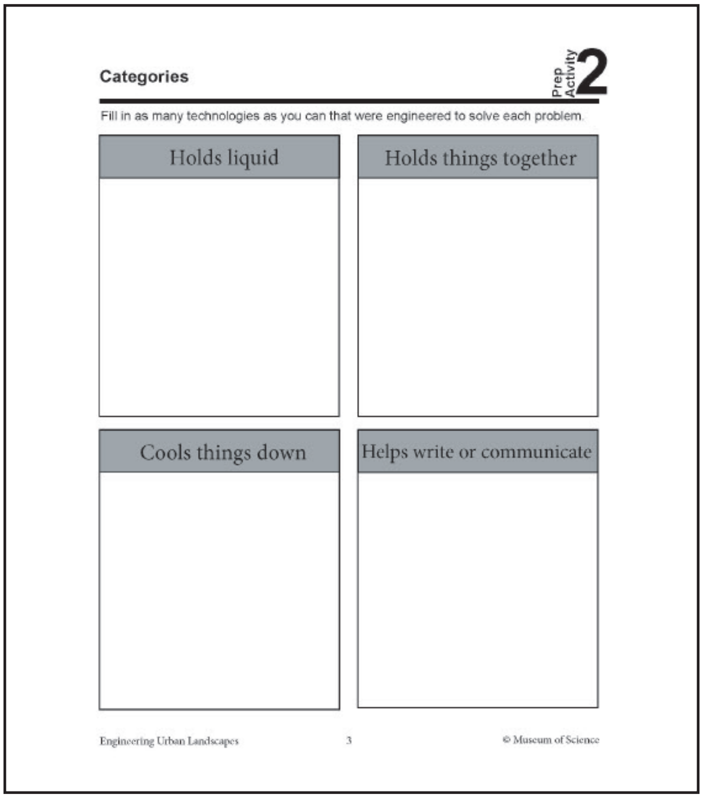
- ☐ Engineering Notebook

Prep 2 Preparation (15 min)

1. Prepare and post the *What's What* and *Team Score* charts as shown on the next page.
2. Use paper to make answer cards for each small group. On one side write Y and the other N.
3. Post the Engineering Design Process poster.

Notebook Pages for Prep Activity 2

Categories, p. 3



Categories Prep Activity 2

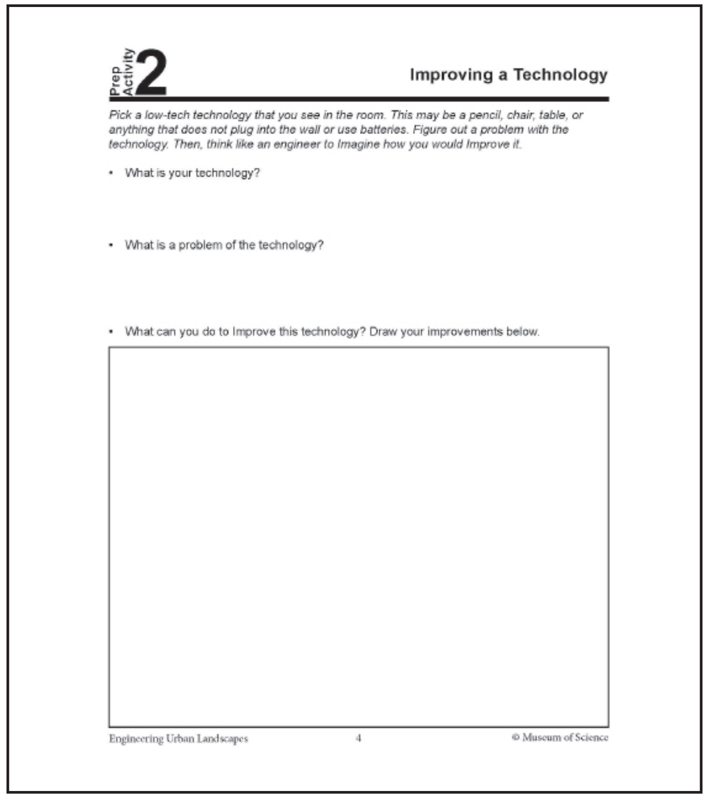
Fill in as many technologies as you can that were engineered to solve each problem.

Holds liquid	Holds things together

Cools things down	Helps write or communicate

Engineering Urban Landscapes 3 © Museum of Science

Improving a Technology, p. 4



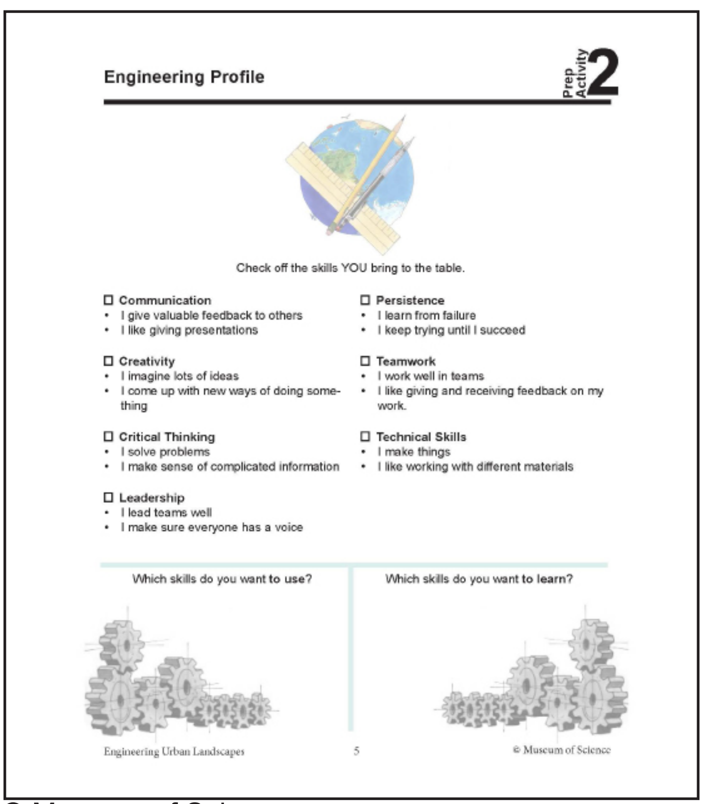
Prep Activity 2 **Improving a Technology**

Pick a low-tech technology that you see in the room. This may be a pencil, chair, table, or anything that does not plug into the wall or use batteries. Figure out a problem with the technology. Then, think like an engineer to Imagine how you would Improve it.

- What is your technology?
- What is a problem of the technology?
- What can you do to Improve this technology? Draw your improvements below.

Engineering Urban Landscapes 4 © Museum of Science

Engineering Profile, p. 5



Engineering Profile Prep Activity 2

Check off the skills YOU bring to the table.

- ☐ **Communication**
  - I give valuable feedback to others
  - I like giving presentations
- ☐ **Creativity**
  - I imagine lots of ideas
  - I come up with new ways of doing something
- ☐ **Critical Thinking**
  - I solve problems
  - I make sense of complicated information
- ☐ **Leadership**
  - I lead teams well
  - I make sure everyone has a voice
- ☐ **Persistence**
  - I learn from failure
  - I keep trying until I succeed
- ☐ **Teamwork**
  - I work well in teams
  - I like giving and receiving feedback on my work.
- ☐ **Technical Skills**
  - I make things
  - I like working with different materials

Which skills do you want to use? | Which skills do you want to learn?

Engineering Urban Landscapes 5 © Museum of Science

Charts for Prep Activity 2

What's What Chart

What's What	
Technology	Not a Technology

Team Score Chart

Team Score	
Team 1 Name	Team 2 Name

Technologies at Work

Youths will understand:

- that a technology is anything designed by humans to solve a problem.
- engineers design technologies.

Tip: If you have a large group, you may want to split up the group into smaller teams of 4-5.

What is Technology? (15 min)

1. Tell youths that today they will complete several activities to help them figure out more about what engineers do.
2. Explain to everyone that, as engineers, they will use their skills to design technologies. Ask:
   - **What do you think the word "technology" means?**
3. Tell youths they will investigate technology, and the goal of the first activity is to be the first team to correctly identify 10 technologies.
4. Split the group into two teams, and give each team an answer card. Explain you will read an item from the *Is it Technology?* list. Teams will have 15 seconds to make a decision, and they will hold up the Y if they think it is a technology and N if they think it is not.
5. If a team is correct, you will give the team a point. If a group is incorrect, they score nothing. They are aiming for 10 points.
6. Start the game, writing the correct answer on the *What's What* chart when all teams have given their answers.
7. When a team reaches 10 points, stop the game. Tell youths that engineers are people who design technologies. Have teams consider the *What's What* chart. Ask:
   - **What do you think the technologies have in common?** *People designed them, they make things easier, they solve problems.*
   - **What do you think the items that are NOT technologies have in common?** *They are natural. People did not design them.*
   - **Do you think the towers we engineered are technologies? Why or why not?** *Yes, because we designed them to solve a problem!*
8. Tell youths that, as engineers, they will do lots of designing and improving of technologies during this unit.
9. Write the definition of technology on the board for youths to reference during the rest of the activity: ***Technology is anything that is human made that solves a problem or fulfills a need.***

Technologies Solving Problems (15 min)

1. Split youths into groups of 2 or 3. Explain that they will focus on the problems technologies solve and the needs they meet.
2. Hold up a small box/container and ask:
   - **What problem does this container solve?** *It holds small*

objects, etc.

3. Tell groups that they will have ten minutes to come up with as many technologies they can think of that solve certain problems. Review the problem categories on p. 3 of the Engineering Notebooks.
4. Start the timer, letting youths know when time is almost up.
5. Have groups share out how many items they came up with and name a few items from each of their categories.

Improving Technologies (20 min)

1. Explain that now that youths have a definition and understanding of technology, they are ready to consider technologies from an engineer's perspective. Many engineers *improve* existing technologies. They need to determine the problem with the technology and figure out how to *improve* it.
2. Have youths pair up and turn to p. 4 of their Engineering Notebooks. Explain that groups will have 10 minutes to *imagine* how to *improve* a technology in the room. Then the whole group will do a gallery walk to see the improvements.
3. To make sure youths understand, hold up a pencil. Ask:
   - **What is a problem with this pencil?** *It could be easier to hold.*
   - **How could this pencil be *improved*?** *Make a place to hold it.*
4. Have pairs choose a simple, low-tech technology they see in the room and begin. Let youths know when there are 10, 5, and 2 minutes left.
5. When all groups are done, have pairs do a gallery walk to all the different notebooks to see the different designs.
6. Once all groups have seen the designs, ask:
   - **Can you think of other ways to *improve* these technologies?** *Encourage all answers.*
   - **Why do you think engineers come up with many designs?** *So they can see how many different ideas they can come up with, they can pick the design they think would work best, etc.*

Tip: Pairs may want to discuss the problems and possible improvements for their technology, and each come up with an individual design. Engineers may do this to see all the possible ideas that they can come up with.

Reflect (10 min)

1. Have the group summarize what they learned. Ask:
   - **After doing this activity, what would you tell others about technology? Who designs technologies?**
2. If youth do not mention some of the following, underscore the following important points:
   - Technology is anything human-made that solves a problem or fulfills a need.
   - Engineers are people who create or improve technologies.
3. Have youth fill out their *Engineer Profile,* p. 5, and reflect on engineering skills they feel are easy for them, and any engineering skills they would like to work on throughout the unit. Giving youths time to fill out an *Engineer Profile* will help reinforce the idea that they are engineers and guide them to reflect on themselves as engineers.

Tip: Pay attention to the skills youths identify with and what they would like to work on. This can help you track youths' growth and place them into groups that will help them learn.

Technologies at Work

Read the items in the order given in order to play the game.

Item	Is it a Technology?
computer	yes
camera	yes
paper cup	yes
turtle shell	no
pencil	yes
spider web	no
television	yes
wind-up toy	yes
tying a shoe	yes
tree	no
bird	no
dog food	yes
lightning	no
play ground	yes
piano	yes
hiccup	no
flashlight	yes
toenail	no
blanket	yes
chair	yes

Note about technology:
We define technology as anything designed by humans to solve a problem or meet a need. Technologies can be objects, systems, or processes. Tying your shoe is a process, with distinct steps that go in a certain order. For some youths, just focusing on objects is a good place to start, but once comfortable, incorporating processes as examples can really expand the definition of technology.

This definition can get complicated around the edges. For example, if a human uses a rock to solve a problem, like creating an arrowhead, is the rock considered a technology? Yes, because the human designed a new use for the rock. If a crow uses a stick as a tool, is that tool considered a technology? That depends. The stick may solve a problem for the crow, but can we prove that the crow designed the tool?

If these questions arise in your group, congratulate everyone for thinking so deeply about technology! Engineers debate these questions all of the time. It is up to youths to decide what stance they would like to take and to justify their decision.

Activity

1 The Pollution Solution

Educator Preview

Overview: Youths will be introduced to the problem they will be working to solve: how can we keep polluted runoff out of a river?

Note to Educator: Engineers are people who design and *improve* technologies in order to solve problems or meet needs in their communities, such as preventing pollution from contaminating local waterways. Be sure to save the *City Pollution Chart* and the model city for use in Activities 4, 5, and 6.

Activity Timing:

Identify:	20 min
City Planning:	10 min
Pollutants:	5 min
Polluting:	10 min
Reflect:	5 min
	50 min

21st Century Skill Highlight:

Critical thinking

Activity 1 Materials

For the whole group

- ☐ *Engineering Everywhere Special Report* DVD, or the link below, and a computer to play it on
- ☐ Model city (see preparation below)
- ☐ 1 bag of plastic sequins
- ☐ 1 box of food coloring
- ☐ 1 cardboard sheet
- ☐ 1 container of dish soap
- ☐ 1 container of sprinkles
- ☐ 1 permanent marker
- ☐ 1 roll of aluminum foil
- ☐ 1 roll of duct tape
- ☐ 1 spray bottle
- ☐ 1 tray, foil, 10” x 18” x 3”
- ☐ 2 cups, 3 oz.
- ☐ 3 boxes, 4.5” x 3.25” x 2.5”

For each youth

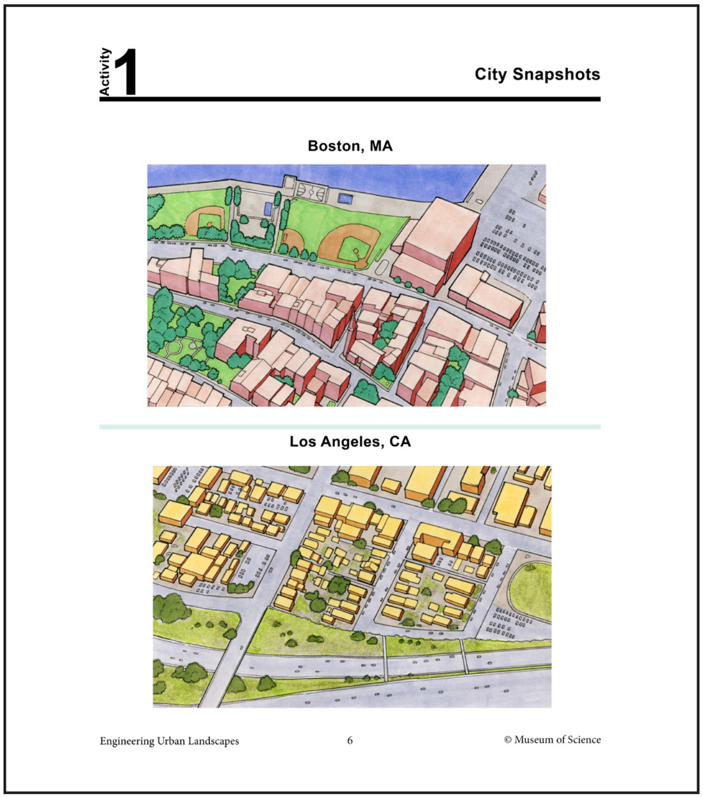
- ☐ Engineering Notebook

Activity 1 Preparation (15 min)

1. Have the *Special Report* (10:13) video ready to play. You can also access it from http://www.eie.org/engineering-everywhere/curriculum-units/dont-runoff
2. Post the Engineering Design Process poster.
3. Make the model city, and set it up. See directions in this guide, pp. 17-19.
4. Prepare a *City Pollution Chart* as shown on the next page.
5. Fill the spray bottle with water.

Notebook Pages for Activity 1

City Snapshots, p. 6



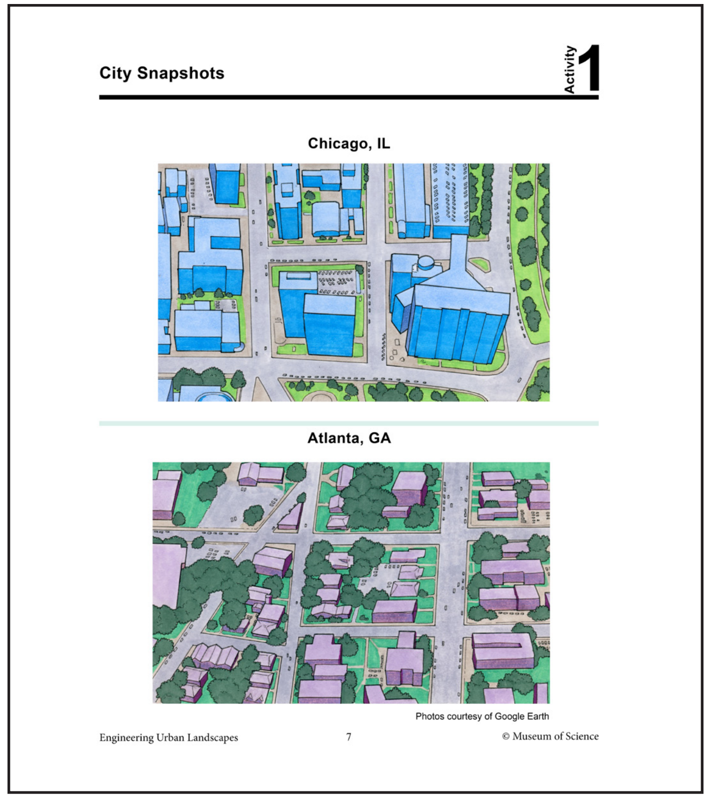
Activity 1 City Snapshots

Boston, MA

Los Angeles, CA

Engineering Urban Landscapes 6 © Museum of Science

City Snapshots, p. 7



City Snapshots Activity 1

Chicago, IL

Atlanta, GA

Photos courtesy of Google Earth

Engineering Urban Landscapes 7 © Museum of Science

Charts for Activity 1

City Pollution Chart

City Pollution Chart			
Item	Pollutant	Location in City	Amount

Youths will understand:
- engineers design technologies.
- their main challenge in this unit is to design technologies to help prevent runoff in a model city.

Identify the Problem (20 min)

1. Tell youths that today they will *identify* and start *investigating* their challenge.
2. Explain that for the rest of the unit they will work as groups of environmental engineers to create technologies to solve a problem. The problem is connected to pollution and runoff, and it affects people living everywhere in the world. Ask:
   - **What comes to mind when you hear the word pollution?** *Encourage all answers.*
   - **Have you heard the term runoff? What do you think it means?** *For now, accept all answers.*
3. Show everyone the Engineering Design Process. Ask:
   - **As engineers, what step do you think we should use first in order to solve the problem?** Identify *the problem.*
4. Tell everyone you have a Special Report video that will give them more information about their challenge. As youths watch the video, they should consider how runoff affects everyone in the world.
5. Play *Engineering Everywhere Special Report* (10:13): http://www.eie.org/engineering-everywhere/curriculum-units/dont-runoff
6. After, to check for understanding, ask:
   - **How did the video describe storm water runoff?** *Water from rain that runs across driveways and roads and eventually goes into rivers and oceans.*
   - **What are some technologies environmental engineers have designed to help reduce pollutants in runoff?** *Porous pavers, trenches, vegetated swales, storm water planters.*
   - **What are some advantages of running a pilot program?** *You can try a new project and monitor the results to make sure it has the desired effects, you can use successes and failures from other pilot programs to decide what to try next.*
   - **While this report focuses on the Charles River in Boston, how might this issue affect everyone living in the world?** *Everyone needs clean water; dirty runoff pollutes water that we drink and affects the ecosystem.*
7. Tell youths they will get the chance to engineer technologies to help solve this problem throughout the unit.

Tip: Some of the technologies are described as follows:

porous pavers: cover walkways with space between the pavers so that water can be absorbed into the ground but the surface is still easy to walk over.

trenches: filled with gravel and sandy soil so that water can easily flow into the ground.

vegetated swales: designed to carry water slowly and allow water to filter through plants into the ground.

Tip: If youths are unfamiliar with models, tell them models represent something else; either an object, part of an object, or system.

Tip: Other possible pollutants groups could chose to represent include plastics, chemicals, or animal waste.

City Planning (10 min)

1. Show youths the model city that will help them identify problems caused by polluted runoff. Explain that as environmental engineers, they will use an established city model, since many cities need to reduce runoff in an already existing set up.
2. Today they will be using one model as a whole group. Ask:
   - **What do you notice about the surface of this model?** *It is foil, and it is smooth.*
   - **How does this surface contribute to the runoff problem?** *All of the water runs off of it; no water can soak in.*
3. Have youths look at the images on *City Snapshots,* pp. 6-7 in their Engineering Notebooks. Ask:
   - **What do you notice about the surfaces of these cities?** *They are mostly paved, and smooth with little green space.*
   - **How do you think these paved surfaces are similar to the foil in our model?** *All of the water runs off of it; no water can soak in.*

Introducing the Pollutants (5 min)

1. Ask youths if they remember any of the pollutants from the video or if they have seen any pollutants in real life.
2. Show everyone the model pollutants they will use in their city model: food coloring, dish soap, sprinkles, and plastic sequins.
3. Divide everyone into four Pollution Research Groups and assign each group one of the items.
4. Give each group a few minutes to think about which real-life pollutants their item could best represent. For example, the plastic sequins might represent plastic bags or they might represent discarded food.

Pollute the City (10 min)

1. Gather youths around the city model and invite each Pollution Research Groups to share their item. Ask:
   - **What pollutant(s) does your item represent?**
   - **Where might you find these pollutants in this city?**
   - **How much of the material should we use to represent the pollutant in each spot of the city?**
2. Write responses on the *City Pollution Chart*. Tell groups that the placement and amount of pollutants decided on today will be what is used as they test their own city models in later activities.
3. As each group presents, have them add their pollutant to the model by sprinkling an amount they've decided on (we recommend about 1-3 tablespoons) over the city or placing it in areas of the city where they would expect to find that particular type of pollutant.
4. Once everyone has added their pollutant, tell them they are going to spray water over the city to see what happens during a rainstorm.
5. Place the model city into the foil tray, leaning on two cups (it will fit at

a tilt). Tell everyone the foil tray represents a river of clean water that flows near to the city. Ask:

- **What do you predict will happen? Why do you think so?**

6. Have volunteers take turns spraying a steady rain onto the city for 30 seconds. Ask:
   - **What do you notice?** *The water is running over the surface of the city. It is picking up pollutants and carrying them into the river, making the river water dirty.*
7. Tell youths that the water they see running over the surface of the city is runoff. Ask:
   - **How do you think this runoff might affect the model city?** *It pollutes the river, so it might harm the plants and animals in the river, it could affect the people who use the river for water or recreation.*

Reflect (5 min)

1. Tell youths they are going to work together to engineer an urban landscape made of buildings, roads, and open spaces that will keep polluted runoff out of the clean river. Ask:
   - **What step of the Engineering Design Process did we use today to get us started solving this problem?** Identify *and* investigate.
2. Encourage youths to look for examples of runoff reducing technologies around their program site, school, and homes.

Tip: To clean up, wipe down the model with a paper towel. The polluted water can be strained through a paper towel or strainer and then rinsed down the sink.

Activity 1 Making the Model City

Step 1

- Cover one side of the cardboard with foil. You will need about 12” of foil for this.
- Attach the foil on the back side of the cardboard with duct tape.

Step 2

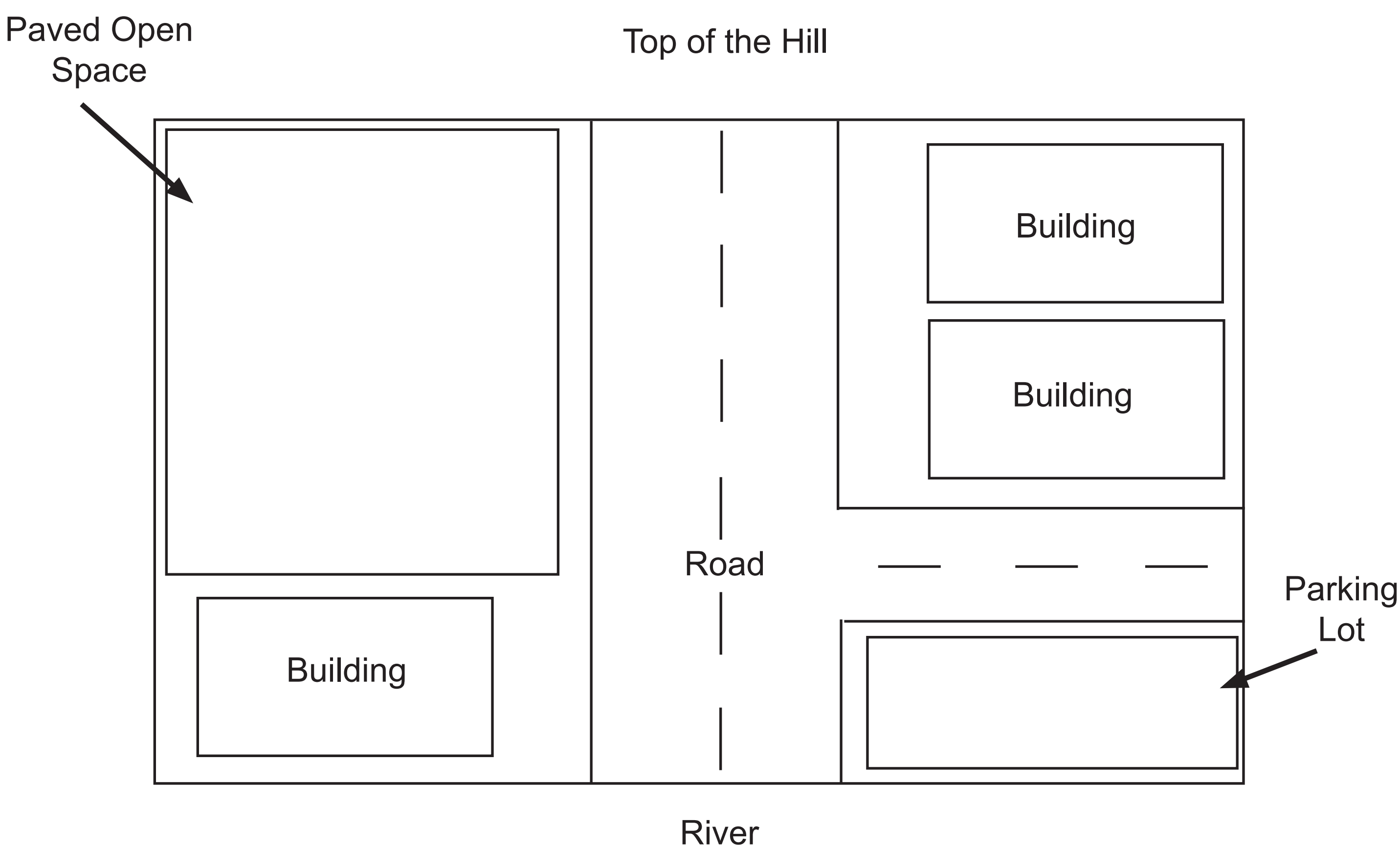
- Cover the boxes (buildings) with foil.
- Try to keep the top and sides smooth. It is okay if the bottom is uneven.

Top

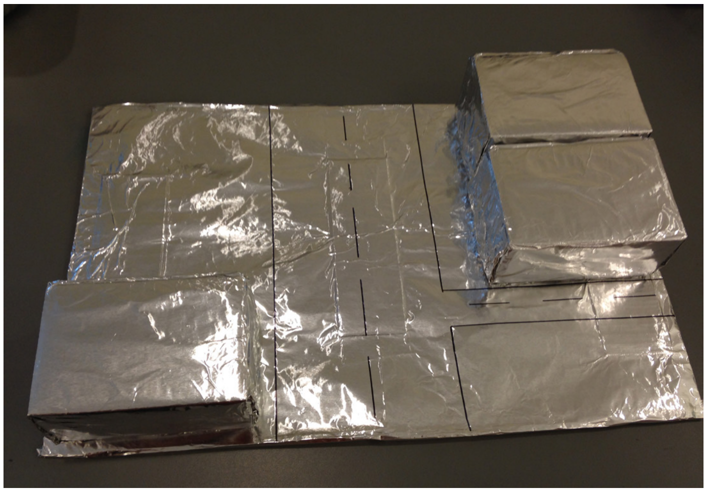
Bottom

Step 3

- Attach the buildings onto the board with duct tape in the spots shown below.
- Use a permanent marker to draw in the road, parking lots, and sidewalk.



Activity 1 Setting Up the Model City



Set up the city model, as described on p. 17.

Cut an 8” piece of aluminum foil in half.
Cover two cups with each piece of foil.
Place the cups near the middle of the foil tray.

Lean the city model on the edge of the foil tray and on the two cups.
Fill the foil tray with 1/2” of water.

Activity 2 Green Possibilities

Educator Preview

Overview: Youths create their own green roofs and investigate the properties of natural materials.

Note to Educator: Although pollutants are always somewhat harmful, it is possible to reduce the harm by spreading certain pollutants out over a large area and allowing them to soak into the soil. Some natural materials in soil can break down specific pollutants, making them less harmful to the environment than if the pollutants travelled directly into bodies of water where they become concentrated and more dangerous.

Activity Timing:

Intro:	5 min
Activity:	35 min
Reflect:	10 min
	50 min

21st Century Skill Highlight:

Critical thinking
Creativity

Activity 2 Materials

For the whole group

- ☐ Engineering Design Process poster
- ☐ *Green Roofs* video clip and a device that will play it
- ☐ 1 container of gravel
- ☐ 1 container of potting soil
- ☐ 1 container of sand
- ☐ 1 container of sphagnum moss
- ☐ 1 roll of paper towels (for clean up)
- ☐ 1 spray bottle
- ☐ 4 measuring cups, 1 cup

For each group of 3-5

- ☐ 1 foil tray, size
- ☐ 1 foot of foil
- ☐ 1 roll of tape
- ☐ 40 index cards

For each youth

- ☐ Engineering Notebook

Activity 2 Preparation (15 min)

1. Post the Engineering Design Process poster.
2. Have *Green Roofs* (2:34): http://tinyurl.com/7famxtv ready to play. If you do not have access to a computer, there is a corresponding article in youth's Engineering Notebooks.
3. Have water available.

Notebook Pages for Activity 2

Green Roofs Article, p. 8

Activity 2 — **Green Roofs Article**

Green Roofs
Ingenuity sprouting from the rooftops

The rooftops of Manhattan are as varied as the city itself. A glance at the city skyline reveals a myriad of shapes and colors. Look a little closer and the shapes reveal themselves to be the things we often see rooted on Manhattan buildings, such as water towers, ventilation systems and communications equipment. But, on a few rooftops, something else is taking root--literally.

"It's a roof with a continuous layer of living plants, and it's a new form of urban vegetation," says Columbia University climate scientist Stuart Gaffin. He's talking about a green roof just like the one he is standing on at the corner of Amsterdam and 118th street in Manhattan.


Photo courtesy of NSF

A green roof is not something you can just have installed on top of your house. The features are mainly for structures with flat roofs, such as office or apartment buildings. A green roof protects the building just like a normal roof, except instead of tar or metal, it is topped off with materials for drainage and a mineral substrate that's lighter than soil and supports plant growth. It is always bottomed with a waterproof membrane to prevent leaking. The cost can run from as little as $5 per square foot to more than $50, depending on the selection of materials and vegetation.

With help from the National Science Foundation (NSF), Gaffin and his two partners, Columbia University civil engineer Patricia Culligan and Lamot-Doherty Earth Observatory geochemist Wade McGillis, are researching what benefits green roofs might have on harsh urban environments. Their initial data suggests the answer is--quite a bit.


Photo courtesy of NSF

Culligan, the project's leader, is working in the lab to make green roofs even greener. She and her students are experimenting with new growing materials, which they test in a special terrarium that emulates weather conditions, such as sunlight and rainfall.

Besides the view, there are important advantages.

"You can start with temperature," Gaffin explains. "Plants are geniuses at staying cool in strong

Engineering Urban Landscapes 8 © Museum of Science

Green Roofs Article, cont., p. 9

Green Roofs Article — Activity 2

sunlight. The temperature differences on a black roof versus a green roof are astonishing." Gaffin points out that he's recorded rooftop temperatures as high as 180 degrees on black top roofs, "and that doesn't have to be during a heat wave," he adds. But on a green roof, "the plants are about the same temperature as the air."

"Water is another very important issue," he continues. "We have acid rain and water quality problems with our rain and rainwater." Work by the research team indicates that green roofs act almost like filters. "We've seen acid rain reduction and we've seen pollutants removed," he says.

Cities have also been struggling with the problem of water runoff from even the most minor of rain storms. "When we get a typical rainfall, we get a wave of water from all these buildings, sidewalks and streets hitting our municipal sewer system, which can't handle it, and so it actually triggers pollution events in our rivers," explains Gaffin. But the research team's data show that after some rainfall events, the green roofs under study were absorbing most, if not all, of the water that fell on them. "Now that's an astonishing thing because the standard roof has 100 percent runoff. Some green roofs, however, have no runoff. Imagine a zero runoff roof," he says.

Water and temperature are just the first two items on the list. The green roofs in this research have also shown that they can help reduce noise pollution and contribute to biodiversity. "When I get on these roofs in the summertime, they become oases of biological activity, including honey bees, butterflies and other things," Gaffin says. "We've restored endangered grasslands that used to be common in the New York region that are all but gone... these systems, as living systems do wonderful things," he adds.


Photo courtesy of NSF

While the initial data seems to support green roofs as beneficial to urban environments, both Gaffin and Culligan point out that research needs to continue so they can more accurately quantify the benefits. If green roofs are as beneficial to urban areas as these scientists and engineers hope, they may end up literally "shouting from the rooftops!"

Miles O'Brien, Science Nation Correspondent
Jon Baime, Science Nation Producer
Courtesy: National Science Foundation

Engineering Urban Landscapes 9 © Museum of Science

Green Roofs, p. 10

Activity 2 — **Green Roof**

Plan your green roof. What materials will you use? How will you use them?

Reflect: What worked well? Did certain materials absorb more water than others?

Engineering Urban Landscapes 10 © Museum of Science

Think About It, p. 11

Think About It — Activity 2

Think about a city you have been to before. Where did you notice natural materials being used?

Think back to the Special Report video, and the runoff reducing technologies you have seen in your area. How can you use natural materials in the city model to reduce runoff?

Engineering Urban Landscapes 11 © Museum of Science

Activity 2 Green Possibilities

Youths will understand:

- the properties of natural materials can help reduce runoff.
- green roofs are a technology they can use in their model city.

Tip: Sphagnum moss is pronounced: sfag-numb.

Introduce the Challenge (5 min)

1. Ask youths if anyone noticed runoff reducing technologies since the last activity. Encourage youths to share what they observed.
2. Tell youths that today they will be exploring natural materials to help reduce runoff. Remind youths that their job is to engineer an urban landscape that can keep polluted runoff out of the river. Ask:
   - **What happened to the pollutants on the model city when we created a rainstorm last time?** *They went into the river.*
   - **What does the foil on the city model represent?** *Pavement.*
   - **If we were to replace paved surfaces with a different material, what material would you choose and why?** *Accept all responses.*
3. Tell youths that some natural materials can break down pollutants, making them less harmful to the environment than if the pollutants traveled directly into bodies of water.
4. Explain that today groups will engineer towers with green roofs. Ask:
   - **What do you know about green roofs, or what do you think they are?** *Encourage all answers.*
5. To show what other engineers in the field are doing, play *Green Roofs,* or have youths read the article in their Engineering Notebooks, pp. 8-9.
6. To check for understanding, ask:
   - **How does green roof technology help reduce runoff?** *They have absorbent materials on top and a water repelling material underneath. Water absorbs into the roof instead of running over pavement and collecting pollution.*
7. Tell the group that they will get the chance to engineer a model building with a green roof that reduces runoff.

Engineering Green Roofs (35 min)

1. Explain that this challenge comes in two parts:
   - engineer a model building at least nine inches high
   - engineer a roof for the building that reduces runoff by absorbing water
2. Show youths the materials they can use in their green roof: gravel, potting soil, sand, and sphagnum moss. Ask:
   - **How might these materials help reduce runoff?** *They might absorb the water, like a sponge.*

3. For the building, each group may use 40 index cards, 1 foot of foil, and a roll of tape.
4. Have groups turn back to their Engineering Notebook, p. 2, and review their notes from their tower designs. Explain that today they will be engineering towers that are 9 inches high. Ask:
   - **What worked well last time you engineered a tower?**
5. Explain that to test, groups will add one cup of water to their rooftop and check to make sure it is all absorbed (none runs off). The building also needs to support the weight of the saturated green roof.
6. Tell groups they should build and test their building in a foil tray, to catch any potential runoff or contain their model if it collapses.
7. Split youths into groups of 3-4 and give groups five minutes to plan using p. 10 in their Notebooks. Once teams have a plan, they can get their supplies and start building.
8. As groups are working, circulate to each group and ask questions like:
   - **What types of materials are you using? Are they working like you thought they would?**
   - **What is working well about your design?**
   - **What is not working well?**
9. When there are five minutes left, have groups test their green roofs by adding 1 cup of water.

Reflect (10 min)

1. Invite groups to share their designs. Encourage them to share what materials they chose, why they chose them, and their results. Ask:
   - **Which natural material do you think works best to reduce runoff? Why do you think so?** *Encourage groups to use data from their investigation to help them support their response.*
2. Revisit *City Snapshots.* Ask:
   - **What do you think the impact would be of adding green roofs to all the buildings you see?** *Encourage all answers.*
3. Show everyone the Engineering Design Process poster. Ask:
   - **What step of the Engineering Design Process do you think we used today?** Investigate *and* imagine*.*
4. Let everyone know that next time, they will continue using the *investigate* step of the Engineering Design Process to explore ways to *improve* pavement so that it can help reduce runoff.
5. Give youths a few minutes to add notes to *Think About It*, p. 11 in their notebooks. Remind groups that they can use these ideas as they start working with their model cities.
6. As youths finish, have them clean up their green roofs and replace any materials that can be reused next time.

Activity 3 Passing Through

Educator Preview

Overview: Youths investigate permeable pavement technology by designing permeable pavement to meet certain criteria.

Note to Educator: Permeable pavement refers to any paved surface that allows water to pass through it. Permeable pavement is engineered so that water can be absorbed into the soil beneath, where organisms and plants can help filter pollutants. There are many different types of permeable pavement, ranging from brick roads and tiled walkways to specially-processed cement that can be used on regular roads.

Activity Timing:

Intro:	5 min
Challenge:	10 min
Investigate:	25 min
Communicate:	10 min
City Example:	10 min
	60 min

21st Century Skill Highlight:

Creativity

Activity 3 Materials

For the whole group

- ☐ Engineering Design Process poster
- ☐ 1 yard of cheesecloth
- ☐ 1 yard of screen
- ☐ 2 wind up walking toys
- ☐ 4 rolls of foil
- ☐ 4 spray bottles
- ☐ 20 craft foam sheets
- ☐ 20 sponges
- ☐ 25 felt sheets
- ☐ 50 cups, 8 oz.
- ☐ 100 cotton balls
- ☐ 500 paperclips

For each group of 3-5

- ☐ 1 large foil tray, 10” x 18” x 3”
- ☐ 1 foil tray, 5” x 1.25” x 7.5”
- ☐ 1 pair of scissors
- ☐ 1 ruler

For each youth

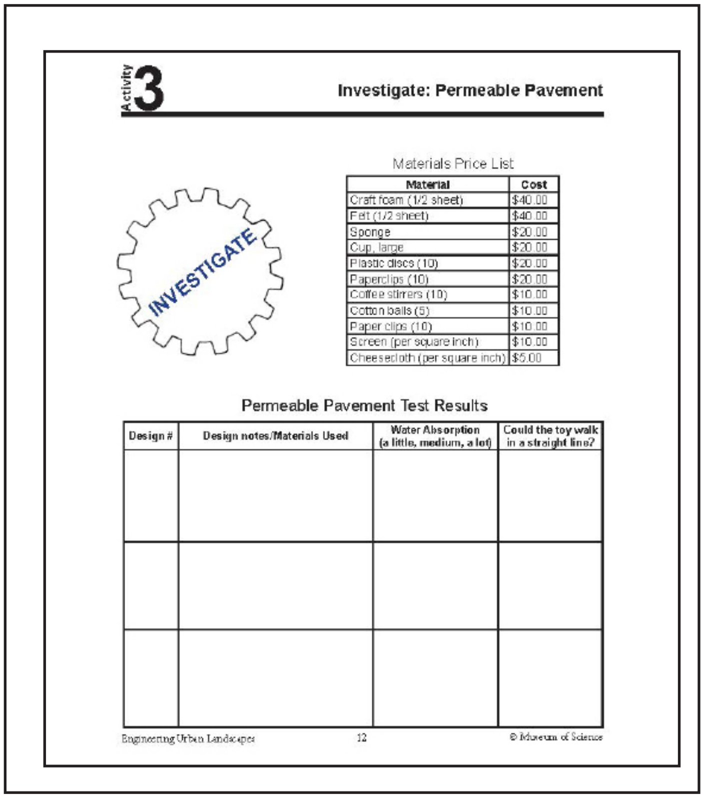
- ☐ Engineering Notebook

Activity 3 Preparation (15 min)

1. Post the Engineering Design Process poster.
2. Have *Green City, Clean Waters* (2:07): http://tinyurl.com/2fxjqeo ready to play.
3. Prepare the *Criteria and Constraints Chart* as shown on the next page.
4. Set up an Investigation Station with the materials above.
5. Fill the spray bottles with water.

Notebook Pages for Activity 3

Investigate: Permeable Pavement, p. 12



Activity 3

Investigate: Permeable Pavement

Materials Price List

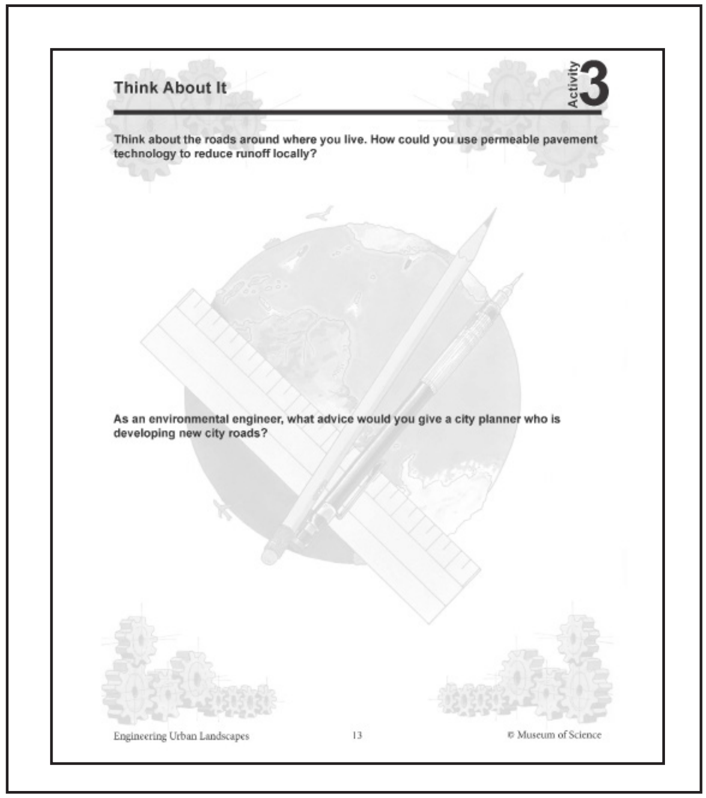
Material	Cost
Craft foam (1/2 sheet)	$40.00
Felt (1/2 sheet)	$40.00
Sponge	$20.00
Cup, large	$20.00
Plastic discs (10)	$20.00
Paperclips (10)	$20.00
Coffee stirrers (10)	$10.00
Cotton balls (5)	$10.00
Paper clips (10)	$10.00
Screen (per square inch)	$10.00
Cheesecloth (per square inch)	$5.00

Permeable Pavement Test Results

Design #	Design notes/Materials Used	Water Absorption (a little, medium, a lot)	Could the toy walk in a straight line?

Engineering Urban Landscapes 12 © Museum of Science

Think About It, p. 13



Think About It

Activity 3

Think about the roads around where you live. How could you use permeable pavement technology to reduce runoff locally?

As an environmental engineer, what advice would you give a city planner who is developing new city roads?

Engineering Urban Landscapes 13 © Museum of Science

Chart for Activity 3

Criteria and Constraints Chart	
Criteria	**Constraints**
The pavement must absorb water.	You have a budget of $200.00
The pavement must be smooth enough for people to use for walking and driving.	

Passing Through

Youths will understand:
- they can use the *investigate* step of the Engineering Design Process to explore how permeable pavement can absorb water and help reduce runoff.
- it is important to think about both criteria and constraints when engineering a technology.

Explanation of the Permeable Pavement Criteria:
1. **The pavement must absorb water.** *The more water it absorbs or lets through into the ground, the less water runs off.*
2. **The pavement must be smooth enough for people to use for walking and driving.** *People still need to be able to use the pavement for safe walking, biking, and driving.*

Set the Stage (5 min)

1. To review, ask:
   - **What is the environmental engineering problem we are trying to solve?** *We need to keep polluted runoff from entering the river in our model city.*
   - **What did we *investigate* last time?** *We* investigated *green roofs and how natural materials might absorb water and reduce runoff.*
2. Tell youths that today they are going to use the *investigate* step of the Engineering Design Process to *investigate* a technology called permeable pavement. Ask:
   - **Why is it useful to have paved areas in cities?** *It is hard, flat, and smooth so people can walk, bike, and drive on it.*
   - **How do paved areas add to the runoff problem?** *The water runs off paved surfaces; it does not sink in.*
3. Remind youths that in the Special Report video, Kate Bowditch said you need to balance nature and the needs of people. An example of this was permeable pavement. It is a type of pavement that is engineered to let water pass through, so the water can be absorbed by the ground underneath.

Present the Challenge (10 min)

1. Post the *Criteria and Constraints Chart*. You may want to remind youths that criteria are requirements, while constraints are limitations.
2. For each item, ask:
   - **Why do you think this criterion is important?** *See the sidebar for possible responses.*
   - **How do you think the cost constraint will affect your work?** *We have to balance how well a material works with cost.*
3. Show youths a small foil tray. Tell them that today they will use the tray to hold their pavement.
4. Show youths the paving materials they can use. Have them turn to *Investigate: Permeable Pavement*, p. 12 in their notebooks to find the price list of all of the materials.
5. Tell groups they can lay the paving materials in their foil tray however they would like to try to meet all of the criteria and constraints.
6. Review the testing procedure. To test, groups should:

Note: Groups will have to share the wind-up toys!

- Place the small foil tray into the large foil tray to catch extra water.
- Test the usability of the pavement by seeing whether a wind-up toy can walk on their pavement in a straight line.
- Spray the pavement with 20 squirts of water.
- Wait 20 seconds. Record how well the water soaks in.

Investigate (25 min)

1. Split everyone into Investigation Groups of 3-5.
2. Give groups 25 minutes to investigate permeable pavement and test their designs. As groups work, check in and ask:
   - **What step of the Engineering Design Process are you using right now? How do you know?**
   - **How well does your permeable pavement design meet the criteria on the chart?**
3. Let groups know when they have 10 minutes left, 5 minutes left, etc.

Communicate (10 min)

1. Tell teams it is time for them to share their work with everyone else!
2. Have each group share. Ask questions like:
   - **Which materials did you use? How well did they absorb?**
3. Gather youths around the Engineering Design Process poster. Ask:
   - **How did you use the steps of the Engineering Design Process to guide your work?**
   - **How can we, as environmental engineers, use what we learned in our investigations to keep polluted runoff out of the river?** *We can make the roads and other paved areas more absorbent so that less water runs off. We can put in permeable pavement and replace some paved areas with natural materials.*
4. Revisit *City Snapshots.* Ask:
   - **What do you think the impact would be of changing the pavement with permeable pavement?** *Encourage all answers.*
5. Give youths a few minutes to record their ideas on *Think About It*, p, 13 in their Notebooks. Groups will be able to refer to their notes when they are engineering their urban landscape.
6. Tell everyone that next time, they will continue using the Engineering Design Process to *imagine, plan, create*, and *test* technologies to keep polluted runoff out of the river of Cement City.

Real Life Runoff: Philadelphia (10 min)

Tip: To reuse the gravel for later activities, rinse it and leave it out to dry. The sand, potting soil, and moss can be left out to dry as well, as long as they are exposed to circulating air.

1. Explain to youths that cities all over the world are dealing with issues connected to runoff. Philadelphia is one city that has come up with a project called Green City, Clean Waters. The project is a 25-year plan to reduce polluted runoff and protect their watershed.
2. Show youths the *Green City, Clean Waters* video (2:07)*:* http://tinyurl.com/2fxjqeo. After, ask what they noticed about the technologies used in this effort. Let youths know they will discuss this project in later activities.

Activity 4 Creating an Urban Landscape

Educator Preview

Overview: Youths work in engineering teams to *plan, create*, and *test* a solution to their environmental engineering challenge of preventing storm runoff.

Note to Educator: Be sure to save the designs groups engineer for the next activity. You may want to have the model Cement City from Activity 1 available for groups to reference as they make their model cities. In the next activity, you may want groups to continue using their own city models, or combine the best of their ideas and make one city model. Let youths know which option you chose early in this activity.

Activity Timing:

Introduction:	5 min
Make Models:	20 min
Plan:	15 min
Create/Test:	15 min
Reflect:	5 min
	60 min

21st Century Skill Highlight:

Creativity

Activity 4 Materials

For the whole group

- ☐ Engineering Design Process poster
- ☐ *City Pollution Chart* from Activity 1
- ☐ 1 container of gravel
- ☐ 1 container of potting soil
- ☐ 1 container of sand
- ☐ 1 container of sphagnum moss
- ☐ 1 container of dish soap
- ☐ 1 pack of food coloring
- ☐ 1 container of sprinkles
- ☐ 1 paper towel roll
- ☐ 1 yard of cheesecloth
- ☐ 1 yard of screen
- ☐ 2 wind up walking toys
- ☐ 4 permanent markers
- ☐ 4 rolls of duct tape
- ☐ 4 rolls of foil
- ☐ 4 spray bottles
- ☐ 20 craft foam
- ☐ 20 sheets of chipboard
- ☐ 20 sponges
- ☐ 25 felt
- ☐ 50 craft sticks
- ☐ 50 cups, 8 oz.
- ☐ 100 cotton balls
- ☐ 100 straws
- ☐ 400 index cards
- ☐ 500 bingo chips
- ☐ 500 coffee stirrers
- ☐ 500 paperclips
- ☐ 500 sequins

For each group of 3-5

- ☐ 1 foil tray
- ☐ 1 pair of scissors
- ☐ 1 roll of masking tape
- ☐ 1 ruler
- ☐ 11” x 17” cardboard sheet
- ☐ 2 cups, 3 oz.
- ☐ 3 boxes, 4.5” x 3.25” x 2.5”

For each youth

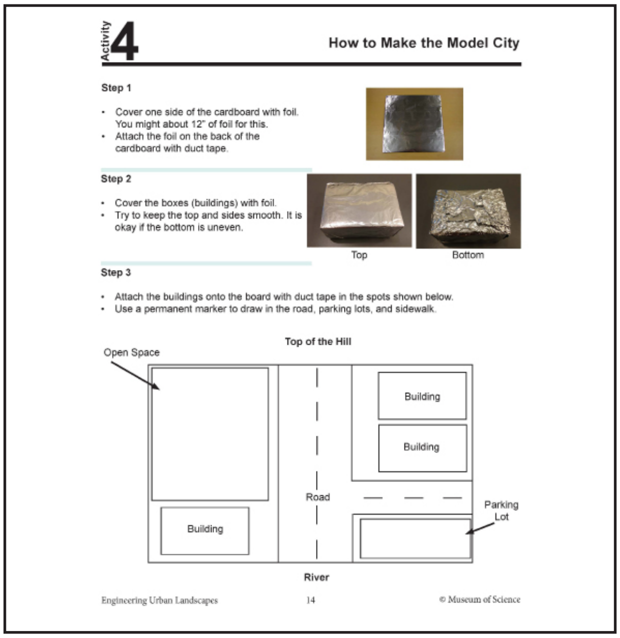
- ☐ Engineering Notebook

Activity 4 Preparation (15 min)

1. Post the Engineering Design Process poster.
2. Have *Green Water Infrastructure Tools* page ready to review. You can access it from http://tinyurl.com/lpqpx4f. If the class will not have access to the page, print some examples of the technology for youths to look at. You may also want to bring youths around the site to see what runoff reducing technologies they can find.
3. Set up a Materials Store with the materials listed.
4. Fill the spray bottles with water.
5. Fill each group's foil tray with 1/2" of water.

Notebook Pages for Activity 4

How to Make the Model City, p. 14



Activity 4 How to Make the Model City

Step 1

- Cover one side of the cardboard with foil. You might about 12" of foil for this.
- Attach the foil on the back of the cardboard with duct tape.

Step 2

- Cover the boxes (buildings) with foil.
- Try to keep the top and sides smooth. It is okay if the bottom is uneven.

Top Bottom

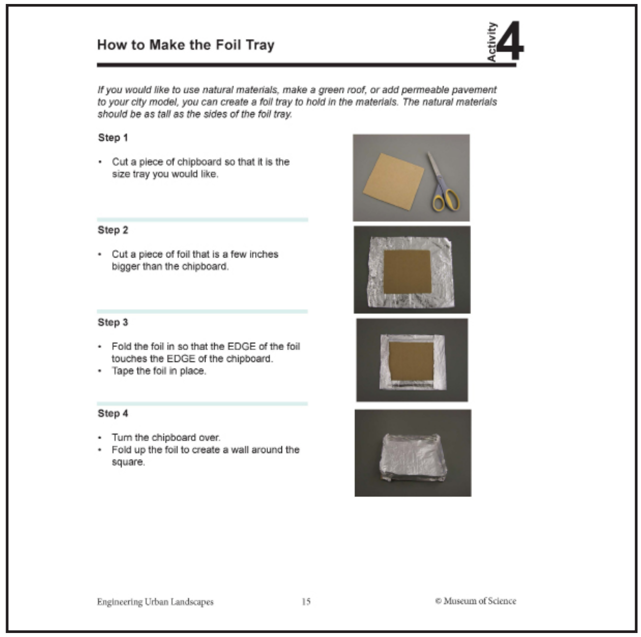
Step 3

- Attach the buildings onto the board with duct tape in the spots shown below.
- Use a permanent marker to draw in the road, parking lots, and sidewalk.

Top of the Hill
Open Space
Building
Building
Road
Parking Lot
Building
River

Engineering Urban Landscapes 14 © Museum of Science

How to Make the Foil Tray, p. 15



How to Make the Foil Tray Activity 4

If you would like to use natural materials, make a green roof, or add permeable pavement to your city model, you can create a foil tray to hold in the materials. The natural materials should be as tall as the sides of the foil tray.

Step 1

- Cut a piece of chipboard so that it is the size tray you would like.

Step 2

- Cut a piece of foil that is a few inches bigger than the chipboard.

Step 3

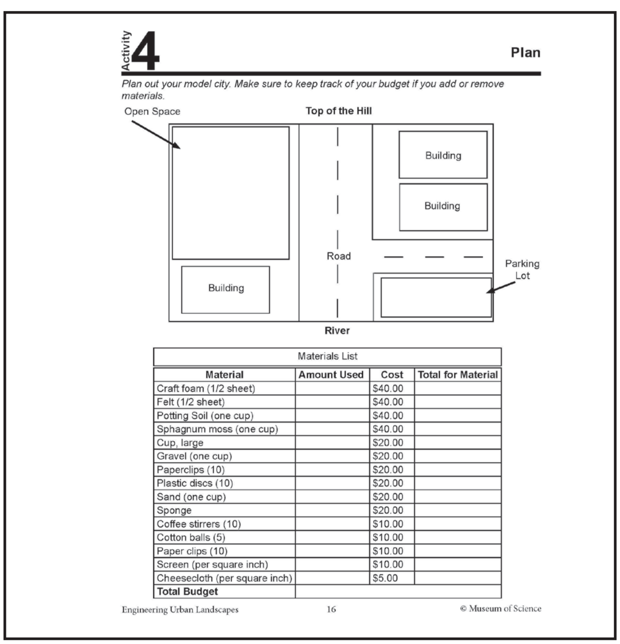
- Fold the foil in so that the EDGE of the foil touches the EDGE of the chipboard.
- Tape the foil in place.

Step 4

- Turn the chipboard over.
- Fold up the foil to create a wall around the square.

Engineering Urban Landscapes 15 © Museum of Science

Plan, p. 16



Activity 4 Plan

Plan out your model city. Make sure to keep track of your budget if you add or remove materials.

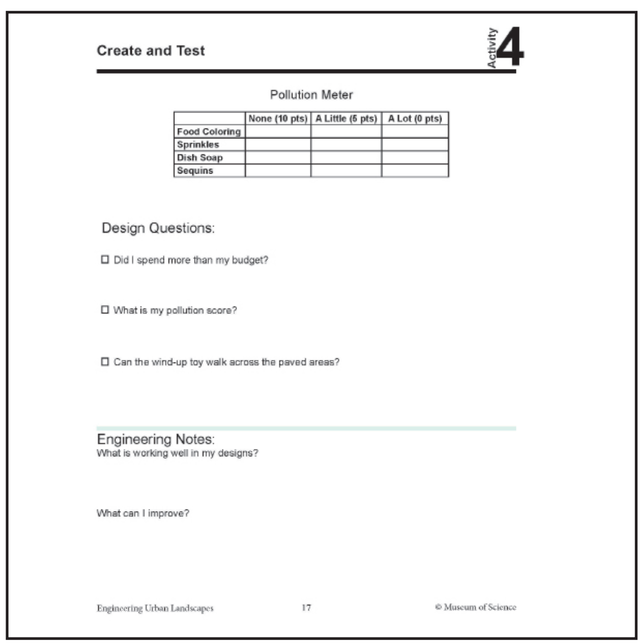
Open Space
Top of the Hill
Building
Building
Road
Parking Lot
Building
River

Materials List

Material	Amount Used	Cost	Total for Material
Craft foam (1/2 sheet)		$40.00	
Felt (1/2 sheet)		$40.00	
Potting Soil (one cup)		$40.00	
Sphagnum moss (one cup)		$40.00	
Cup, large		$20.00	
Gravel (one cup)		$20.00	
Paperclips (10)		$20.00	
Plastic discs (10)		$20.00	
Sand (one cup)		$20.00	
Sponge		$20.00	
Coffee stirrers (10)		$10.00	
Cotton balls (5)		$10.00	
Paper clips (10)		$10.00	
Screen (per square inch)		$10.00	
Cheesecloth (per square inch)		$5.00	
Total Budget			

Engineering Urban Landscapes 16 © Museum of Science

Create and Test, p. 17



Create and Test Activity 4

Pollution Meter

	None (10 pts)	A Little (5 pts)	A Lot (0 pts)
Food Coloring			
Sprinkles			
Dish Soap			
Sequins			

Design Questions:

☐ Did I spend more than my budget?

☐ What is my pollution score?

☐ Can the wind-up toy walk across the paved areas?

Engineering Notes:
What is working well in my designs?

What can I improve?

Engineering Urban Landscapes 17 © Museum of Science

Activity 4 Creating an Urban Landscape

Youths will understand:

- they can use the *plan, create*, and *test* steps of the Engineering Design Process to help them solve problems.
- spending time developing a plan can help them effectively balance criteria and constraints in their designs.

Tip: As a reminder of what models are and why they are useful, you may want to ask youths why they think they will be using models to test instead of a real city. Models are smaller and can be simplified, you can control more variables, etc.

Set the Stage (5 min)

1. Congratulate youths on their investigations so far! They've used the *investigate* step of the Engineering Design Process to find out lots of information about how to reduce urban runoff. Ask:
   - **Who/what is affected by runoff?** *Rivers and bodies of water become polluted and that can impact the people, animals, and plants that use the water.*
2. Tell youths that groups will work on two projects today. First, each group will create their model city. Then, they will work to engineer different ways to prevent runoff in their city.
3. Remind groups that their city model will be on a hill (the board is tilted into the large foil tray) and the river is at the bottom of the hill (represented by the large foil tray). They will prop the model on two small cups to make sure the city is not sitting directly in the river.
4. Have youths share what they have already *investigated* in previous activities to help reduce polluted runoff. They may talk about how natural materials can absorb pollutants and slow down water, or technologies that can reduce runoff, such as green roofs, permeable pavement, swales, and storm water planters.

Making the Model City (20 min)

1. Have youths split into groups of 3-5.
2. Explain that as environmental engineers, they are trying to reduce runoff in an existing city. Have groups turn to p. 14 in their Notebooks to see the city plan for which they will create a model.
3. Tell groups they have 20 minutes to create their models.
4. As groups build, check in and assist with any difficulties. Remind groups that they want the foil to be as smooth as possible on the top and sides of the buildings.

Investigate and Plan for the City (15 min)

1. Once all groups have created their base model, tell everyone that they will use the Imagine, Plan, Create, and Test steps of the Engineering Design Process to engineer solutions to reduce runoff in their model city. Ask:
   - **What are some of the technologies we have explored that might help us?** *Green roofs, permeable pavement, adding more*

plants, etc.

2. Explain that, as engineers, they will need to submit a plan before they can get their materials and start their tests.
3. Before they *plan* with their groups, they are going to quickly revisit Philadelphia's *Green City, Clean Waters* project. Remind youths that in the Special Report, Kate Bowditch explained it was important to see what others are doing.
4. Show youths the *Green Water Infrastructure Tools* page. If there are multiple computers, encourage small groups to look at the overview page and see if there are any additional technologies they want to use in their model city. They may want to see what they can find about runoff reducing technologies in other cities as well.
5. Have youths turn to *Plan*, p. 16 in their Notebooks. Point out the Price List on that page and let teams know they have a budget of $500 to reduce runoff in their model city.
6. Let groups know if they want to make permeable pavement or a green roof, they will need to set it in a tray. There are directions for how to make a foil tray in their Engineering Notebooks, p. 15.
7. Give groups a few minutes to Plan. Encourage groups to use data from their Engineering Notebooks to help them decide on materials and keep track of their budget.

Tip: As an alternative to looking at the *Green City, Clean Waters* website, you may want to bring youths on a quick tour of the program site to see what runoff reducing technologies they can find.

Tip: Let groups know that they can place materials in a foil unit and then attach the units to the model city, or create barriers with materials, such as straws or craft sticks.

Tip: You may want to have groups present their *plan* for approval before collecting their materials.

Create and Test (15 min)

1. Tell groups they will have 15 minutes to create and test their design. Have groups look at the *Pollution Meter,* p. 17 of their Engineering Notebooks. They will use this meter to help them evaluate the success of their designs.
2. Remind groups that in Activity 1, each Pollution Research Group decided which pollutant their material represented, and where it was likely to be found in the city. They will use this to pollute each model city.
3. When groups are ready to test, they should place each pollutant on their model following the amount and location they decided on and recorded on the *City Pollution Chart*.
4. Tell groups they can use *Create and Test*, p. 17 in their Notebooks to keep track of their designs.
5. As groups *create* and *test*, ask questions like:
    - **Can you tell me about the parts of your design?**
    - **What parts are working well? What parts are not working so well?**
    - **How are you keeping track of your work so you can share your ideas later?**
6. Let groups know when there are 10 min left, 5 min left, etc. Encourage groups to take the last few minutes to record their work in their Engineering Notebooks, if they have not been doing so already.

Clean Up and Reflect (5 min)

1. Gather everyone around the Engineering Design Process poster. Have youths think about which steps of the process they used today, and in what order.
2. Have a few volunteers share their process. Ask:
   - **In what similar ways did everyone use this process?**
   - **In what ways did use of the process differ?**
3. Enlist everyone's help in cleaning up the space. Groups should keep their designs intact so they can *improve* them later, but everything else can be cleaned up and materials returned to the Materials Store. Let groups know they may have to remake parts of their model in the next activity.
4. Give youths a few minutes to consider how they would like to *improve* their technology next time on *Create and Test*, p. 17. If the group will make one city model in the next activity, have the whole group discuss which technologies they think worked best when placed in a particular part of the city model.

Tip: To clean up, wipe down the model with a paper towel. The polluted water can be strained through a paper towel or strainer and then rinsed down the sink.

Tip: To reuse the gravel for later activities, rinse it and leave it out to dry. The sand, potting soil, and moss can be left out to dry as well, as long as they are exposed to circulating air.

Activity 5 Improving an Urban Landscape

Educator Preview

Overview: Groups will *improve* their designs to better meet the criteria.

Note to Educator: Be sure to save the designs groups engineer for the Engineering Showcase in Activity 6. If you would like to have the whole group make one city model, start by reviewing the technologies that groups felt worked best to reduce runoff in the previous activity. The whole group should decide how they want to incorporate these technologies into one design.

Activity Timing:

Intro:	5 min
Plan:	15 min
Improve:	30 min
Communicate:	10 min
	60 min

21st Century Skill Highlight:

Collaboration

Activity 5 Materials

For the whole group

- ☐ Engineering Design Process poster
- ☐ *City Pollution Chart* from Prep Activity 2
- ☐ *Engineering Showcase Invitation*, this guide, p. 39
- ☐ 1 container of gravel
- ☐ 1 container of potting soil
- ☐ 1 container of sand
- ☐ 1 container of sphagnum moss
- ☐ 1 container of dish soap
- ☐ 1 pack of food coloring
- ☐ 1 container of sprinkles
- ☐ 1 paper towel roll
- ☐ 1 yard of cheesecloth
- ☐ 1 yard of screen
- ☐ 2 wind up walking toys
- ☐ 4 permanent markers
- ☐ 4 rolls of duct tape
- ☐ 4 rolls of foil
- ☐ 4 spray bottles
- ☐ 20 chipboard sheets
- ☐ 20 craft foam sheets
- ☐ 20 sponges
- ☐ 25 felt sheets
- ☐ 50 craft sticks
- ☐ 50 cups, 8 oz.
- ☐ 100 cotton balls
- ☐ 100 straws
- ☐ 400 index cards
- ☐ 500 bingo chips
- ☐ 500 coffee stirrers
- ☐ 500 paperclips
- ☐ 500 sequins

For each group of 3-5

- ☐ city model from Activity 4
- ☐ 1 foil tray
- ☐ 1 pair of scissors
- ☐ 1 roll of masking tape
- ☐ 1 rubber ducky
- ☐ 1 ruler
- ☐ 1 stack of sticky notes
- ☐ 2 cups, 3 oz.

For each youth

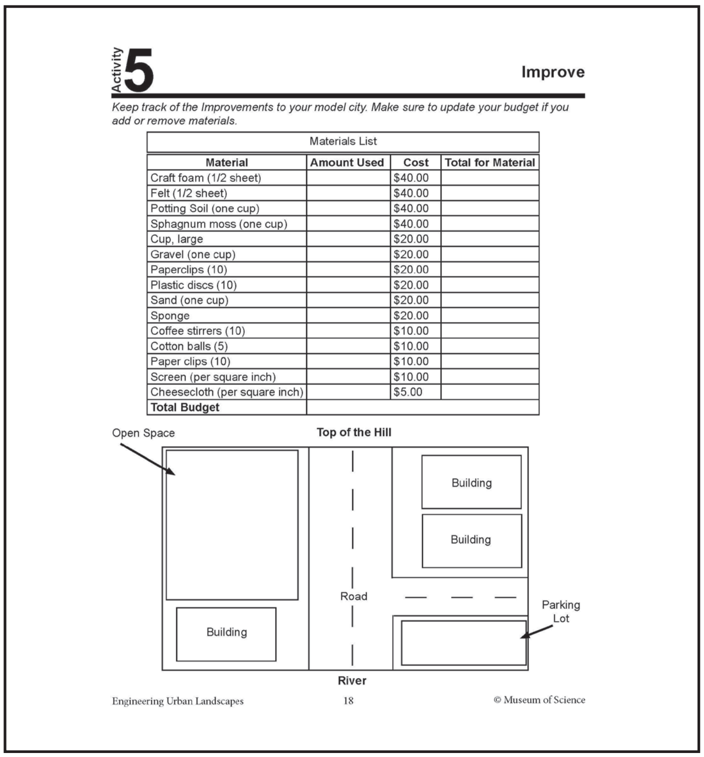
- ☐ Engineering Notebook

Activity 5 Preparation (15 min)

1. Post the Engineering Design Process poster.
2. Have each team's model city available.
3. Set up a Materials Store with the materials listed.
4. Fill the spray bottles with water.
5. Fill each group's foil tray with 1/2" of water.
6. Post the *City Pollution Chart* from Activity 4.
7. Copy the *Engineering Showcase Invitation* for youths to take home.

Notebook Pages for Activity 5

Improve, p. 18



Activity 5 Improve

Keep track of the Improvements to your model city. Make sure to update your budget if you add or remove materials.

Materials List			
Material	Amount Used	Cost	Total for Material
Craft foam (1/2 sheet)		$40.00	
Felt (1/2 sheet)		$40.00	
Potting Soil (one cup)		$40.00	
Sphagnum moss (one cup)		$40.00	
Cup, large		$20.00	
Gravel (one cup)		$20.00	
Paperclips (10)		$20.00	
Plastic discs (10)		$20.00	
Sand (one cup)		$20.00	
Sponge		$20.00	
Coffee stirrers (10)		$10.00	
Cotton balls (5)		$10.00	
Paper clips (10)		$10.00	
Screen (per square inch)		$10.00	
Cheesecloth (per square inch)		$5.00	
Total Budget			

Engineering Urban Landscapes 18 © Museum of Science

The Engineering Design Process, p. 21

Identify
Understand the engineering problem.
Define the problem in your own words.

Investigate
Gather details.
Learn about what others have done.
Explore possible materials or processes you could use for your design.
Conduct science experiments to gather data.

Imagine
Come up with different ways to solve the problem.
Use your creativity to think of lots of ideas that could work.
Evaluate the pros and cons of each idea.
Pick one idea that is a good starting point.

Plan
Figure out the details of your design.
Discuss how it will work.
Draw diagrams and list materials.
Decide how you will test and evaluate.

Create
Build your design.
Follow your plan.
Fix small problems.
Record any changes to your plan.

Test
Evaluate how well your design works.
Test multiple times.
Record your observations and findings.
Figure out which parts are working well and which parts are not.

Improve
Make changes to your design based on testing.
Decide what to change.
Put your changes into a new plan.
Build your improved design and test again.

Communicate
Share your solution with others.
Explain strengths and weaknesses of your solution.
Share how you used the Engineering Design Process.
Ask people for feedback.

Engineering Urban Landscapes 21 © Museum of Science

Chart for Activity 5

City Pollution Chart (from Activity 4)

City Pollution Chart			
Item	Pollutant	Location in City	Amount

Improving an Urban Landscape

Youths will understand:

- they can use the *improve* step of the Engineering Design Process to adjust their designs.
- they can practice using the *communicate* step and *improve* how they talk about their work.

Set the Stage (5 min)

1. Have youths sit in their engineering groups. Explain that they will have 30 minutes to focus on *improving* their designs from last time. Ask:
   - **What worked well in your design last time?**
   - **What are some things that you plan to *improve* today?** *Encourage other groups to share ideas about how groups that are struggling could* improve *their designs.*
   - **Were there any ideas from the Philadelphia project or other runoff reducing technologies you have seen around you that you are incorporating into your design?**
2. Tell groups that they can choose to add two additional elements to their testing during the Showcase: oil (as an additional pollutant) and animals in the river (in the form of a duck). Ask:
   - **Why do you think it might be important to add animals to the river in our model?** *It is realistic since there are animals in the river, we can see whether the pollutants reach the animals, etc.*
   - **Where do you think you would find oil in the city model? How much oil should be used when testing?** *Encourage youths to determine the placement of oil, and how much to add (you may want to suggest 4-5 drops or a teaspoon). This can be added to the City Pollution Chart.*
3. Remind groups that the next step of the Engineering Design Process is *communicate*. As part of the Engineering Showcase, they will do the final *test* of their design, and share their designs.
4. Stress the importance of keeping track of their improvements. Ask:
   - **How do you think keeping track of your work can help you *communicate* about what you have done?**

Tip: If there is computer access and youths would like to review more information about the Philadelphia *Green City, Clean Waters* project, encourage them to do some research. They may want to research other cities' efforts to reduce runoff as well.

Plan (15 min)

1. Encourage groups to look through their Engineering Notebooks and find one idea they think will help them as they *improve* their designs.
2. Give groups 10 minutes to *plan* their improvements, and remake any part of their city that was ruined from the last time they tested. They may need to remake some foil trays, barriers, or wipe down the foil. Groups may also want to replace the piece of foil on the cardboard,

drawing the roads and reattaching the buildings.

Improve (30 min)

1. Tell groups they have 30 minutes to improve the runoff solutions they engineered.
2. Groups should keep track of their work on *Improve*, p. 18 in their notebooks, and update their budget as they change materials.
3. While groups improve, ask questions like:
   - **Can you tell me about your design?**
   - **What did you change from last time?**
   - **What parts are working well? What parts need improvement?**
   - **How are you keeping track of your work so you can share your ideas with the group later?**

Communicate (10 min)

1. Encourage a few groups share their work. Ask:
   - **How did you *improve* your model today?**
1. Have youths think about the oil and duck they can incorporate into their city model when they *test* at the Showcase. Ask:
   - **Do you think your technologies will stop the oil from reaching the river?**
   - **How do you think oil and other pollutants will affect the duck and other animals in the river? How will it affect the people in the city?**
2. Remind everyone that during the Engineering Showcase, teams will need to use the Communicate step of the Engineering Design Process to share their work with others. They will also do the final test of their designs. Ask:
   - **Why do you think it is important to *communicate* your engineering work to others?** *Accept all responses. Guide youths to recognize that by sharing their work, they are educating their community and inspiring others to solve problems.*
3. Tell groups they are going to use the Engineering Design Process as a tool to help them organize their presentation. Have groups take a look at p. 21 of their Engineering Notebooks as a reminder of the steps of the Engineering Design Process.
4. Pass out a set of sticky notes to each group.
5. Give groups 5-10 minutes to write down how they used each step of the Engineering Design Process on a sticky note.
6. When groups are done, have them post their sticky notes on the Engineering Design Process poster next to the appropriate steps.
7. Review the group's findings. Ask:
   - **What step did was used the most? Why do you think so?**
   - **How did everyone use the steps in a similar way?**
8. Hand out invitations to the showcase to staff members, other youths in the program, or to families.

You're Invited...

ENGINEERING Showcase

Where:

When:

What:

Come support your local engineers as they share their environmental engineering work!

Activity 6 Engineering Showcase

Educator Preview

Overview: Youths host an Engineering Showcase to share their engineering work with each other and with visitors.

Note to Educator: The Engineering Showcase is a chance for youths to share all of the engineering work they have done. You may want to set up the Showcase so that youths can invite their peers, families, and other guests.

Activity Timing:

Intro:	5 min
Prepare:	20 min
Showcase:	20 min
Reflect:	10 min
	55 min

21st Century Skill Highlight:

Communication

Activity 6 Materials

For the whole group

- ☐ Engineering Design Process poster
- ☐ leftover materials from Activity 4 and 5, in case groups need to replace any part of their design
- ☐ 1 container of vegetable oil, 1 cup
- ☐ 2 wind up walking toys
- ☐ 4 spray bottles

For each group of 3-5

- ☐ city model from Activity 5
- ☐ 1 pair of scissors
- ☐ 1 rubber ducky
- ☐ 1 ruler
- ☐ 1 foil tray

For each youth

- ☐ Engineering Notebook

Activity 6 Preparation (10 min)

1. Post the Engineering Design Process poster.
2. Fill the spray bottles with water.
3. Have the remaining materials available for easy pick up by each group.

Notebook Pages for Activity 6

Improve Results, p. 19

Improve Results Activity 6

Pollution Meter

	None (10 pts)	A Little (5 pts)	A Lot (0 pts)
Food Coloring			
Sprinkles			
Dish Soap			
Sequins			
Oil			

Design Questions:

☐ Did I spend more than my budget?

☐ What is my pollution score?

☐ Can the wind-up toy walk across the paved areas?

Engineering Notes:
Which improvements worked well?

Which improvements did not work so well?

IMPROVE

Engineering Urban Landscapes 19 © Museum of Science

Engineering Profile, p. 20

Activity 6 **Engineering Profile**

Think about how you have changed as an engineer, and update your engineering profile.

☐ **Communication**
- I give valuable feedback to others
- I like giving presentations

☐ **Creativity**
- I imagine lots of ideas
- I come up with new ways of doing something

☐ **Critical Thinking**
- I solve problems
- I make sense of complicated information

☐ **Leadership**
- I lead teams well
- I make sure everyone has a voice

☐ **Persistence**
- I learn from failure
- I keep trying until I succeed

☐ **Teamwork**
- I work well in teams
- I like giving and receiving feedback on my work.

☐ **Technical Skills**
- I make things
- I like working with different materials

Which skills have you **used**?	Which skills have you **learned**?

Engineering Urban Landscapes 20 © Museum of Science

Engineering Showcase

Youths will understand:

- *communicating* their ideas to fellow engineers and to guests gives their work meaning and value in the community
- they are engineers!

Set the Stage (5 min)

1. Remind everyone that today is the Engineering Showcase, where they will share their engineering work with each other and visitors.
2. Ask:
   - **What are some ideas you had about how to successfully *communicate* your work?**
3. Record all ideas on a piece of chart paper to use as a reference.
4. Tell groups they will have 20 minutes to prepare for the Engineering Showcase. Request that one youth prepares to explain the engineering challenge to the visitors when they arrive.
5. Remind groups that they will need to decide whether they would like to add oil as a pollutant in their city model.

Prepare (20 min)

1. Allow groups to gather any materials they would like to use as part of their presentations. Remind groups that as part of their presentation, they will be testing their final design.
2. If youths are looking for things to do, encourage them to create visuals for their team, or practice asking and answering questions about their work.

Engineering Showcase (20 min)

1. As visitors come in, have them do a gallery walk of the model cities before sitting for the presentations.
2. Have a volunteer explain the engineering challenge to the visitors.
3. Give each group a few minutes to share their design and *test*. As groups are *testing,* ask questions like:
   - **What are some things you *investigated* to help you solve this problem?**
   - **What technologies did you use in the model city to reduce runoff?**
   - **What did you test that worked really well or really poorly?**
   - **What is working well about your model?**
   - **What other technologies could you incorporate to further *improve* your model city?**
   - **How did the Engineering Design Process help you reach this final model design?**

- **What do you like most about engineering?**

4. After all groups have presented, allow visitors to walk around to the model cities and ask the environmental engineers any additional questions they have about the design.

Reflect (10 min)

1. Gather everyone in a circle and congratulate everyone on their engineering work!
2. Point out the *Improve Results,* p. 19 in the Engineering Notebook. Ask groups to take a few minutes to record the results from their final test. Remind youths that there is always room for improvement, and encourage them to think about what they would do if they had more time with the challenge.
3. Give youths a few minutes to complete the *Engineering Profile*, p. 20. Have youths revisit the *Engineering Profiles,* p. 5, to reflect on how they have grown as engineers.
4. Go around in a circle and have everyone share their responses to these questions:
    - **What are you most proud of doing as part of this engineering group?**
    - **What is something from this engineering group that you'll always remember?**
    - **Why do you consider yourself an engineer?**

Ready, S.E.T., Go! Team Problem Solving Worksheet

Director ____________ Administrator ____________ Technician _____________ Logistics _____________

Blueprints and Answers to Questions may be completed on attached paper.

PROBLEM Define in your own words the problem you need to solve.

Conditions: Make a list of requirements that the solution must include.

Constraints: Identify anything that might limit a solution, such as cost, availability of materials, safety.

PLAN Research the topic to better understand the problem. Write your questions and answers here.	Draw on your knowledge to brainstorm possible solutions. List some of them here then Identify the design you selected List the reasons you selected this design:

CREATE

Make a detailed sketch of selected design. Label with dimensions and materials needed to build a model.

List the materials actually used to construct the model. Include cost of materials and total cost if a budget was required.

Write a detailed procedure for building the model or prototype.

Lesson Contributed by: Theresa Guthrie

Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

EXPERIMENT

Write a **hypothesis** about your design's performance during testing.

Describe your method of testing to see if your model solves your problem.

Data Table of Results and Other Observations:

Analysis

• Describe the strengths of your design.

• Describe the weaknesses of your design.

• What changes, or compromises, in your design (if any) had to be made due to constraints.

• Decide if your design solved the problem identified in Step 1.

IMPROVE Based on the results of your tests, identify the changes that you would make. Give reasons for the changes.

COMMUNICATE Present your findings to your teammates for feedback.
Organize your findings in a poster, digital collage, PowerPoint, or short video documentary.

REFLECTION:

Describe how your team's solution solves the problem.

Challenge Specific Questions: How does your design compare to those of your teammates.
What green roof materials seem to absorb water best?

Which permeable pavement materials reduce runoff the most? …the least?

Which pollutant seemed most difficult to keep from running off into the river?

As an environmental engineer, what advice would you give a city planner who is developing new city roads and buildings? (Be persuasive!)

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Save the Bay Robotic Device Challenge

The Chesapeake Bay Foundation's *2014 State of the Bay* report presents a mix of good and bad news.
The great news: Water quality indicator scores have improved significantly over the 2010 and 2008 scores. The worrisome news: Blue crabs and striped bass are not doing well. The declines in these metrics and in the phosphorus indicator offset the improvements in water quality. Overall, the 2014 score is unchanged from 2012.
We can celebrate the water-quality improvements. However, the Bay and its rivers and streams still constitute a system dangerously out of balance. We continue to have polluted water, risks to human health, and lost jobs—at huge societal costs. The future is just around the corner; 2017—the year when 60 percent of programs to achieve the Chesapeake Clean Water Blueprint pollution reduction targets are to be in place— is in our sights.
We must accelerate pollution reduction, particularly from agriculture. Runoff from farm fields remains the largest source of pollution to the Bay and its rivers and streams. Ironically, this pollution is the least expensive to reduce and has the most generous federal and state cost-share funding available.
In some jurisdictions, polluted runoff from urban and suburban areas is the only source of pollution continuing to grow. Investments in reducing this source of pollution must be increased as well.
The Clean Water Blueprint is working so far, but there are danger signs ahead. States must expedite required implementation of agricultural and urban pollution reduction. If they do not, EPA must impose sanctions.

Problem - The EPA is requiring everyone in the Chesapeake Bay watershed to be responsible stewards by reducing their negative impact on the Bay. Localities must enforce penalties on homeowners and businesses if pollutants are found in the bay as a result of local activity.

Scenario –

Yorktown has entrusted the Chesapeake Bay Foundation (CBF) to assist in efforts to monitor negative bay activity. The CBF are looking to promote the purchase of devices that can monitor and clean-up pollutants from local properties. These devices will be sold to homeowners and businesses throughout the county. Environmental engineering companies must develop a device that is *effective* in monitoring pollutants, offers some *clean-up* capabilities, can be *placed* in areas of properties where run-off is likely to carry pollutants, and is *affordable* for the average citizen.

Roles -

Project Manager: collect materials used for the project, monitor design criteria & the timeline.
Publicity: put together a presentation for the group's final product group presentation to CBF.
Design Engineer: lead programmer and prototype tester of the group's model.
Construction Engineer: lead builder and prototype tester of the group's model.

Resources -

- Equipment can be purchased from the EPA warehouse.
- You may use "other" materials with approval and pricing agreement.

Assessment -

You will be presenting your Save the Bay device to the Chesapeake Bay Foundation on _______. You will need a "working" model to show them that is has at least 3 "functions" that will assist with monitoring and clean up of pollutants that could enter the Bay. You must prove your team has followed the Engineering Design Process and met the EPA's expectations of an *efficient* and *economical* device.

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Save the Bay Device Materials Cost per item

Item	Cost	Quantity	Total Cost
Hot Glue Gun Stick	$100		
Popsicle Stick	$50		
Construction Paper	$25		
Pipe Cleaners	$30		
Clamps	$20		
Paper clips	$5		
Foam Sheets	$50		
Pvc pipe/fittings	$75		
String/Wire (1 foot)	$30		
Tape (1 foot)	$25		
Zip Tie	$35		
Brads (x2)	$50		
Mesh shelf liner by approx. square foot	100		
Cardboard by approx. square foot	$200		
Servo	$1000		
Motor	$1500		
Vibration Motor	$500		
LED	$100		
TriColored LED	$150		
Sensor (any)	$500		
Other			
		Total	

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Save the Bay Device Rubric

Team Name:

Rating/ Criteria	Excellent: 10 points	Very Good: 9 points	Satisfactory: 7 or 8 points	Needs Improvement - 6 points or less	Total
Building Costs	-Building costs were accurately presented - also included the “product waste”	-The costs were accurate and presented.	-Only part of the cost was calculated and presented.	-Little or No calculations were presented.	X 1
Three Functions	-The device has three functions/ purposes.	-The device has two functions/purposes	-The device has one function/purpose	-The device has no clear function/purpose	X 1
Simulation/ Exhibition	- Three functions were modeled with minimal human interaction	- Three functions were modeled with human assistance.	- Two functions were modeled	- Only one function was modeled.	X 1
Programming	- Programming was done successfully with use of loops and conditional scripts	-Programming was done successfully in Scratch or Visual Programmer.	-Programming had minor errors in sequencing.	-There was little to no successful programming.	X 1
Delivery	- Captured the audience with eye contact and clear voice -well- prepared	-Good eye contact -Prepared fluid delivery -Good voice	-Little eye contact - Somewhat prepared -Choppy delivery - Hard to hear and follow	-No eye contact -Unprepared -Very poor delivery -Very difficult to hear and follow	X 1
Content	The presentation explained in convincing and scientific detail how the device will protect the bay.	- The presentation accurately explained how the device will protect the bay.	-There was a presentation, but they only provided part of what the EPA/CBF needed to know.	-There was little to no complete presentation.	X 1
Engineering Design Process	Clear problem; plan is sketched and executed; Improvements made; results	Problem is apparent but not clearly identified. or Plan is minimal; or improvements	Problem is apparent but not identified. Plan is minimal; improvements not	Problem is not identified or communicated; product does not follow a clear plan	X1

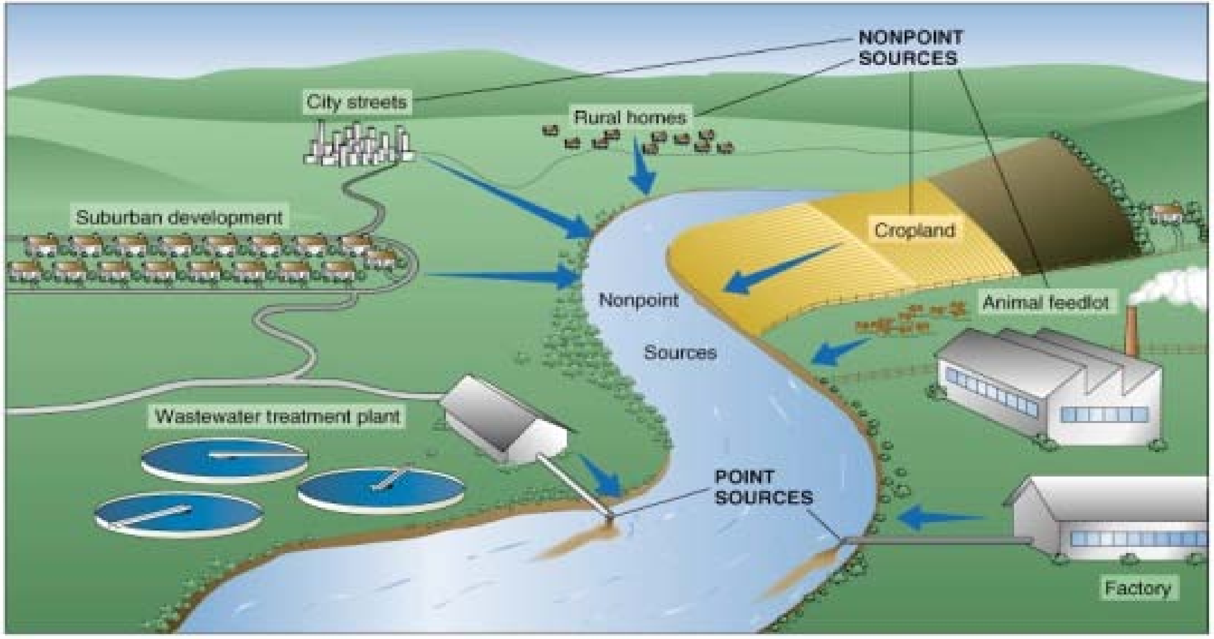
Lesson Contributed by: Theresa Guthrie

Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

	communicated	not identified	identified		
Teamwork	-Clear evidence of teamwork and equal division of labor. -Tasks have been distributed within the group -Assigned tasks performed by each member.	-Adequate evidence of teamwork and fairly good division of labor -Tasks have been distributed within the group -Assigned tasks performed by most of the members.	-Some evidence of teamwork and some division of labor. -Most of the work was done by 1 person.	-Little evidence of teamwork and division of labor. -Only 1 person did all of the work.	X 1
Member Contribution Name/ Role:	Your member contribution is exceptional. You completed your tasks and encouraged contributions from others.	Your member contribution is adequate. You completed all tasks as expected.	Your member contribution is minimal. You did not complete your tasks.	Your member contribution is not apparent.	**X 2**
1.					
2.					
3.					
4.					
Total					

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Save the Bay



LESSON CONTRIBUTED BY: THERESA GUTHRIE

FUNDED THROUGH A 2015 STATE COUNCIL OF HIGHER EDUCATION FOR VIRGINIA (SCHEV) GRANT, PISTEM II.

Day 26:

Chesapeake Bay

Objectives:

Examine cause and effect of surface Run-off

Journal Reflection:

How can city planners prevent pollutants from getting into the rivers?

Today:

- City solutions 10 min video
- Learn about the causes and consequences of 4 types of water pollution. Gizmo on ipads and worksheet in pairs.
  - 1st page individual notes
  - 2nd page Activity B - 1 per pair – turn in
- Return the Coral Reef Gizmo to complete in pairs and turn in for grade.

Quiz: Environmental Engineering Tuesday 5/3

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Day 27:

Objectives:
Describe factors affecting the health of a watershed
Use the Engineering Design Process to identify a problem, brainstorm solutions, and develop a plan to reduce pollutants in the Chesapeake Bay.

Chesapeake Bay

Journal Reflection:
What is a watershed?

Today:

- **What are the problems/solutions?**
  - Chesapeake Bay health indicators
  - State of the Bay Report Expert
  - CBIB
  - What is stormwater runoff
- **Environmental Engineer as career**
  Urban Landscape Design Challenge
  Green Roof
  Permeable pavement
- **Quiz review**

Quiz: Tuesday 5/3
Environmental Engineering

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

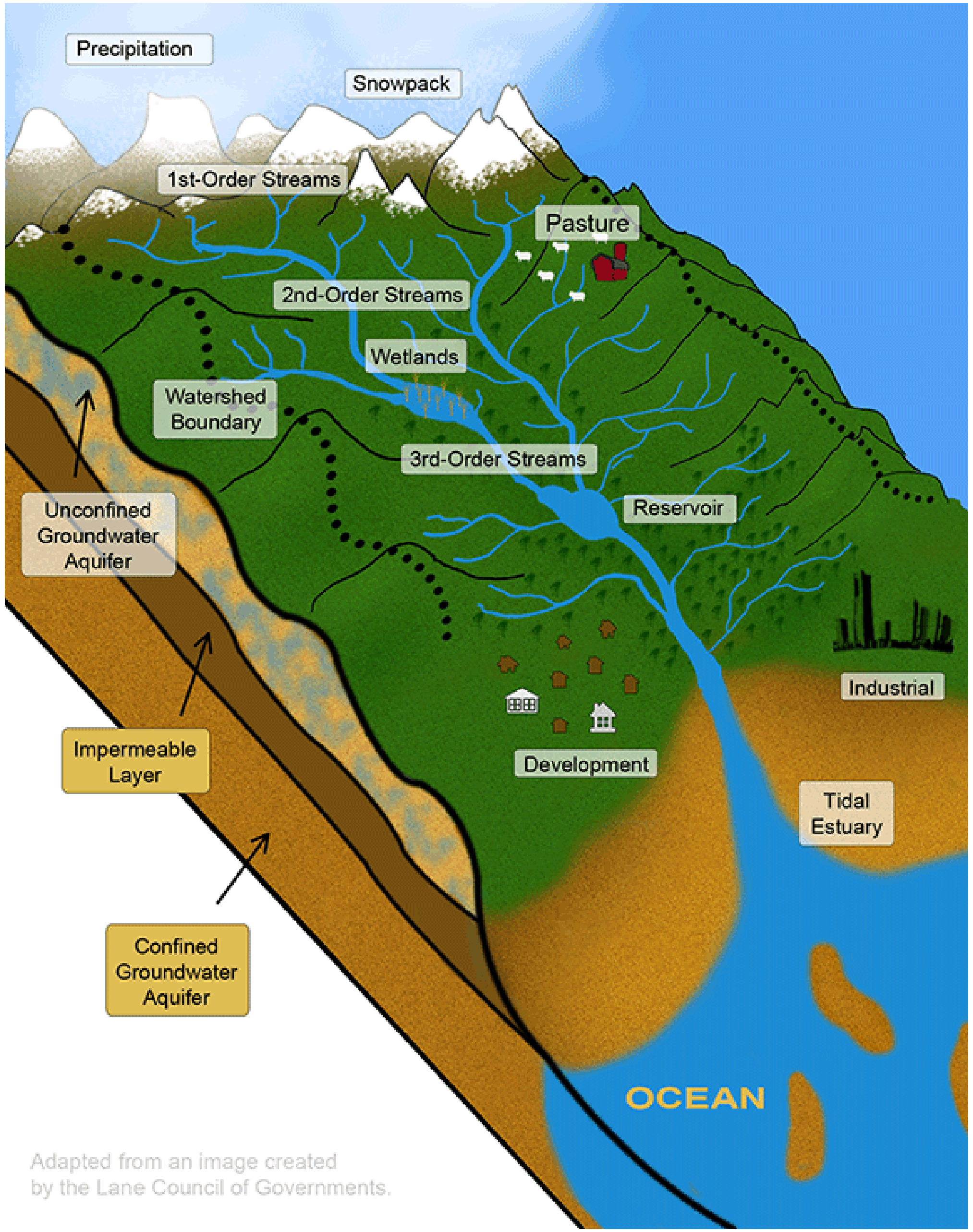
This is a picture of a typical watershed. A watershed is the area of land that water flows over to reach a river, lake, or a stream.

Everyone lives, works, and plays on land that drains to a body of water. Your local watershed may lead to a tiny creek, but that eventually drains into a river, bay, or ocean.

Question

Think about the location of your school. Where does the water go after it rains at school?

Try using many of the vocabulary words displayed in the diagram in your answer and include any features like sewer, manholes, etc. that might be found in the schoolyard.



Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

About the Bay

- It's More Than Just "the Bay"
  - The Susquehanna River
  - Watershed Geography & Facts
  - Land Use and Pollution Across the Bay Watershed
  - Habitats of the Chesapeake
  - Creatures of the Chesapeake
  - Plants of the Chesapeake
  - Chesapeake Destinations
- The Issues
- Maps
- State of the Bay 2014
- Bay Glossary
- Other Resources
- 10 Things You Didn't Know About the Bay

Stay up to date about the Bay!

E-MAIL ADDRESS

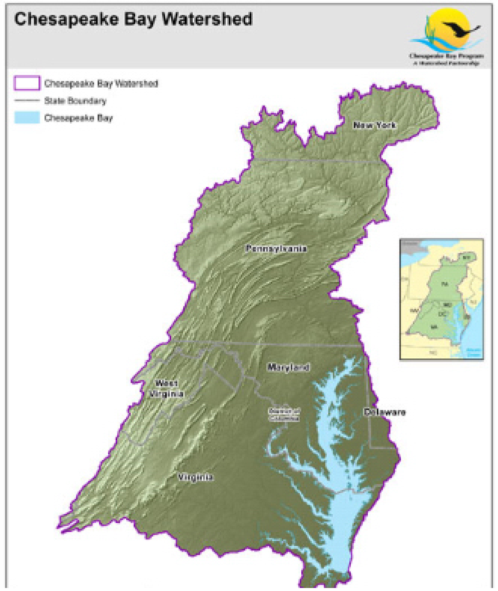
It's More than Just "the Bay"

An osprey tends her chicks. Photo by Bob Quinn

The Chesapeake Bay is an estuary, a body of water formed where freshwater from rivers and streams flows into the ocean, mixing with sea water.

But when we speak of "saving the Bay" we are not speaking only of saving the 200-mile-long estuary that runs from Havre de Grace, Maryland to Norfolk, Virginia.

We are also speaking of the 50 major rivers and streams that pour into the bay each day, and the creeks that feed those rivers and streams. We are talking about the roughly 64,000 square mile watershed covered with forests, farms, and wildlife habitat; cities and suburbs; waste water treatment plants and heavy industry. A watershed that starts as far north as New York and runs through six states and the District of Columbia on its way to the ocean.



As the saying goes, "everything flows downstream." If we are to "save the Bay" we must also save the hundreds of waterways that flow into it. Hundreds of waterways from New York to Virginia have been listed on the Clean Water Act's "dirty waters" list. Not only do they have a negative effect on local communities, they also contribute to the Bay's ills.

We can "save the Bay" only if we clean up our local creeks, streams, and rivers.

Seventeen-million people live, work, and play in the Chesapeake Bay watershed, and each one directly affects the Bay. What will your impact be?

[10 things you didn't know about the Bay]

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Water Pollution Vocabulary

- Bacterial pollution – the presence of harmful bacteria in water supplies.
  - Harmful bacteria can cause sickness or infection. Boiling or filtering water can remove these bacteria and make water safe to drink.
  - Many types of bacteria are beneficial. These bacteria help clean water by breaking down pollutants and returning nutrients to the environment.

- Nutrient pollution – the presence of excess nutrients in the water.
  - Nutrient pollution usually refers to excess nitrogen and phosphorus.
  - Nutrient pollution can result in blooms of algae that die and deplete oxygen as they decay. The lack of oxygen kills fish and other animals.
  - The most common source of nutrient pollution is fertilizer. During rainstorms, excess fertilizer runs off of farms and lawns and pollutes streams and rivers. Some soaps and detergents also contain high levels of phosphorus.

- Sediment pollution – the presence of excessive sediments such as silt and clay in water.
  - Sediments can harm marine plants and animals by blocking sunlight and covering sensitive organisms. Sediment pollution can be especially devastating to coral reefs.

- Toxic pollution – the presence of toxic substances in water.
  - Examples of toxic pollutants include pesticides, oil, industrial waste, household chemicals, mining waste, lead, and radioactive nuclear waste.
  - Toxic pollution can increase rates of cancer, birth defects, and other rare diseases in affected regions.

- Water pollution – the introduction of harmful substances into water.

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Environmental Engineering

Background

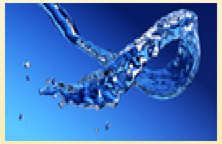
- Environmental engineers focus on removing pollution from the environment, minimizing the harmful impacts of pollution already in the environment, and preventing pollution from entering the environment in the first place.
- Every time pollution enters an ecosystem, regardless of the type or the quantity, it has an impact on that ecosystem. Some of these impacts are direct and easily observable, while others are indirect, and appear slowly over time.
- Environmental engineers often work alongside city planners and civil engineers to ensure that new structures, such as roads and buildings, are constructed with minimal impact and are designed to minimize transfer of pollutants into the environment.

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Careers

Water Resources Specialist

Often working for a county, the water resources specialist will regulate drinking water quality, devise plans for emergencies, and implement safe water plans and procedures.



Qualifications

Minimum: Bachelor's Degree.

Salary

$33,000 - $67,000

Coursework

HS: biology, chemistry. Colle
hydrology, engineering, geol

Creative Commons CareerSight Concord Cor
Uploaded by: Carolyn

Wastewater Treatment Plant Operator

Responsible for operating waste treatment plants. Operates machinery that converts wastewater in drains and sewers into a form that is safe to release into the environment. Primary responsibilities are to control equipment and monitor processes that remove or destroy harmful materials, chemicals, and microorganisms from wastewater. Run tests to make sure that the processes are working correctly. Keep records of water quality and other indicators. Operate and maintain the pumps and motors that move water and wastewater through filtration systems. Monitor the indicators at their plants and make adjustments as necessary. Read meters and gauges to make sure that plant equipment is working properly. Take samples and run tests to determine the quality of the water being produced. Adjust the amount of chemicals, such as chlorine and fluorine, being added to the water. Use computerized systems to monitor plant processes. Plan emergency reaction protocols. Fix chemical leaks and oxygen deficiencies. And Keep records that document compliance.*

Qualifications

State wastewater operator license. A Class III Wastewater Treatment license. Physical fitness and ability to lift 75 lbs.

Salary

$20/hour

Coursework

math, chemistry

Creative Commons
Concord Consortium Careersight

Environmental Science Technician

Also called an Environmental Science and Protection Technician, a person in this position works in the office, lab and in the field to investigate sources of pollution which are a threat to public health.

Qualifications

Associate Degree

Salary

$20/hour

Coursework

Math, Chemistry

ITSISU Activities:
Links:
US Bureau of Labor Statistics

Creative Commons
Concord Consortium

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Urban Landscape Challenge

This challenge has three parts:

- engineer a model building at least nine inches high
- engineer a roof for the building that reduces runoff by absorbing water
- engineer a parking lot of permeable pavement
- describe how your landscape is saving the bay (pollutant description of cause and effect

Criteria:
Budget: $500
Free Building materials: 1 sq. foot foil, tape, 40 index cards
Building: exactly 9 inches tall
Green roof: on top of bldg must support 1 cup water
Road: 3inches x 11 inches
Permeable pavement parking lot to fit at least 4 cars

Deliverables today:

- Draw your plan and get approved
- Collect your building supplies
- Create your green roof building
- Place your building on the block.
- Mark off your street.
- Lay out your permeable pavement
- Place your toxins on the model
- Test over a trashcan.
- Prepare your report.

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Experimental Design Process Report

1. Problem clearly identified.
2. Plan drawn, labeled measured

   Materials list Budget written and calculated.

   Pollutant identified and explained – type, source consequence
3. Create green roof and permeable pavement

4. Test with water storm

5. Describe improvements needed.

6. Present to results to class.

Clean-up

- Unwrap buildings and place on front table.
- All foil and tape in trash.
- Clean and sort all building supplies for reuse

LESSON CONTRIBUTED BY: THERESA GUTHRIE
FUNDED THROUGH A 2015 STATE COUNCIL OF HIGHER EDUCATION FOR VIRGINIA (SCHEV) GRANT, PISTEM II.

Environmental Engineering Unit Quiz

- List the 4 pollutants and give an example of each.
- What is an environmental engineer?
- What is a green roof? Why are they important?
- What is permeable pavement? What is its purpose? Where would it be advantageous to have them?
- What is a watershed?
- What watershed do we live in?

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Vocabulary

- **Constraint:** A limitation or restriction on a design.
- **Criterion:** A requirement for a design.
- **Environmental engineer:** Someone who uses his or her creativity and knowledge of math, science, and natural systems to design technologies to solve problems relating to reducing pollution in the environment.
- **Engineer:** Someone who uses his or her creativity and knowledge of math and science to design technologies that solve problems.
- **Engineering Design Process:** The steps that engineers use to design technologies to solve a problem.
- **Technology:** Anything designed by humans to help solve a problem.
- **Green roof:** A roof that is partially or fully covered with vegetation over layers of material to absorb water, with a waterproof membrane on the bottom to prevent leaking.
- **Runoff:** The water that flows over the surface of a landscape during and after a rainstorm.
- **Permeable pavement:** An absorbent pavement allowing water to pass through it.
- **Pollutant:** Something that contaminates the air, water, or soil of an environment.
- **Pollution:** The introduction of pollutants into the environment.

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

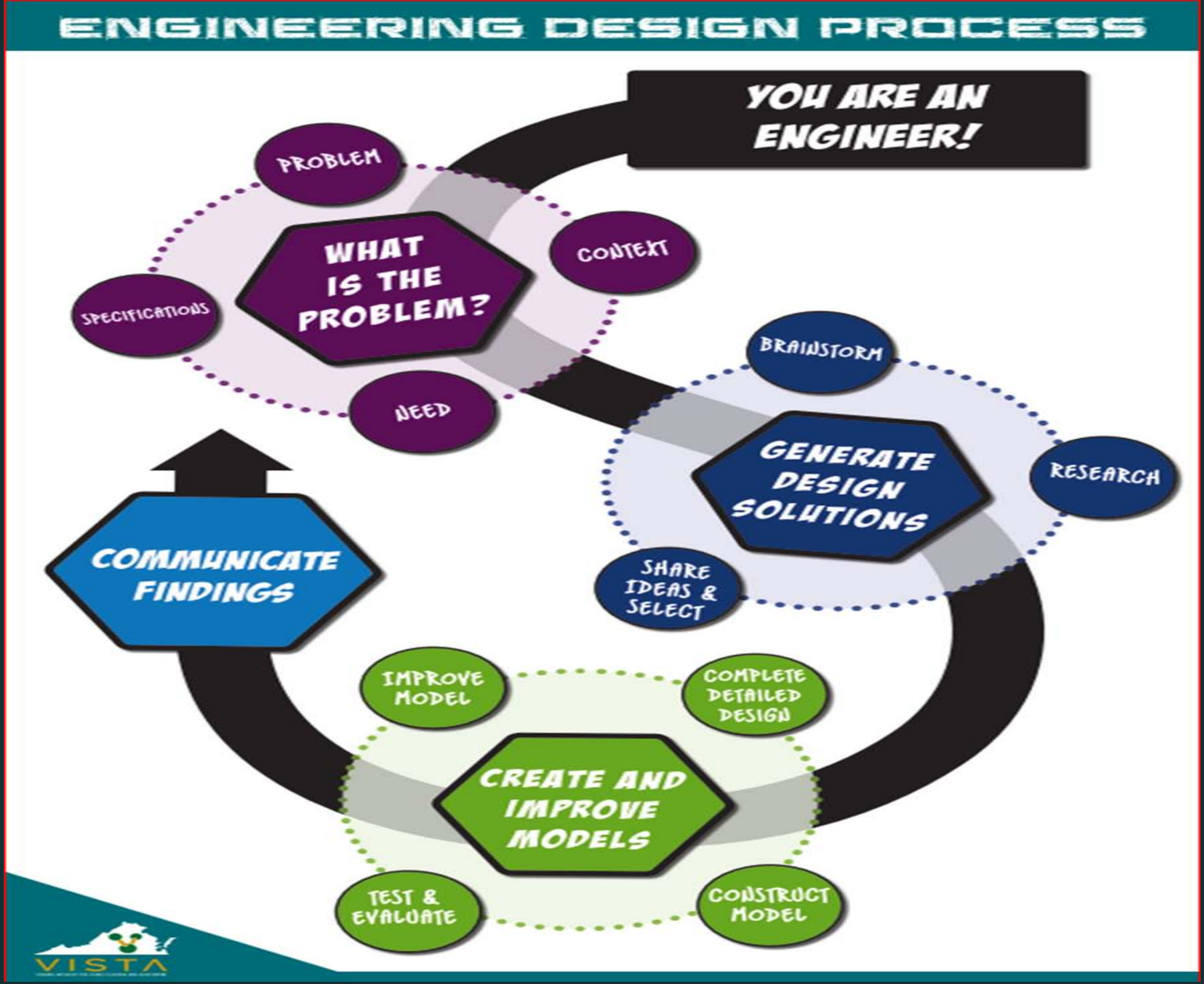
Hummingbirds Design Challenge

Problem - The EPA is requiring everyone in the Chesapeake Bay watershed to monitor their impact on the Bay and be able to remove certain pollutants.

Design and build a prototype robotic device that is able to collect real data about a place and offer some solution.

Your solution must collect information about its environment and use that information to decide an action to take, the way a robot might. You'll need to think about the type of data you collect, because it needs to inform the user of environmental conditions in order to take preventative action so that the Chesapeake Bay can improve or maintain specific qualities.

LESSON CONTRIBUTED BY: THERESA GUTHRIE
FUNDED THROUGH A 2015 STATE COUNCIL OF HIGHER EDUCATION FOR VIRGINIA (SCHEV) GRANT, PISTEM II.



LESSON CONTRIBUTED BY: THERESA GUTHRIEFUNDED THROUGH A 2015 STATE COUNCIL OF HIGHER EDUCATION FOR VIRGINIA (SCHEV) GRANT, PISTEM II.

Engineering Journal Reflection:

- What are the main concerns with the Chesapeake Bay? State of the Bay Report

Objective:

Use the Engineering Design Process to define a problem and develop an efficient solution.

Nutshell: Design, build, a device .

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Requirements: See *Save the Bay* device

Conditions

Build and program a “working” model of a device that is has at least 3 “functions” that will assist with monitoring and/or cleaning up pollutants that could enter the Bay.

You must prove your team has followed the Engineering Design Process and met the EPA’s expectations of an *efficient* and *economical* device.

Constraints

You will be presenting your Save the Bay device to the Chesapeake Bay Foundation on JANUARY 7TH .

Equipment can be purchased from EPA warehouse.

You may use “other” materials with approval and pricing agreement.

LESSON CONTRIBUTED BY: THERESA GUTHRIE
FUNDED THROUGH A 2015 STATE COUNCIL OF HIGHER EDUCATION FOR VIRGINIA (SCHEV) GRANT, PISTEM II.

What makes your “Save the Bay” device special?

- What pollutants are you monitoring?
- What can it clean up?
- Where will purchasers place the device for maximum effectiveness?
- What makes it worth the price?

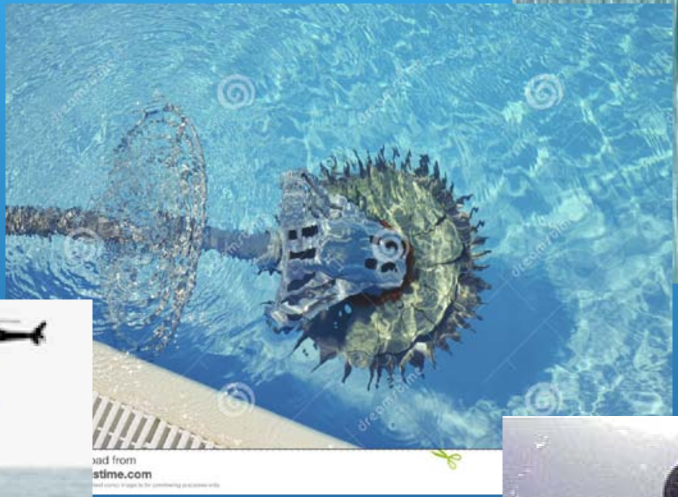
Objectives:

Use the Engineering Design Process to define a problem and develop an efficient solution.

Communicate effectively with others (e.g., peers, teachers, experts) in collaborative learning situations.

Lesson Contributed by: Theresa GuthrieFunded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

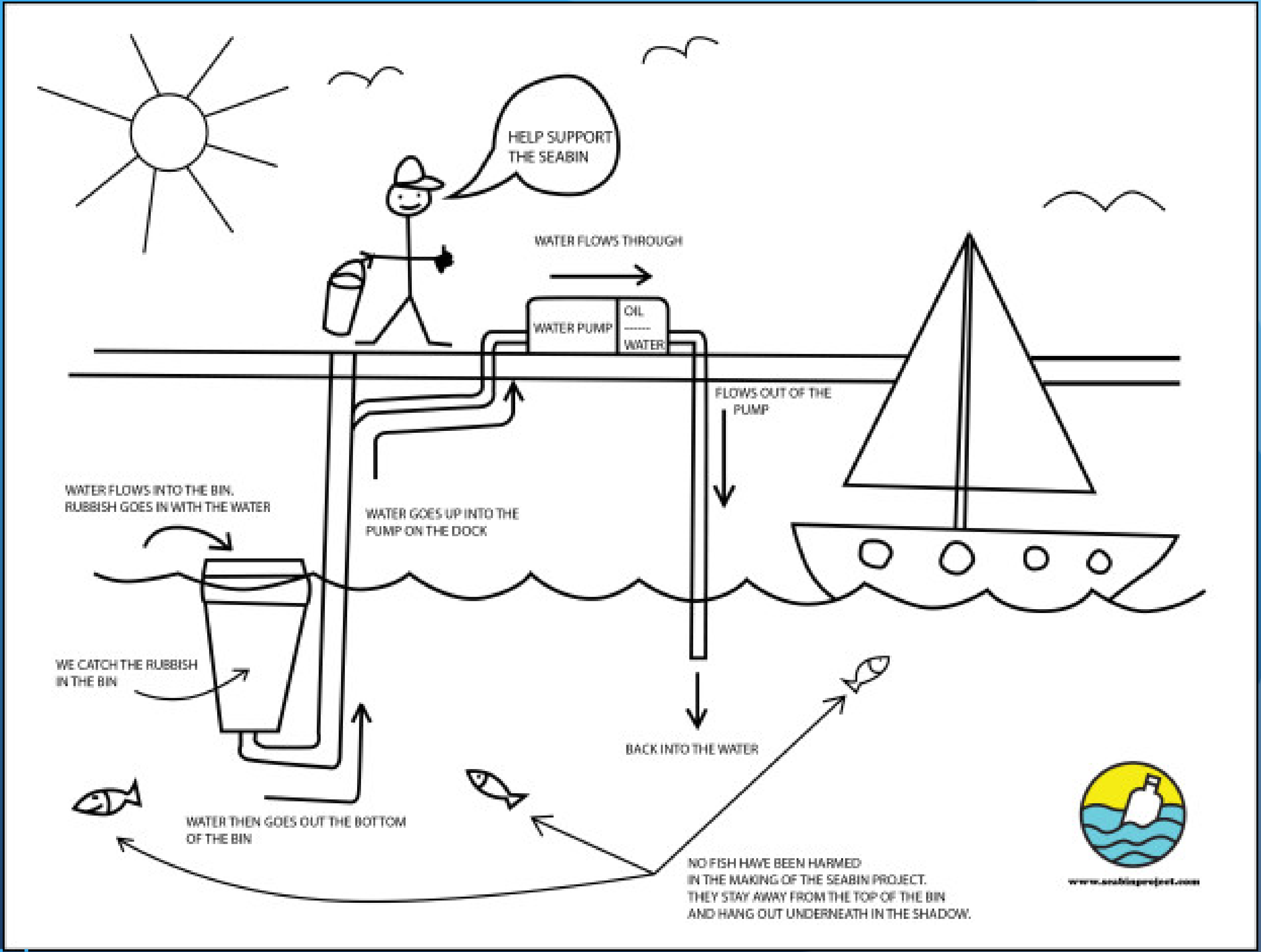
Water Cleaning Robot Presentations



[The Sea Bin Project]

Lesson Contributed by: Theresa GuthrieFunded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

How does the Seabin Work?



Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Hummingbird

Check out the box, hook it up

Hummingbird kits : Connecting electronics

Using Scratch with the Hummingbird

- Open the Bird Brain application
- Open Scratch
- From Scratch, go to file/open/desktop/**scratch with hummingbird.sb2**
- Under **More Blocks**, you will find commands to use specifically with the hummingbird.

Save your files: Go to File/save as and save your file as a document on the desktop. Put your name in the filename. Save often so you don't lose work. Laptop batteries have short lives!

LESSON CONTRIBUTED BY: THERESA GUTHRIEFUNDED THROUGH A 2015 STATE COUNCIL OF HIGHER EDUCATION FOR VIRGINIA (SCHEV) GRANT, PISTEM II.

3 Student Presentations
Pictures of activities

Lesson Contributed by: Theresa GuthrieFunded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Save The Bay!

"Operation Lilypad"

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Jobs

- Colton- Construction Engineer
- Abby- Construction Engineer
- Lexi- Design Engineer
- Gabby- Design Engineer
- Alayna- Project Manager, Publicity

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Problem

- The EPA is requiring everyone in the Chesapeake Bay watershed to monitor their impact on the Bay and put some effort in to cleaning it of pollutants. Some of the many pollutants of our bay's watershed include:
  - An excess amount of nitrogen and phosphorus.
  - Sediment pollution such as dirt and gravel, which is caused by deforestation.
  - Toxic chemicals like paint and oil that kill important wildlife.
  - Untreated animal (including human) waste that contaminates the water.

Lesson Contributed by: Theresa GuthrieFunded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

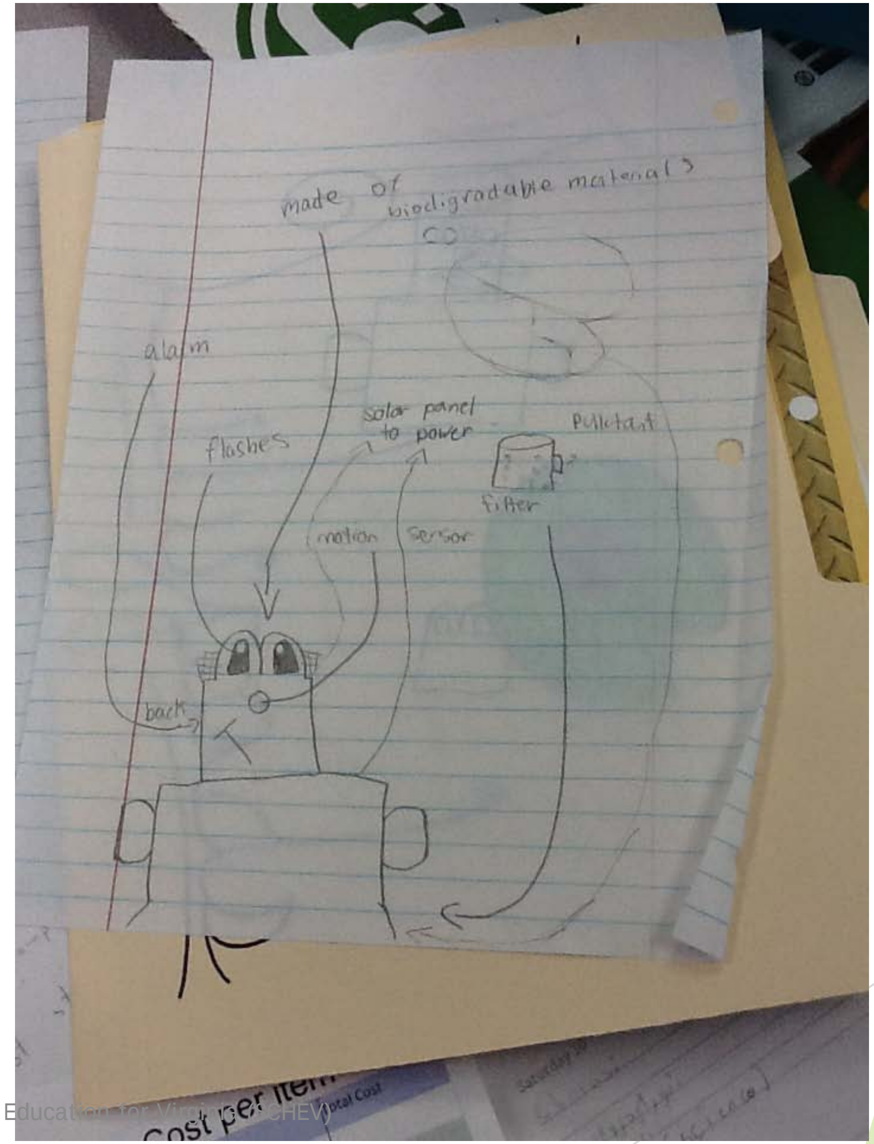
Sediment Levels

- Dirt and gravel amounts are overabundant in the Chesapeake, and this is very harmful to our beloved watershed. These types of sediment poisoning, along with a few others, come from deforestation and leaving large patches of dirt from construction unattended. Some terrible things that are the result of this large amount of sediment are listed below:
    - The water becomes so clouded that water life does not receive enough sunlight, especially plants, which need sunlight for photosynthesis.
    - The dirt is washed from streams and rivers in to the bay and in to the ocean, making it harder to be cleaned in general.
    - An abundance of money is lost by this depletion of wildlife, as game rates go down because of the need to stop hunting these animals.

Lesson Contributed by: Theresa GuthrieFunded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

What’s to do?

- As you can tell, these large amounts of sediment are detrimental to our environment. We have produced a device that can help inform people of the dangers of sediment pollution and can also detect high levels of dirt and gravel in the water, and alert any people who may be around.
- We call our device F.H.R.O.G.I.E.H. (pronounced ‘froggy’), or For Help and Reduction Of Gravel (and other sediment pollution) or Inspection of Environmental Health.



Lesson Contributed by: Theresa GuthrieFunded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

What Does F.H.R.O.G.I.E.H. Do?

- F.H.R.O.G.I.E.H. is a very advanced piece of Hummingbird Robot technology. Our device has a small motion sensor attached to the lily pad it sits a few cm above the water, and it detects cloudy water, which is a common result of sediment pollution. F.H.R.O.G.I.E.H.'s eyes will light up green to alert it's owner of the new pollutant.
- F.H.R.O.G.I.E.H. has a bit of text on him relating to sediment pollution and where they can go to learn more information about it.
- F.H.R.O.G.I.E.H. is made of the most environmentally friendly materials that were available.
- F.H.R.O.G.I.E.H. has small "fins" on its sides to help it move through the water periodically. It can be programmed to move a specific way through the water.

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Building Process

- Abby and Colton are our builders, and they will now explain the building process.

Lesson Contributed by: Theresa GuthrieFunded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Programming

- Our programmers are Gabby and Lexi, and they will now explain how the coding went.

Lesson Contributed by: Theresa GuthrieFunded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Improvements

- Throughout the process of designing, we realized that a few improvements could be added to F.H.R.O.G.I.E.H. if we had the material. These included the following:
  - It could be solar powered.
  - A small filter could be added to collect pollutants.
  - More biodegradable particles could be used.
  - Instead of only having a place you could go for more info, it could have a speaker to tell the people more information.

Lesson Contributed by: Theresa GuthrieFunded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Aqua Programmers

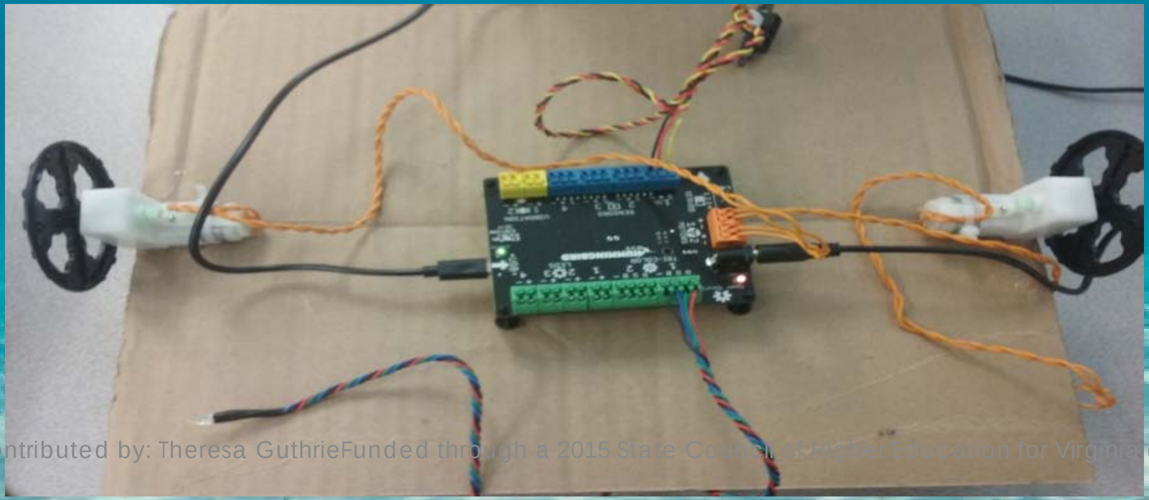
By Chris, Daniel, Keon, and Michael

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Aqua Programs

- Our objective was to build a robot with the humming bird duo kit that could save the Chesapeake bay
- Our 1st idea was something that picked up trash on our water shed

We eventually came up with a robot that swims around filtering mainly sedimentary pollution



Lesson Contributed by: Theresa GuthrieFunded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Aqua Programs

How our robot functions:

The paddles move the robot around the bay; when it senses an object it turns on the LED light and warns the robot of collision with the object. Then it turns around.

The robot also filters sedimentary pollution as it moves

This is especially useful because sedimentary pollution like dirt that is filtered through our robot usually makes it hard for sunlight to get to living things at the bottom of the bay

CHESAPEAKE BAY FOUNDATION
SAVE THE BAY ®

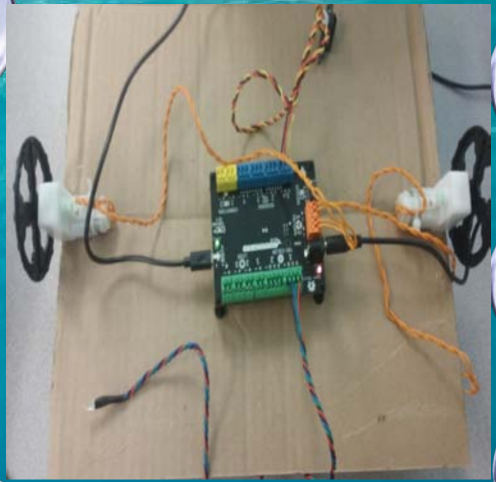
Lesson Contributed by: Theresa GuthrieFunded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

Aqua Programs

Materials
Hot Glue Gun Stick: 4 Costs $400
Mesh shelf liner: 1 square foot Costs $100
Cardboard: 2 square foot Costs $400
Motor: 2 Costs $3000
TriColored LED: 1 Costs $150
Sensor: 1 Costs $500
Tray: 1 Costs $100
Wheels: 2 Costs $100
Popsicle stick: 3 $300
Pipes: 2 $150
Tape: 1 foot $25
Total cost would be $4925

Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

The End



Lesson Contributed by: Theresa Guthrie
Funded through a 2015 State Council of Higher Education for Virginia (SCHEV) grant, PISTEM II.

SAVING THE BAY

BY MATTHEW, JOHN, DREW, JOSEPH

LESSON CONTRIBUTED BY: THERESA GUTHRIE

FUNDED THROUGH A 2015 STATE COUNCIL OF HIGHER EDUCATION FOR VIRGINIA (SCHEV) GRANT, PISTEM II.

WASTE AND RUNOFF

- A lot of people dump their cans and trash out in the street ,and other wasteful garbage. The things you thought were harmless just entered the Chesapeake Bay. It is killing clams, fish, and a lot of other marine

LESSON CONTRIBUTED BY: THERESA GUTHRIE
FUNDED THROUGH A 2015 STATE COUNCIL OF HIGHER EDUCATION FOR VIRGINIA (SCHEV) GRANT, PISTEM II.

OUR IDEA

- There are a lot of solutions to this problem ,but one solution is not killing the oysters. As our promotion we built a underwater submarine that filters water. Our goal is to make our environment clean and safe for animals.

LESSON CONTRIBUTED BY: THERESA GUTHRIE
FUNDED THROUGH A 2015 STATE COUNCIL OF HIGHER EDUCATION FOR VIRGINIA (SCHEV) GRANT, PISTEM II.

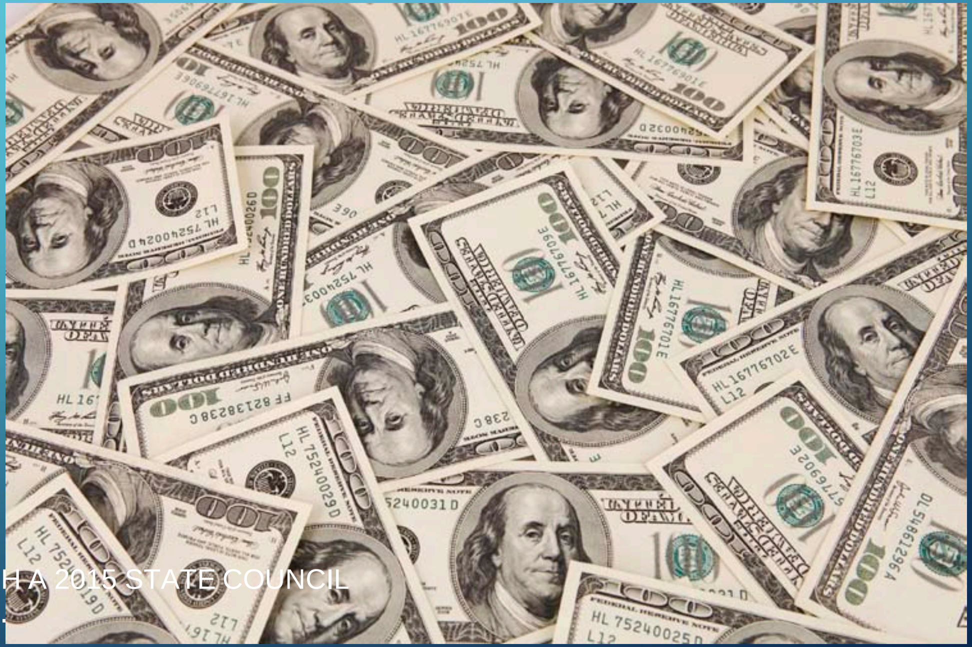
WHY YOU SHOULD HELP

- Some of you don’t care ,but think of all the animals that are dying or being badly injured. They are suffering because of us so we should fix it. So we ask you all to help us do this. This will also help our environment stay clean. SAVE THE BAY!!!

LESSON CONTRIBUTED BY: THERESA GUTHRIE
FUNDED THROUGH A 2015 STATE COUNCIL OF HIGHER EDUCATION FOR VIRGINIA (SCHEV) GRANT, PISTEM II.

BUDGET

- We bought 1 servo, 2 motors, 2 hot glue, 1 box, and 1 sensor. The total cost of this was $4,700.



LESSON CONTRIBUTED BY: THERESA GUTHRIEFUNDED THROUGH A 2015 STATE COUNCIL OF HIGHER EDUCATION FOR VIRGINIA (SCHEV) GRANT, PISTEM II.

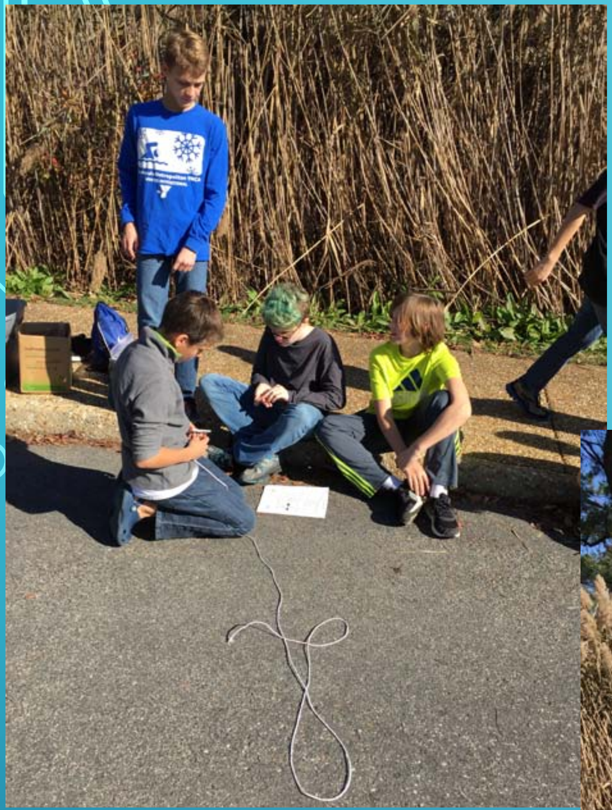
SAVE THE ENVIORMENT AND HELP THE WORLD GO GREEN!

LESSON CONTRIBUTED BY: THERESA GUTHRIE

FUNDED THROUGH A 2015 STATE COUNCIL OF HIGHER EDUCATION FOR VIRGINIA (SCHEV) GRANT, PISTEM II.

Kayaking at Back Creek to observe pollution sources and consequences

LESSON CONTRIBUTED BY: THERESA GUTHRIE
FUNDED THROUGH A 2015 STATE COUNCIL OF HIGHER EDUCATION FOR VIRGINIA (SCHEV) GRANT, PISTEM II.



Urban Landscape Testing

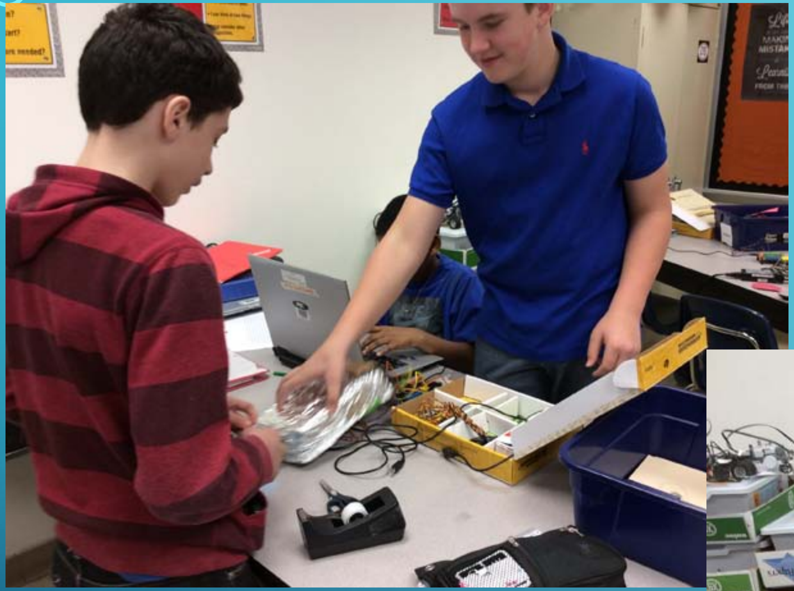
LESSON CONTRIBUTED BY: THERESA GUTHRIE

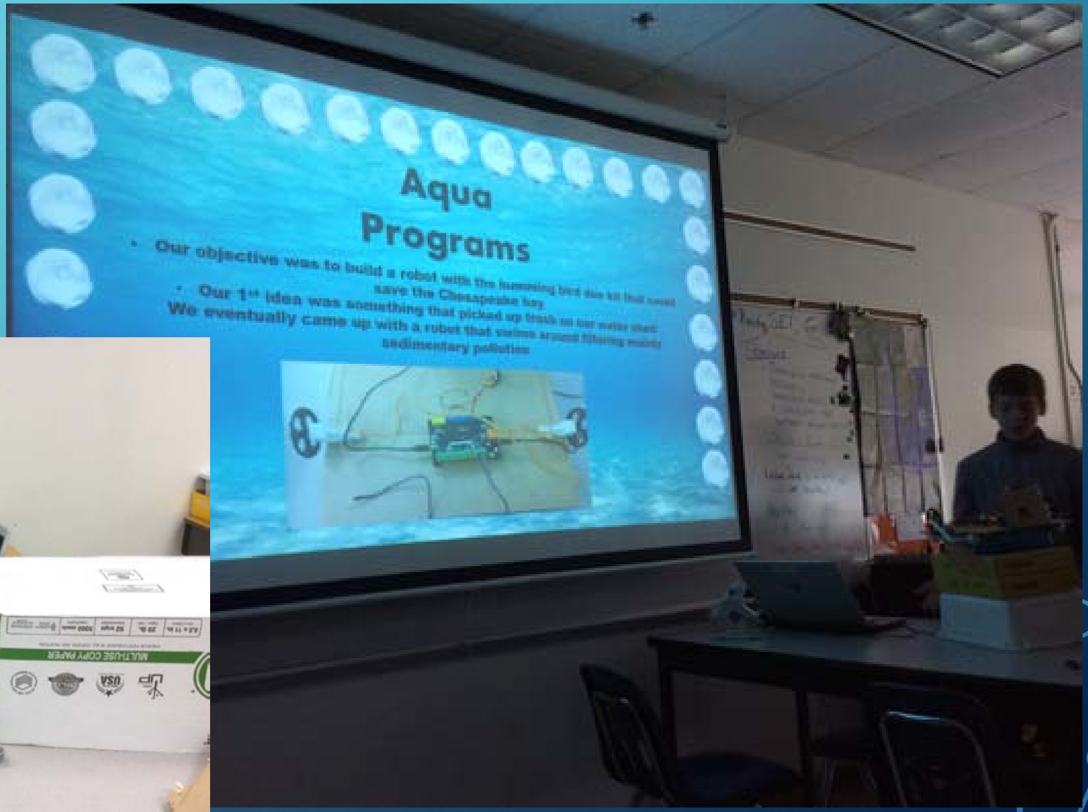
FUNDED THROUGH A 2015 STATE COUNCIL OF HIGHER EDUCATION FOR VIRGINIA (SCHEV) GRANT, PISTEM II.

Urban Landscape Testing

LESSON CONTRIBUTED BY: THERESA GUTHRIE
FUNDED THROUGH A 2015 STATE COUNCIL OF HIGHER EDUCATION FOR VIRGINIA (SCHEV) GRANT, PISTEM II.

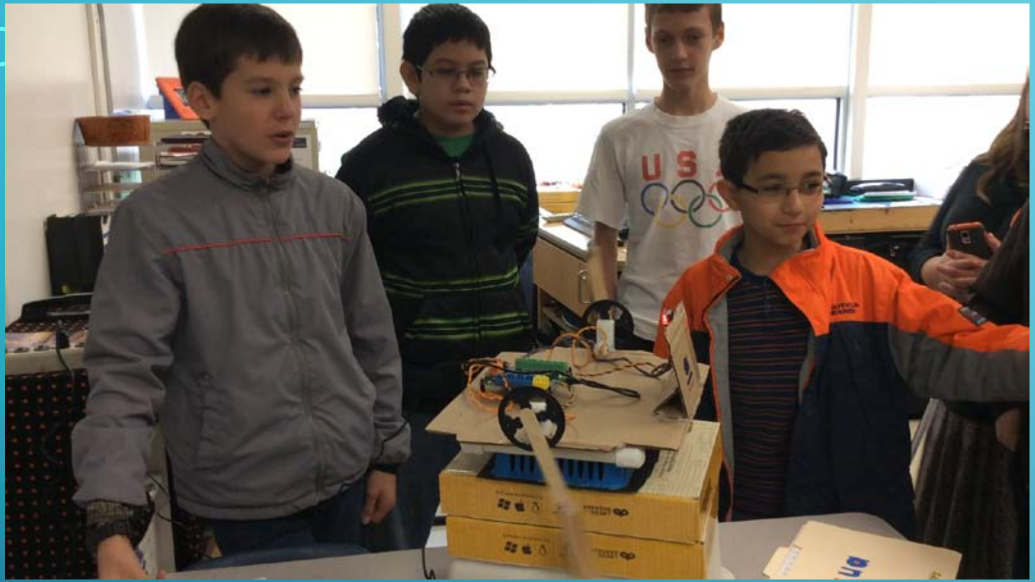
Students created and presented their devices to the Chesapeake Bay foundation and EPA

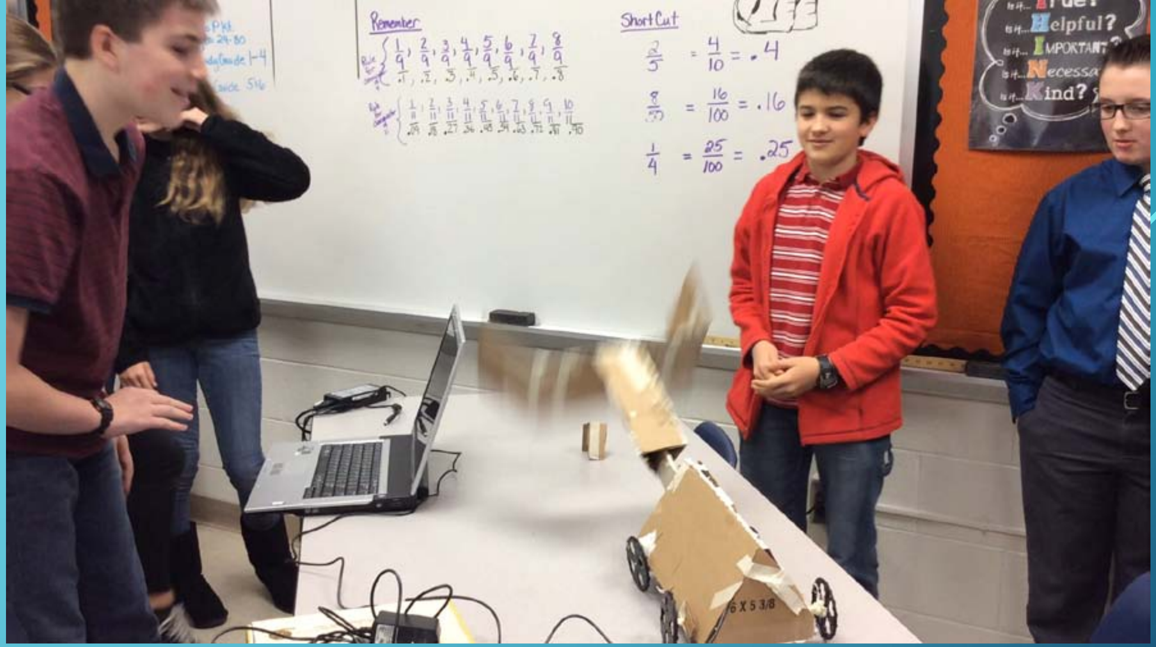




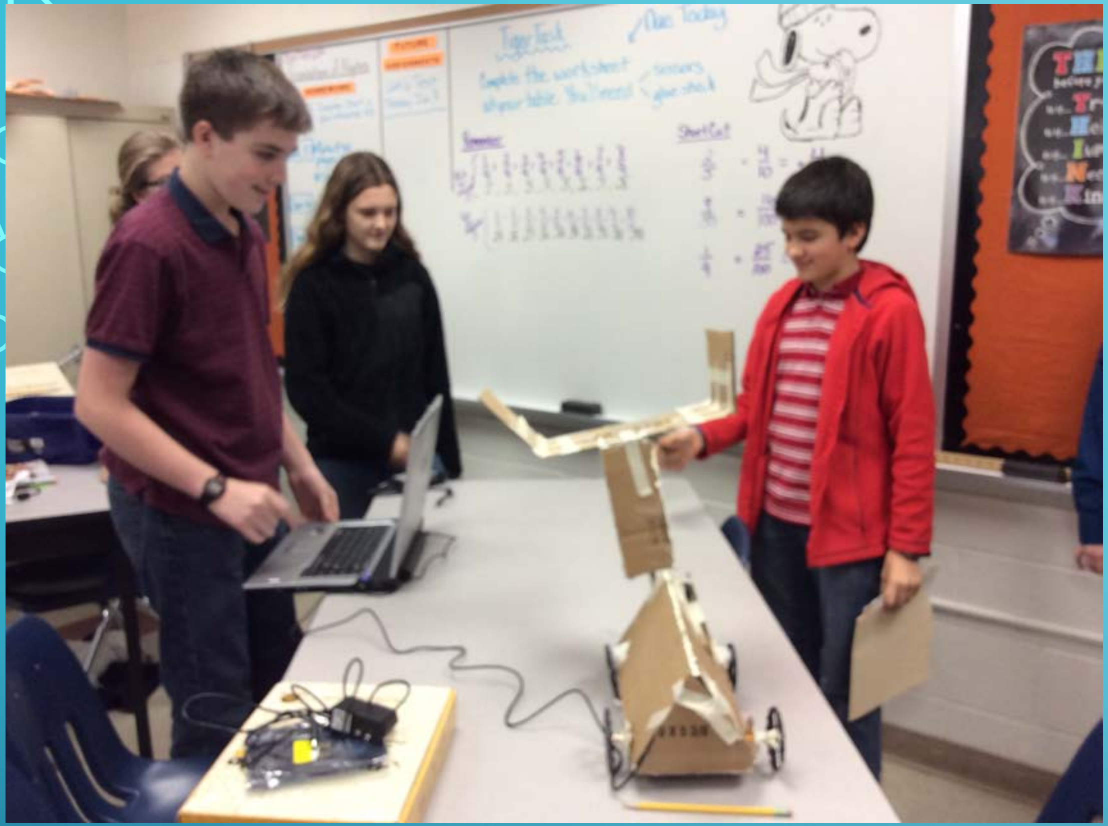
LESSON CONTRIBUTED BY: THERESA GUTHRIE
FUNDED THROUGH A 2015 STATE COUNCIL OF HIGHER EDUCATION FOR VIRGINIA (SCHEV) GRANT, PISTEM II.

Video clips of device in action!





LESSON CONTRIBUTED BY: THERESA GUTHRIE
FUNDED THROUGH A 2015 STATE COUNCIL OF HIGHER EDUCATION FOR VIRGINIA (SCHEV) GRANT, PISTEM II.



LESSON CONTRIBUTED BY: THERESA GUTHRIE
FUNDED THROUGH A 2015 STATE COUNCIL OF HIGHER EDUCATION FOR VIRGINIA (SCHEV) GRANT, PISTEM II.