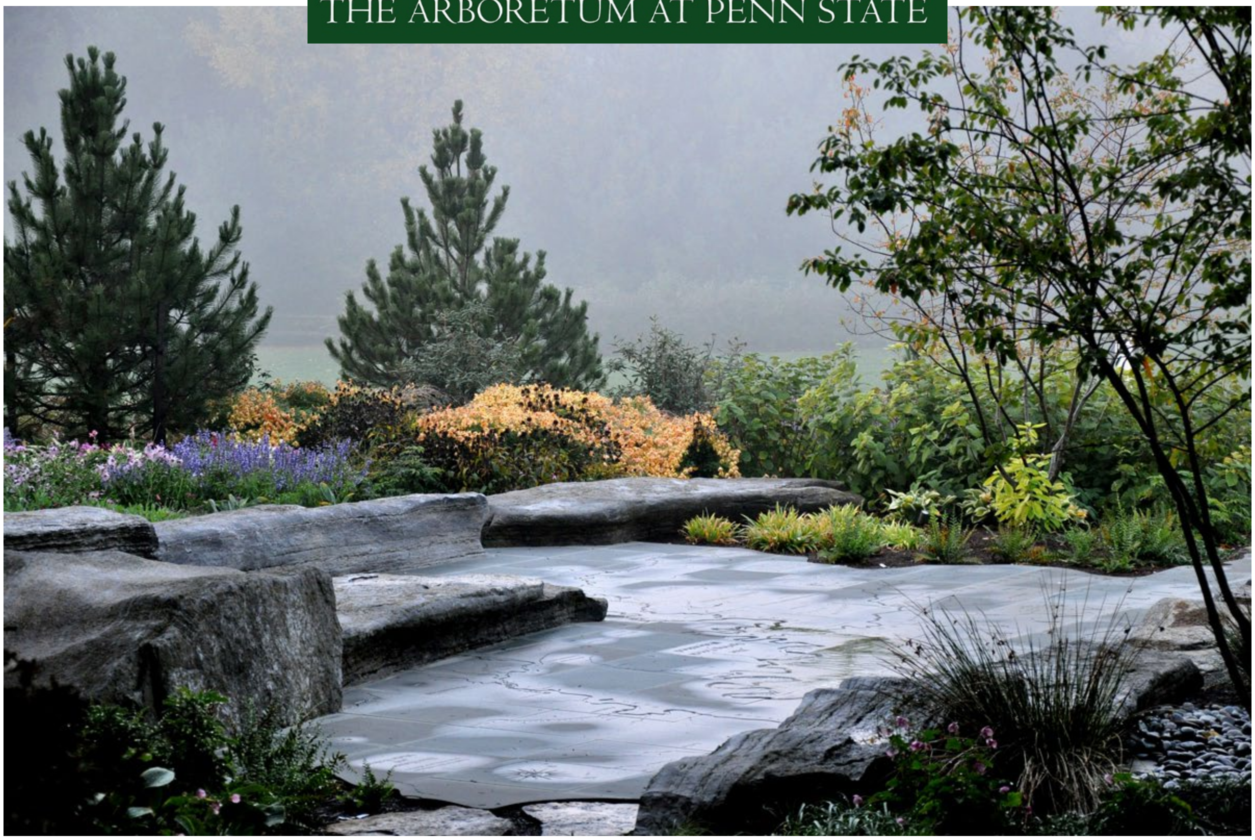
THE ARBORETUM AT PENN STATE



WATERSHED RESOURCES
AT THE ARBORETUM AT PENN STATE

A Guide for Educators

PennState

The Arboretum at Penn State
The Pennsylvania State University
320 Forest Resources Building
University Park, Pennsylvania 16802
arboretum.psu.edu

VISITING THE ARBORETUM AT PENN STATE

The Arboretum is open from dawn to dusk every day. There is no entrance fee. Parking is free. Cars must display a parking pass on weekdays; free day passes are available from the caddy on the door of the Overlook Pavilion office. Bus parking is not available in the Arboretum lot but is available in the Porter North lot on Porter Road near Beaver Stadium

Organized groups and field trips must schedule their visit to the Arboretum. You can schedule your group trip by contacting Kelly Oleynik (keo5114@psu.edu) or by using the group visitor inquiry form on the Arboretum's website. Scheduling your trip will ensure that your group enjoys the best possible experience and is able to access the resources you wish to use.

Information about garden rules, parking, child:adult ratios, and much more can be found on the visitor information page on the Arboretum's website, arboretum.psu.edu. Please familiarize yourself with these requirements before your trip.

We look forward to seeing you!

INTRODUCTION

Resources that are useful for teaching about local and regional water issues can be found throughout The Arboretum at Penn State. This publication is intended to provide teachers with a guide to water-related features of the following areas:

- The Dr. James J. and Lynn D. Ramage Marsh Meadow
- Childhood's Gate Children's Garden
- Ridge and Valley Sculpture and Watershed Map
- Big Hollow.

It also covers some case studies that show the impact of pollution on local water issues.

Key concepts are highlighted in bold and defined in a glossary on page 11.

In addition, this guide provides suggestions for some activities that may help students understand the things they learn at the Arboretum. These activities are located at the end of the document, pages 12-13.

THE DR. JAMES J. & LYNN D. RAMAGE MARSH MEADOW

Why is the first thing visitors encounter at the Arboretum a marsh instead of a garden or a building? The answer is that the Marsh Meadow (Fig. 1) preserves an environmentally sensitive area where water drains into the soil (Fig. 2).

As urban development has covered more and more of the State College area with **impervious surfaces** like buildings, sidewalks, roads, and parking lots, water that used to drain slowly into the soil now runs off over the land surface or is piped away in storm drains. More **surface runoff** increases the risk of flooding and makes flood events more intense.

Natural areas like the Marsh Meadow are like sponges, absorbing **precipitation** and letting it filter slowly into the ground instead of running off over the land surface. Water coming from the Penn State campus and from the College Heights neighborhood is absorbed into the ground in the Marsh Meadow.

Figure 1: The Marsh Meadow today, as seen from East Park Ave.

Figure 2: Runoff ponding on the site of the Marsh Meadow prior to the construction of the Arboretum.

Core concept:

The expansion of impervious surfaces in urban areas prevents water from draining into the ground and increases stormwater runoff and flooding.

Natural areas like the Marsh Meadow absorb water, allowing it to drain into the ground. Preserving natural areas reduces flood risk and protects groundwater resources.

The Marsh Meadow makes a particularly good sponge because of its underlying bedrock. The limestone underneath the marsh is permeated by cracks and sinkholes, allowing water to drain very rapidly into the ground. These sorts of voids are characteristic of the limestone valley bottoms of the Ridge and Valley Appalachians. Because of these rapid surface-subsurface connections, our area has many streams but little standing water.[1]

Water that enters the Marsh Meadow flows under the ground and eventually returns to human use via wells located in Big Hollow.

Activity for the Marsh Meadow: “Percolation Education”

[1] We can thank geology for the lack of mosquitoes in our area. Little standing water means that mosquitoes have few places to breed.

CHILDHOOD'S GATE CHILDREN'S GARDEN

The entrance to Childhood's Gate Children's Garden

The children's garden was designed as a natural classroom in which children of all ages can discover central Pennsylvania's flora, fauna, geology, and history. The Bedrock Boulders, the Limestone Cave, the In-and-Out Creek, and the animal sculptures near the garden entrance all present water-related educational possibilities.

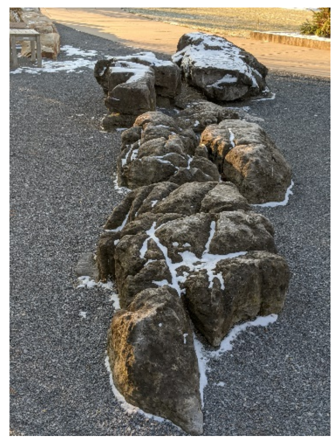
BEDROCK BOULDERS

These deeply fissured limestone boulders provide an opportunity to understand how water in our region moves from the earth's surface into the ground, and the geochemical processes associated with the bedrock of our valley floors.

Core concept:

Surface water moves rapidly from surface to subsurface in the Centre County region because the limestone bedrock is deeply weathered and permeated by cracks and sinkholes.

The fissures and holes in the boulders were created over a long period of time by **weathering**. Weak acids from rainwater and decaying vegetation dissolved the rocks over time. If we could remove all the soil from the valley floor, we would see a landscape that resembles the boulders on both large and small scales.



These boulders are marked by deep fissures where natural acids have dissolved the rock.

LIMESTONE CAVE

The children's garden cave presents an opportunity to walk through central Pennsylvania's subsurface geology and see geochemical processes in action.

Over time, dissolution of **carbonates** from limestone bedrock can enlarge cracks and voids to the point where they become caves.

When water carrying dissolved carbonate percolates into a cave, it leaves behind a small deposit of carbonate minerals.

Stalactites, stalagmites, and columns in the Limestone Cave in the children's garden

Over time, small deposits grow larger, forming stalactites, stalagmites, and columns.

The large stalactites, stalagmites, and columns in the cave are artificial. However, since the cave was built, small, straw-like stalactites have begun to form along the cracks in the ceiling, where water percolating through the roof of the cave redeposits carbonate minerals dissolved from the concrete.

Core concept:

Because of the chemical interactions between naturally acid rainwater and limestone bedrock, caves are common in our region. Groundwater carries calcium carbonate dissolved from pre-existing rock into caves, where it is redeposited as cave formations.

The chemical reactions that create caves and cave formations are:

1. Water and atmospheric carbon dioxide combine to form carbonic acid. This reaction causes rainwater to become weakly acidic.

$$H_2O + CO_2 \rightarrow H_2CO_3$$

2. Acidic water percolates into the ground, where the carbonic acid dissolves carbonate from rocks. Over time, dissolution enlarges cracks and creates voids, caves, and sinkholes in the bedrock.

$$CaCO_3 + H_2CO_3 \rightarrow Ca^{2+} + 2\ HCO_3^-$$

3. When the water carrying dissolved carbonate enters a cave, lower partial pressure of carbon dioxide in the air in the cave results in carbon dioxide gas leaving the aqueous solution. The water becomes less acidic and can no longer carry the carbonate minerals, which precipitate on surfaces in the cave.

$$Ca^{2+} + 2\ HCO_3^- \rightarrow CaCO_3 + H_2O + CO_2$$

Activity for the cave: “Acid-Base Reaction”

IN-AND-OUT CREEK

The cave shows how water flows under our region. The In-and-Out Creek demonstrates how it flows *through* our region. **Water gaps,** places where a stream or river cuts across a mountain rather than winding around it, are common features of the Appalachian Mountains. In the pre-automobile era, water gaps made it possible to bypass difficult climbs over the high mountain ridges.

The In-and-Out Creek flows through the rock ridges in the children’s garden.

Geologists see water gaps as evidence that the Appalachian Mountains were once eroded nearly flat. Water gaps formed when streams and rivers present on the flat land surface cut through the mountains as they were re-uplifted by plate tectonic movements.

Water gaps have played an important role in American history. Native American footpaths passed through water gaps. Braddock's Road, the first improved road to cross the Appalachians, passed through the Cumberland Narrows water gap along the route of a Native American trail called Nemacolin's Path. Braddock's Road was built by British and Colonial soldiers during the French and Indian War (1754-1763) as part of an unsuccessful attempt to win Fort Dusquesne from the French. The soldiers who helped build the road included a young Virginia surveyor named George Washington, who gained fame and valuable military experience during the expedition but nearly lost his life; he wrote his mother,"*I luckily escapd witht a wound, tho' I had four Bullets through my Coat, and two Horses shot under me.*"

Core concept:

Water flows through the Appalachian Mountains via features called water gaps, which cut through mountain ridges instead of flowing around them.

ANIMAL SCULPTURES

The pools near the entrance to the children's garden feature bronze sculptures of creatures which are especially dependent on water: the Great Blue Heron (*Ardea herodias*), American bullfrog (*Lithobates catesbeianus*), and hellbender salamander (*Cryptobranchus alleganiensis*).

The hellbender salamander, Cryptobranchus alleganiensis.

The hellbender, also known as the "snot otter," "Allegheny alligator," and "mud devil," is Pennsylvania's state amphibian. Hellbenders are the largest salamander in North America, averaging 4 to 5 lbs. and sometimes growing over 2 feet long. Their preferred habitat is a fast-flowing stream with plenty of flat rocks to provide hiding places for the animals and their eggs. The hellbender's diet consists of crayfish and other small aquatic animals. Because they are shy and nocturnal, hellbenders are rarely seen except by fishermen, who sometimes kill the entirely harmless creatures in the mistaken belief that they are venomous.

Hellbenders are fully aquatic salamanders, breathing primarily through their permeable, wrinkly skin. As a result, they need water that is clear and cool, with plenty of dissolved oxygen. Hellbenders disappear from rivers when water temperatures rise or the water becomes slower and muddier, conditions that cause oxygen levels to drop. Modification of stream habitats by dams, agriculture, accumulation of silt and pollution, and alterations to stream courses all threaten this increasingly rare amphibian. Even something as simple as moving rocks in a river can destroy the hellbender's fragile habitat!

Core concept:

Aquatic animals, including hellbenders and their relatives around the world, need clean water to survive. Even small changes to aquatic ecosystems can harm the animals that depend on them.

Hellbenders are a member of the giant salamander family (also known as the Cryptobranchidae). The Japanese giant salamander (*Andrias japonicus,* up to 5 ft. long and 55 lbs.) and several highly endangered species of Chinese giant salamander

The giant salamander family has been around since the Jurassic (middle period of the Age of Dinosaurs). Salamanders related to hellbenders and Asian giant salamanders were roaming the planet at the same time as dinosaurs like Stegosaurus! If you visit the Time Spiral during your trip to the Arboretum, the Jurassic period is marked by the fifth medallion back from the center of the spiral.

The Time Spiral in the children's garden. The yellow arrow points to the medallion indicating the Jurassic, the earliest time period from which fossil hellbenders are known.

THE RIDGE AND VALLEY SCULPTURE AND WATERSHED MAP

The Watershed Map. The closest line of boulders represents Tussey Mtn., and the most distant one represents Bald Eagle Mtn. The person in the picture sits on the boulders that stand in for Mt. Nittany.

The Ridge and Valley sculpture was created by environmental artist Stacy Levy. It depicts the Spring Creek **watershed**, a subdivision of the **Chesapeake Bay** watershed.

One of the things that makes the Spring Creek watershed special is that it sits at the **headwaters** of the Chesapeake Bay watershed. Headwaters are the point on a river that is farthest from the point where it joins another water course. All the water in the Spring Creek watershed arrives as rain or snow, rather than flowing in from an upstream source.

Water exits the Spring Creek watershed through a water gap in Bald Eagle Mountain and flows into the Susquehanna watershed, which ultimately empties into Chesapeake Bay. The bluestone pavers in the map are intentionally set at an angle so that water drains between the boulders, just as water in the Spring Creek watershed flows out through a gap in Bald Eagle Mountain and into the Susquehanna watershed. Start your visit by pouring a bottle of water on various parts of the map's channels, and it may be flowing off the map by the time you are ready to leave.

Please note that the map is not to scale. The channels representing water courses are intentionally larger-than-life, to make them easier to see. The boulders at the sides and center of the map represent Bald Eagle, Nittany, and Tussey mountains, and the spaces between the boulders depict water gaps, stream-carved passages which slice through the ridges. The sinuous channels depict permanent streams. "Bumpy" channels represent underground and intermittent water flow. Pits show the location of old iron mines.

Because the Spring Creek watershed sits at the headwaters of the Chesapeake Bay watershed, its waters are some of the cleanest in the entire system. There's no pollution spilling into our water from upstream. Pollution in our watershed is created by the people who live on the watershed and travels out of our watershed and into downstream communities.

Activities for the Watershed Map:

- "Where Do You Live?"
- "Wreck the Watershed"

Core concept:

The Spring Creek watershed sits at the headwaters of the Chesapeake Bay watershed. How we treat water within our watershed has the potential to affect everyone who lives in the watershed, as well as communities downstream all the way to the Chesapeake Bay.

BIG HOLLOW


View of Big Hollow from the rear of the Arboretum's Overlook Pavilion

Big Hollow is visible from the rear of the Overlook Pavilion. It is an **underdrained valley** in which water flows underground rather than in a surface stream.

Some of the water in Big Hollow's wells comes from water that filters into the soil in the Marsh Meadow.

The Arboretum's Hartley Wood is visible from the Watershed Map. This patch of forest contains some trees that started growing before the first European settlements were built in central Pennsylvania and provides an opportunity to imagine our region when it was covered by forest.

Iron mining and refining were major industries in central Pennsylvania from the mid-1700s until the mid-1800s. Charcoal-fired iron furnaces consumed about an acre of wood per day, resulting in rapid destruction of the region's forests. Forest clearing opened the land for agriculture, which prevented forest regrowth. The Hartley Wood is a rare survivor of the area's iron smelting and agricultural past.

State College remained largely agricultural until the 20th century, when the town surrounding the University started to expand rapidly. Expansion of impervious surfaces (houses, roads, sidewalks) transformed the watershed by diverting water into ditches, storm drains, and channels. New types of pollution became problematic, including sewage and chemical wastes. As we learned at the Watershed Map, pollution in the Spring Creek watershed comes from the Spring Creek watershed.

Core concept:

Big Hollow presents an opportunity to think about the history of our region and how human settlement has impacted regional water quality.

POLLUTION CASE STUDIES

Below are examples of how pollution affects the Spring Creek watershed.

FISH KILLS

Large die-offs of fish are a part of the Spring Creek watershed's history. Many of them were linked to low levels of oxygen in the stream stemming from aquatic plant overgrowth fueled by sewage and phosphate pollution. Improved sewage treatment and reduced levels of phosphates in detergents have mostly eliminated fish kills stemming from low oxygen levels.

Chemical spills are another notable source of fish kills. The most infamous incident occurred in 1957, when someone at Penn State's Naval Research Laboratory disposed of sodium cyanide by dumping it down a sink. Untold numbers of fish and other aquatic organisms died by poisoning, including around 147,000 fish at the Benner Spring and Bellefonte hatcheries, indicating that the spill was still toxic 10 miles downstream from the point where the sodium cyanide was dumped.

https://www.fishandboat.com/Fish/PennsylvaniaFishes/Trout/Documents/fisherySpringCreek.pdf

CENTRE KEPONE SUPERFUND SITE

The Nease Chemical Company's chemical manufacturing facility produced pesticides called kepone and mirex. Waste from the pesticide manufacturing process were sprayed on an irrigation field and also stored in drums. The drums leaked, and waste flowed into Spring Creek. High levels of pesticide residues in the fish led to portions of the creek being designated catch and release only until 2001, and the site was designated as a Superfund site in 1983. Elevated levels of chemical waste remain in the groundwater, including in plumes flowing out of the site.

https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.Cleanup&id=0300444#bkground

SKYTOP RIDGE

Excavation for I-99 on Skytop mountain exposed a deposit of rock rich in the mineral pyrite (fool's gold). When pyrite is exposed to water and oxygen, it forms sulfuric acid. Shortly after the pyrite-rich rock was exposed, water with the pH of battery acid began to flow into nearby streams and wells. A large volume of rock had to be removed from the site and dumped along with limestone intended to help neutralize the acid. The remediation of the pyrite-rich rock added two years and around $83 million dollars to the construction costs for the road.

https://www.nytimes.com/2008/12/28/us/28highway.html

KEY CONCEPTS GLOSSARY

Carbonate: a mineral containing CO_3^{2-}. When exposed to acid, minerals that contain carbonate undergo a chemical reaction that results in CO_3^{2-} dissolving into an aqueous solution.

Chesapeake Bay: a shallow body of water lying between the Delmarva Peninsula and the North American mainland. This highly productive ecosystem is the source of many commercially important fish and shellfish species. Pollution flowing into the bay from the Chesapeake Bay watershed has caused the decline of many animal and plant species in the bay.

Headwaters: the point on a stream or river that is farthest from its junction with another water course; the source of a stream or river.

Impervious surface: a surface covered by a water-resistant material like rock, asphalt, or concrete. Roads, driveways, houses, and parking lots are examples.

Precipitation: water that falls from the sky as rain, snow, sleet, or hail.

Surface runoff: water from rain, snow, or other sources that flows over the land surface before reaching a watercourse like a stream or river.

Underdrained valley: a valley in which water flow occurs under the land surface.

Weathering: changes in color, texture, form, or chemical composition of rocks and other earth materials resulting from exposure to weather conditions.

Water Gap: a gap that cuts across a mountain ridge, containing a stream or river.

Watershed: an area of land where all water courses drain out to a common outlet. Also known as a drainage basin or cachement.

ACTIVITIES FOR STUDENTS

The following activities have been developed by the Arboretum to complement field trip experiences. Some, like “Percolation Education” and “Acid-Base Reactions,” are best carried out in the classroom. Others, like “Wreck the Watershed,” can be carried out while you are at the Arboretum.

PERCOLATION EDUCATION

Goal: To get students thinking about how the surface connects to the groundwater, and how water flows at the surface and underground.

Materials: Sand, clay, gravel, broken rock, clear plastic containers (soda bottles with the top cut off work well), and water.

Procedure: Construct various soil profiles by pouring layers of sand, gravel, rock, and clay into clear plastic containers. Vary the position of the materials and thickness of the layers. Have students come up with a hypothesis about how fast water will flow through various layers.

Result: The larger the grain size, the faster water will flow through the material. Water will flow very rapidly through gravel and broken rock, fast through sand, and very slowly through clay. The smaller the space between individual particles, the slower the water flows.

Follow-up Question: Ask students to predict how fast water would flow through a completely solid surface like a road or driveway. (Very slowly or not at all)

How it Applies: Areas where there are plenty of voids in the soil and bedrock let water flow into the ground faster than areas where the soil has lots of clay or where there is a lot of pavement.

ACID-BASE REACTIONS

Goal: To get students to think about what happens when mildly acid rainwater hits basic limestone.

Materials: Baking soda (sodium bicarbonate, base, solid), vinegar (acetic acid, liquid), container.

Procedure: Place a small amount of baking soda in the container and add a small amount of vinegar. The mixture will bubble as the reaction between acid and base releases gaseous carbon dioxide. Add more vinegar until the reaction is finished and no more bubbles form. At this point, you should be left with a dilute solution of sodium acetate, and there will be little or no solid material left in the container.

Application: The acid-base reaction you just performed is similar to the reaction between limestone (base) and rainwater (acid).

SNOT OTTERS NEED CLEAN WATERS/BE A HELLBENDER DEFENDER

Goal: To educate children about hellbenders, their need for clean water, and their connection to their endangered relatives in Asia.

Activity: Have students locate the animal sculptures in the children's garden and determine which animals are most dependent on water resources. Focus in on the hellbender salamander (*Cryptobranchus alleganiensis*), Pennsylvania's state amphibian. Have students craft their own paper hellbender and write some interesting facts on the back.

WHERE DO YOU LIVE?

Goal: To have students think about where they are on planet earth.

Activity: Have students locate where they are standing now and where their school or house is on the map.

Questions for students: "Where are we now?" "Where do you live?" "What mountain is closest to your house?" "What stream is closest to where you live?"

WRECK THE WATERSHED

Goal: To familiarize students with types of watershed pollutants, demonstrate the cumulative nature of pollution, and get students thinking about how what we do upstream affects downstream areas.

Activity: Have students stand along stream channels on the Watershed Map, from upstream areas near the mountains to the watershed outlet (water gap) in Bald Eagle Mountain. Give each student a pollution token (e.g., animal waste, fertilizer, litter, oil spills, chemical wastes). Have students hand their tokens downstream until all tokens are collected by the person standing at the watershed outlet, to demonstrate how pollution accumulates in a watershed.

Making it personal: Ask students questions like "Who likes to eat fish/oysters/crab cakes/ sushi?" Ask them how pollutants disposed of in their local watershed could affect the animals downstream, particularly in the Chesapeake Bay where all streams and rivers in the watershed end.