Phinizy Swamp Nature Park
Teacher Field Trip Preparation Guide

Program: Hydromania

The following academic standards are covered on this field trip:
GPS6: CS1, CS2, CS4b, CS5, E3a, E3b, E5i, E5j, E6b
GPS7: CS1, CS2, CS4b, CS5, S7L4c, S7L4e
GPS8: CS1, CS2, CS4b, CS5, S8P1c, S8P1e, S8P1f
S.C. Science Standards: 6-4.2; 7-1.1, 1.7, 4.3, 4.5, 4.6; 8-1.6, 8-1.7

Objectives: To understand the urban water cycle, how water moves in a watershed, and how this relates to pollution and water quality.

Vocabulary:

Aquifer: A geological formation that can store enough water that it may be used as a well or spring. The underground formation is made up of sand, gravel or permeable rock resting upon a layer of impermeable material, such as clay.
Buffer Zone: An area of land dividing one land use from another, such as wildlife habitat from a commercial area.
Condensation: A change from a vapor to a liquid.
Deposition: A change from a vapor to a solid, without passing through an intermediate liquid phase.
Erosion: Describes the wearing away of the earth's surface by the action of wind, water, or ice.
Evaporation: A change from a liquid to vapor.
Evapotranspiration: The movement of water from a plant by direct evaporation and transpiration into the atmosphere.
Groundwater discharge: Occurs when water that leaves an aquifer and flows to the surface. This happens when the water table meets the land surface and water emerges as springs or seeps.
Groundwater recharge: Occurs when water from precipitation infiltrates down through the soil and into groundwater.
Hydrology: The study of the movement of water on the planet. A scientist who studies hydrology is called a hydrologist.
Infiltration: To enter or filter into or through something, such as precipitation entering soil.
Impervious: Describes a material that water cannot infiltrate, such as concrete or asphalt.
Municipal: Belonging to the people of a community, such as a wastewater treatment plant or public library.
Non-point Source Pollution: Surface water runoff containing pollution from many sites.
Nutrient: A substance that nourishes and promotes growth.
Pathogen: A microorganism that causes disease.
Percolation: The gravitational movement of water through the soil.
Point Source Pollution: Pollution that enters a body of water from a specific point, such as a pipe.
Pollution: Contaminants or impurities deposited on land or in air, water, or soil.

Potable: Describes water that is safe and suitable for drinking.
Precipitation: A deposit on the earth of hail, mist, rain, sleet, or snow.
Residence time: The length of time water remains in a particular location in the water cycle.
Retention pond: A man-made pond that holds storm runoff, usually from a nearby paved area such as a large parking lot, in order to minimize the impacts of flooding, sedimentation, and pollution on nearby natural waterbodies.
Runoff: Rainwater that flows over land and into a body of water, usually carrying contaminants deposited on the land surface.
Sediment: Small particles of clay, soil, sand, or organic matter.
Silt Fence: A barrier, usually made of plastic liner held with posts, designed to block sediment from entering a nearby water body. Silt fences are often at construction sites.
Sublimation: A change from a solid to a gas without passing through an intermediate liquid phase.
Transpiration: The release of water from plant leaves into the atmosphere.
Urban: Of or relating to a city or a community with a large number of people.
Urban Water Cycle: The movement of water through air, land, and waterbodies of the planet, as well as through man-made structures, such as storm drains, retention ponds, septic systems, homes and businesses, irrigation systems, and wastewater treatment plants, among others.
Waterborne disease: An illness spread through contact with water contaminated by pathogens.
Water Cycle: The continuous movement of water around the air, land, and waterbodies of the planet.
Watershed: The land area from which water, sediment, and dissolved materials drain to a common point along a stream, wetland, lake or river.
Water Table: The level below which soil is completely saturated with groundwater. Water tables rise and fall with seasonal precipitation, water absorption by plants, and the withdrawal of groundwater from wells, among other factors.

Teacher Background Information:

About the Urban Water Cycle

The **water cycle** (sometimes called the hydrologic cycle) is the continuous movement of water through the land, air, and water bodies of the planet. The **urban water cycle** also includes the passage of water through various man-made structures and systems, such as sewer pipes, irrigation systems, swimming pools, homes and businesses, drinking water and wastewater treatment plants, and retention ponds, among others.

- In an urban water cycle, impervious surfaces, such as roads, buildings, sidewalks, and parking lots, increase the amount of storm runoff in an area, which can increase flooding. Furthermore, impervious surfaces don't allow precipitation to infiltrate the soil to allow groundwater recharge or natural filtration of pollutants from runoff.
- Water in urban areas is impacted by non-point and point source pollution, further threatening water quality.

Water can exist in three states of matter

Water exists in three states: liquid, solid, and vapor (gas).

- In the solid state, water exists as ice and snow and can be found in massive amounts in the glaciers and in polar and alpine regions.
- Water in the gas or vapor state is easily felt on days of high humidity and seen in the clouds, fog, steam from boiling water, or the vapor trail left by a passing airplane.

- The liquid state of water is the one we are most familiar with and it includes everything from oceans, rivers and lakes, and rain to drinking water.

Movement through the water cycle

Water is in constant motion, changing from liquid to solid or vapor and back again. Ways in which it moves include:

- **Precipitation:** The process by which water falls from the sky as rain, snow, sleet, or hail. As the amount of water vapor in the atmosphere (known as humidity) increases, it eventually changes to a liquid or solid and falls to the Earth as precipitation.
- **Condensation:** The process by which water is changed from a vapor to a liquid. As humid air cools, water vapor condenses to form clouds, dew, condensation on the outside of a cold cup, or even fog on your glasses as you walk from an air conditioned room to the humid outdoors.
- **Evaporation:** The process by which water is changed from a liquid to a vapor. As air temperature rises allowing the air to hold more water vapor, liquid water from oceans, rivers, lakes, body sweat, or even rain water on an asphalt surface vaporizes into the atmosphere.
- **Absorption:** Describes the process by which a plant takes up water from the soil through its roots, as well as the action of an animal drinking water.
- **Surface Runoff:** Describes precipitation that falls to the ground and flows over the landscape, eventually ending up in creeks and rivers. As this water flows over the land it can pick up many pollutants, such as sediment and pesticides.
- **Infiltration:** The process by which liquid water enters the soil.
- **Percolation:** The process by which water travels down through soil and into groundwater.
- **Subsurface Flow:** The horizontal flow of water, either through soil or groundwater, beneath the Earth's surface. Water that enters the soil and groundwater can flow both laterally and downward to a point of lower elevation. This subsurface flow often re-emerges in a spring, seep, or body of water.
- **Stream Flow:** Streams, creeks, and rivers flow downstream by gravity in a process known as stream flow. Small creeks empty into bigger creeks, bigger creeks empty into rivers, and rivers flow to the oceans.
- **Sublimation:** The process by which water as a solid converts into the gas state with no intermediate liquid state. Snow and ice often change into water vapor in the air without first melting into a liquid.
- **Deposition:** The process by which water vapor converts to a solid without passing through the liquid state. An example of deposition is the formation of frost on a leaf. As the humid air cools to below 32°F, frost will form on the leaf without first condensing into liquid dew.
- **Transpiration:** The process by which liquid water is transported up the stems of plants and released to the air as a vapor. Water and nutrients from the soil are absorbed by plant roots and drawn up into leaves and stems. Some of this water is returned to the air by transpiration.
- **Evapotranspiration:** The process by which water is discharged to the atmosphere as a result of evaporation from the soil and transpiration by plants. During a rain, some liquid water will land on plants. After the rain, this water can evaporate into the air. Some

water may also transpire from the plant. The combination of the evaporation and transpiration is known as evapotranspiration.

- **Groundwater Discharge:** The process by which liquid water is discharged to the earth's surface from groundwater, either becoming surface runoff or entering into a waterbody.

Residence time

Although water is constantly moving throughout the water cycle, under certain conditions, it is possible for water to remain in a particular location for an extended period of time, known as the residence time. Approximate residence times for water molecules at different locations are listed below (modified from Project WET 2.0):

- Oceans and seas: 4,000 years
- Groundwater: 2 weeks to 10,000 years
- Lakes and reservoirs: 10 years
- Icecaps, glaciers, and permafrosts: 1,000 to 10,000 years
- Soil: 2 weeks to 1 year
- Rivers: 2 weeks
- Atmosphere: 10 days

Several factors determine the residence time of water at different locations. Whether a molecule of water stays in the groundwater for a few weeks or several thousand years will depend on how deep the groundwater is as well as how close it is to a lake, spring, seep, or well. How long a molecule of water stays in the soil will depend on the type of soil, the types of plants in the soil, and weather, among many other factors.

Soil infiltration and surface runoff

Soil infiltration rates are influenced by many factors:

- **Topography** -- On a steep slope, water is more likely to quickly flow downhill. The presence of vegetation on the slope could slow this downhill surface runoff. On flat land, the water is more likely to puddle, allowing more time for infiltration.
- **Soil type** -- Water moves through bigger holes faster, so soils with large pore spaces (such as sandy soils) tend to have higher infiltration rates than soils with small pore spaces (such as soils with high clay content). Water saturated soils (due to a high water table or recent heavy rains), however, tend to be impermeable regardless of soil type.
- **Storm intensity** -- During a heavy downpour more stormwater is likely to become surface runoff than during a light, all-day continuous rain. This happens when the rate of rainfall is faster than the soil infiltration rate. In other words, the rain is falling faster than it can soak into the soil. As a result, pore spaces become filled with water quickly and the rest of the rain becomes surface runoff.
- **Impervious surfaces** – Water landing on impervious surfaces (surfaces that water cannot infiltrate) ---such as parking lots, roofs, streets, and patios---either evaporates or becomes surface runoff. The more impervious surfaces located in a watershed, the less chance for water to infiltrate the soil to recharge groundwater, and the greater the chance for surface runoff and flooding.

About Water Availability

Distribution of water on Earth

- More than 70% of the Earth's surface in covered in water, however, there is a limited amount of water available for consumption.

- Approximately 97% of the planet's water is in the ocean and is unavailable for drinking. 2.5% of the water is stored on land and .001% is contained in the atmosphere
- Of the 2.5% stored on land, about 79% is ice (glaciers and sea ice), 20% is groundwater and 1% is surface water. In other words, about 2% of the water on Earth is frozen.
- This leaves only 0.5% of the water on Earth stored in the watersheds (groundwater and surface water). In fact, less than 0.03% of the Earth's water is in streams, lakes, rivers, and wetlands. Think about how little drinking water there is left if our surface water becomes polluted!

Common pollutants in water include:

- Chemicals from pesticides such as herbicides, fungicides, and insecticides as well as chemical waste from manufacturing.
- Heat, which can kill organisms because hot water holds less oxygen.
- Litter.
- Sediment from construction sites, clearcut areas, and eroded stream banks, which clogs gills of fish and reduces light penetration to underwater plants.
- Excess nutrients, possibly coming from fertilizers on farmland and lawns. These can cause excessive growth of algae, which can use up all dissolved oxygen in a water body and cause other aquatic organisms to die out.
- Organic matter from septic tanks, wastewater treatment plants, or sewage spills. Certain types of organic matter can contain pathogens.
- Oil and gas.

Categories of water pollution

- **Point source pollution** is released directly into bodies of water such as through pipes from industry.
- **Non-point source pollution** originates from many points on the land surface and is washed into the water by rain or snow melt. Examples include soil that is eroded and washed into lakes, pesticides that wash into creeks, or heated water that runs off from parking lots and roads.

Methods to reduce water pollution

- **Silt fences** at construction sites prevent sediment runoff into nearby waterbodies.
- Farmers place fences adjacent to creeks and ponds to keep their livestock from entering the water to avoid contaminating the water with livestock feces.
- **Labels on storm drains** remind people to not dump unwanted items such as oil or paint that could end up in streams.
- **Wetlands** provide buffer zones between impervious surface areas and waterways that reduce erosion and sedimentation, remove excess nutrients from runoff, and provide wildlife habitat.
- **Retention ponds** are used to collect storm water runoff from impervious surfaces, such as large parking lots. Retention ponds allow sediments and other pollutants time to settle or be removed by microorganisms. Furthermore, water that has been unnaturally heated on a surface such as a parking lot has a chance to cool before entering a natural water body.
- **Public education** initiatives teach citizens how to maintain healthy water quality, such as using less fertilizer on lawns, not throwing grass clippings and other organic debris into

local waterways, proper disposal of cooking oil, motor oil, and household chemicals, composting waste, using eco-friendly cleaning products, picking up pet waste, etc.

About Watersheds

Watershed basics

- A watershed, also called a catchment area or a drainage basin, is the land area from which water, sediment, and dissolved materials drain to a common point along a stream, wetland, lake or river.
- A watershed catches precipitation and stores it in a stream or water body. The precipitation makes its way to the stream by surface runoff, subsurface flow, and groundwater discharge from the surrounding land (watershed).
- Most watersheds have an outlet or mouth where the water enters into a drainage system. The mouth may be where it flows into another river or stream (this point is known as a confluence), or the place where it empties into a lake, estuary, or ocean.
- Topography, the shape of the land surface, determines the boundaries of all watersheds. The highest points surrounding the stream or water body are called divides. Water (rain) falling on the other side of the divide will flow into a different watershed.

Watersheds come in all sizes

- Like creeks and rivers, watersheds vary in size and can be as small as a stream in your backyard or as large as the drainage basin for the Mississippi River.
- Large watersheds usually contain many smaller watersheds within them. The Butler Creek Watershed here at Phinizy Swamp Nature Park is part of the larger Savannah River Watershed.
- In North America some of our drainage systems enter the Atlantic Ocean, the Pacific Ocean, the Gulf of Mexico, and the Arctic Ocean. These drainage systems are separated by the continental divides.

Human impacts on watersheds

- Humans have been altering watersheds since ancient times. Roman aqueducts often carried water from one watershed and deposited it in another watershed several miles away.
- Humans often alter watersheds when they create a dam, build a channel to connect two water bodies, mine a mountain top, bring in or take out fill dirt, or put in a culvert.
- As human demand for water increases due to population growth and the demand for more power, irrigation and recreation, so does the need to alter the watershed we live in. Some of these changes have brought improvements, but many have been harmful.
- Humans add many types of pollution to the land such as pesticides and herbicides (non point source) and directly into water by pipes from factories and wastewater treatment plants (point source). These pollutants affect the quality of the watershed.
- Humans remove vegetation from the landscape and add cement and asphalt, which increases the amount of impervious surface, causing water to flow more quickly into water bodies and have less opportunity to infiltrate into the soil. This also causes more flooding of streams and rivers as well as erosion and heavy sediment loads to streams.

About Water Conservation

How water is used

- The majority of available freshwater is used:
  - In agriculture for irrigation and livestock. More water is used for agriculture than for any other purpose.
  - To generate electricity.
  - In homes, schools, and businesses.
  - For industry and mining.
- Water in the home is consumed by:
  - Watering lawns and gardens. This is the single largest residential use of water.
  - Flushing toilets.
  - Washing laundry.
  - Showers, bathtubs, and sinks.
  - Dishwashers.
  - Leaking pipes and faucets.
- A significant amount of water is used to grow, process, and produce commodities. According to the Water Footprint Network, producing one cotton t-shirt consumes 713 gallons of water (source: www.waterfootprint.org; accessed Sept. 2011).

Why conserve water?

- Conserving water saves energy and money. Energy is needed to pump water into homes and to heat water for baths, showers, dishwashers, and washing machines.
- Efficient water use makes it easier for a community to withstand and recover from a drought.
- Conserving water lessens the demands on municipal drinking water and wastewater treatment facilities, eventually leading to lower water and sewer bills.

Simple ways to conserve water include:

- Water lawns in the early morning or at night to minimize water lost to evaporation.
- Use a rain shutoff switch with automatic sprinklers to avoid watering in the rain.
- Use native plants and grasses in gardens and yards to reduce the need to water.
- Water your lawn with rain collected in a barrel.
- Turn off faucets when brushing teeth.
- Use water-efficient appliances.
- Fix leaky toilets, faucets, and pipes.
- Minimize time spent in the shower.
- Keep a container of water in the refrigerator so cold water is always available, eliminating the need to run the faucet until the water is cold.
- Wash full loads when using the dishwasher and washing machine.