The Water Cycle

Program Purpose:
The purpose of this program is to introduce students to the components and importance of the water cycle, and to demonstrate how groundwater moves using a model.

Program Length: 1 ½ hours

Age: Grades 3rd -8th

Maximum Number of Participants: 25

Outcomes/Goals:
After completion of this activity students should be able to:
- List 9 places on earth where water is found.
- Define the terms cycle and water cycle.
- Explain how energy from the sun powers the movement of water molecules through the water cycle.
- Be able to describe the five processes through which water molecules move through the water cycle.
- Explain how groundwater enters, moves through, and exits the soil.
- Identify four sources of pollution to groundwater.
- Describe 3 ways humans can conserve water.

Preparation:
Before the class arrives:
- Obtain the "Water Cycle" kit from the storage room and set up the "Incredible Journey" game in the exhibit room
- Set up the groundwater model. Make sure buckets are placed so that water can enter and leave the model.
- Have dyes and syringes on hand for use during the groundwater model demonstration.

Materials:
Dry erase board and markers
Water cycle poster
Nine "Incredible Journey" dice and posters, set up in stations
One "Incredible Journey" sheet per student
Box of pencils
Earth beach ball and Earth Jar
Groundwater Model and related materials:
- two lengths of rubber tubing connected with Y-junction
- two buckets
- electric water pump
- extra large jug of water
- wet erase marker
- 3 bottles of dye
- 3 syringes

Basic Outline:
I. Introduction (5 min)
II. The Water Cycle (15 min)
III. Water Pictionary (5 min)
IV. "The Incredible Journey" game (25 min)
V. Earth Jar (5 min)
VI. The Groundwater Model (25 min)
VII. Review/Conclusion (5 min)

Introduction:
Write a favorite water quote or water fact up on the board before the class arrives (Appendix A). Introduce yourself to the class and if time allows have them tell you their name and a way they use water. Write these things up on the board

Say that it is obvious we depend on water for everyday use and without it we wouldn't survive. Explain that today they are going to learn about where all this water comes from that they use everyday and how it travels all over the Earth. They will play a game where they will "become" water molecules, and write a story about their journey through the water cycle. Finally, they will learn what groundwater is and how as humans we affect it.

The Water Cycle:
Ask the students what are the nine places where we can find water on the earth? (*Hand out the "Water Cycle" worksheet to the students along with pencils. They should draw whatever is up on the board, along with the terms that correlate)*

Have them help you draw these things up on the board.
Clouds, Glaciers, Rivers,
Plants, Groundwater, Soil,
Animals, Lakes & Oceans

Explain that water is constantly moving from place to place. This process is called a cycle. It may be helpful to use an analogy, like a bicycle, which has two wheels that go around and around.

- *A cycle is a process in which any material moves round a system.*

Tell the students that today we are going to talk about the water cycle.

- *The water cycle is the process by which water travels to and from the nine places where it exists on earth.*

There needs to be an energy source in order for this cycle to work. Ask the students what is going to power the water cycle? The Sun!! Draw it up on the board with the other nine water sources. Explain that with out it our water wouldn't move!

Ask the students how water moves in the cycle? How does water get from a puddle up into the sky or from the sky into a tree? Have them draw with arrows on the board and correlate the proper terms that go with it. Fill in the gaps if they run out of ideas so that all the terms below are covered.

CONDENSATION: The process by which water changes from a gas into a liquid.
Cooling of water vapor to become liquid.
As water vapor rises into the atmosphere, it cools and turns back into liquid water.
Examples: Vapor cools as it rises in the atmosphere. Clouds form at heights and fog forms at ground level. Clouds are just condensed water in the atmosphere, as is fog. Small droplets merge to form larger droplets, which may lead to dew from fog or rain from clouds.

EVAPORATION: The process by which water changes from a liquid to a gas.
Say you walked to school and there was a puddle on the sidewalk and when you left school it was gone? What happened to the puddle? The heat from the sun changed the liquid water in the puddle into water vapor, or water in its gaseous state.
Examples: Steam. Water can evaporate from Lakes, Glaciers, Rivers, Soil, Animals, and Oceans.

INFILTRATION: The process by which water enters the soil and groundwater by moving in between soil particles.
Ask the students to raise their hand if they have heard the term used in the movies that they are going to infiltrate the enemy? This means that they are going to "move in" on them. In the water cycle, the water is moving into and through the soil. Plant roots may then remove water in the soil or it can exit via rivers, lakes, and oceans. We will look at this more with the groundwater model demonstration.

PRECIPITATION: Water that falls from the atmosphere onto the earth's surface. Precipitation falls from clouds when the condensed water droplets become heavy enough for gravity to pull them down to earth. Precipitation can return water to Glaciers, Rivers, Soil, Lakes, and Oceans.
Examples: It can take the form of rain, snow, sleet, and hail.

TRANSPIRATION: The process by which plants give off water vapor through pores (stomata) in their leaves.
The trees let off their "sweat" back into the atmosphere. This is also called evapo-transpiration.

Water Cycle Review:
Use these riddles to review the water cycle terms.

Below the surface of the Earth
In between particles of dirt
That's where this water is found
Saturating everything deep underground
-Groundwater

In between and all around
Through the soil without a sound
Water seeping down down down
Slowly moving underground
-Infiltration

Heat from the sun makes water rise
Up as vapor to the skies
-Evaporation

Cumulus, stratus, cirrus too,
Water vapor visible in skies of blue
-Cloud

Down is the direction this water falls
As crystals, drips or even balls
-Precipitation

Once a gas but then it's changed
Into a liquid to be seen again
-Condensation

From the pores of plants
water vapor escapes
Into the air without a trace
- Evapo-transpiration

Water going round and round
Changing form but not amount
-The Hydrologic Cycle

Water Cycle Pictionary:
To explain some additional terms within the water cycle play a game of pictionary where the students have to guess a "water term" that their classmate is drawing. Explain to the students that the words all have to do something with the water cycle. Choose words that are age/ability appropriate.

Here are some words you can use:

Acid Rain	Well	
Hail	Flood	Drought
Snow	Roots	Fertilizer
Glacier	Leaf	Runoff
River	Landfill Soil	Dam
Lake	Wetland	

"The Incredible Journey":
Tell the students now that we know where the water can go and how it gets there, they are going to transform into water molecules themselves and take the incredible journey of a water molecule. You never know where nature might take you!

Give each student an "Incredible Journey" sheet and pencil. Students will start at a station (one of the nine places on earth where water is found). As they move from station to station they will record their journeys (all the places they have visited) on their sheets. Further instructions can be found as an attachment to the lesson plan.

Tips:

- Make sure that they are in pairs
- Remind them to keep dice by the picture
- Tell them if they roll "Stay" four times then they can move on to another picture on the dice
- Explain the cloud part thoroughly
- Set up a time when everyone will be finished, they might not get a chance to fill up all 15 lines

When finished, students will each write a story about their personal journeys through the water cycle. They can be as creative as they want and explain that they should be using the "tion" words (evaporation, condensation, etc.) in the story of what happened to them. An example to give them is that they started out in the ocean, they saw a shark go by and luckily they evaporated into the sky. They floated around in the sky as a cloud for a while until they precipitated as a raindrop. If they need help figuring out how they got from one place to the next, there is a great "water cycle table" in the Incredible Journey lesson that can help out. Invite students to share their stories to each other.

Earth Jar:
Ask the students how much of the Earth is covered by water? Hold up the Earth beach ball as a reference. About 70%! Show the Earth jar to the students and tell them that we are going to pretend that the jar contains all the water on the Earth. Ask them where most of it is located? Ninety-seven percent of the water on Earth is saltwater. Dump about 97% of the water from the jar into a bucket until you have approximately 3% left. This 3% represents all of the freshwater on Earth. Ask them if all of the fresh water is available for us to drink? Why not? Talk about water frozen in glaciers and ice caps. Now take an eye dropper and drop one drip of water into a tin can. Explain that all of the fresh water available to people from the surface or the groundwater of the Earth (~0.6%) is represented by that one drop out of that entire jar of water.

The Groundwater Model:
Freshwater is very precious on Earth. Ask the students if they know where their drinking water comes from? Let them know that it probably comes from groundwater. Seventy percent of Wisconsin's drinking water comes from groundwater. Some people call it Wisconsin's buried treasure. Tell them that many people have no idea what groundwater is and think that it is some underground river that we tap into. Today they are going to learn exactly what it is and how humans affect it.

Plug the groundwater model motor in and explain that we are looking at a slice of the Earth with the grass on top and soil down below. Have them watch as the water infiltrates through the model.

<u>The Hydrologist</u>
Ask for a volunteer to come up and be a hydrologist. Tell them that a hydrologist is a person that studies water. Have the volunteer measure where the water table is by having them mark the level in each piezometer (pea-zom-a-tur). Explain that piezometers are wells that are installed to monitor groundwater. Then have them connect all the lines, which will represent the water table. Explain that below the line that they have drawn, the ground is saturated with water….which is called groundwater!! Ask the hydrologist if they can tell which way the water is moving? Because of gravity, groundwater flows in a downhill direction. It isn't in a visible river or channel underground, which is what most people think.

Important Concepts: Definition of water table and piezometer. Water flows from areas of high elevation to areas of low elevation.

<u>The Rain</u>
Another misconception is that our groundwater source is from far away like Lake Superior. Have another student come up and be the rain and dump water at the top of the model. Have them watch the water as it infiltrates down into the groundwater. Tell the students that if they were to stand up on the roof of their house that they would be able to see where their water is coming from….just a couple of miles from around their house.

Important concept: Groundwater generally comes from nearby sources.

Farmer Joe or Jane
Have a student be a farmer. Have the student "overspray his/her fields" with a syringe full of dye into a piezometer or a well because he really wanted his/her plants to grow extra good this year. Have the kids predict what is going to happen next. It should leak out of the piezometer/well and into the groundwater.
The dye will also give them an opportunity to see the definite movement of groundwater from one side to the other.

Explain that most groundwater pollution starts out at or near the surface of the ground. Ask the students if there are other sources of pollution that might be similar to this situation? (ex. Lawn with fertilizer, underground storage tank for gasoline or fuel, a septic system, manure pit, or landfill) We won't even realize that this type of pollution is happening and it is hard to detect the source to prevent it!

Important Concept: Groundwater pollution can happen easily.

Upham Woods Camper
Ask the students who is feeling thirsty? Have that person be the Upham Woods camper. Give them a syringe and have them start drawing the water out of the shallow well (the one that is two away from the lagoon with a square bottom). Have the kids predict what is going to happen next! Have the thirsty camper keep drawing water from the well until you can see dye in the water.

Find another person that is thirsty. Say that this person thought their well would be safe because they were at a higher elevation from the farmer field. Ask the students if they think he will get polluted water? Why or why not? Have them pump with the syringe from a piezometer to the left of the leaky lagoon for a while. The dye should start to move backwards a bit and will eventually contaminate their drinking source, as well. We can actually change the direction that the groundwater flows by pumping on a well.

Discuss with the students about how pollution can enter our drinking sources. What can we do to prevent this? (placing wells in good locations…not near septic or landfill, have hydrologists periodically check our drinking water, stricter regulations on what is put on the ground, etc.)

Reiterate the point that pollution within a couple of miles from their house affects their water.

Important Concept: Humans can contaminate their own drinking water source.

Bottled Water Company Worker
Get another volunteer who would like to make money. Explain that today people like to get extra-clean artesian water and will pay lots of money to have it. So our bottled water person is looking for a place to drill a well to get the cleanest water. Ask where would they advise the company to drill the well? Hopefully, the students will get to the fact that they might want to drill deeper.

Show the confining layer of clay that separates the upper sand layer and the artesian or confined aquifer below. The clay doesn't let water or pollutants through very easily. That is why clay liners are used for landfills. So sometimes wells at different depths can have very different water quality. Ask them if this source of water can get polluted, too? Yes, it can. What if Farmer Joe or Jane decided to dump old gasoline down one of their old, deep wells? Demonstrate this.
Wells are a direct connect from the surface of the Earth to our groundwater, so we need to be extra careful with those!

EPA Superfund Site Manager
Select a student as an EPS superfund site manager. Explain than an abandoned well has allowed some spilled gasoline to leak into the confined aquifer. Explain that the whole city draws water from this well. How can the site be cleaned up and the water be made safe for the city to drink? Have the student take the syringe and start sucking out of the same well that the gas was dumped down into until all of it is gone. Have them do this in the upper groundwater area as well to clean up any dye that was left. Give the EPA person a round of applause for cleaning up our water!

Important Concept: It is possible to try to clean up contaminated groundwater.

Conclusion:
Ask the students if they now view their connection to the water cycle any differently? If so, in what way?

In summary today what did we learn?
1. Groundwater is a local resource that comes from rain and snowmelt.
2. It moves underground, but not in an underground river.
3. It is affected by what we do at the surface of the earth.

What actions can they take in their community? Do they feel water conservation is important? What is one action they can take at home to conserve water? Write these ideas up on the board.

Here are some ideas:
- Treat water as though our lives depend on it, because they do!

- Conserve water in their home
- Repair dripping faucets
- Plant plants in your yard that consume little water.
- Turn off water when brushing your teeth
- Place a layer of mulch around trees and plants to retain water
- Clean sidewalks with a broom instead of a hose
- Hold a clean-up day around a local lake, river, or reservoir
- If you use pesticides or fertilizers, follow the directions
- Become aware of alternatives to using hazardous household chemicals.
- Follow procedures for using, storing and disposing of household chemicals

To clean up groundwater model:
Make sure all the dye is gone from the model before you unplug the motor!

References:

The Groundwater Foundation. 2005. www.groundwater.org.

"The Incredible Journey," Project WET Curriculum and Activity Guide, p. 161.

The Illustrated Dictionary of Ecology and Plant Life, Merilyn Holme, ed. 1993. ASBN 1-85737-002-3.

"Using the Groundwater Model," Upham Woods Lesson plan, adapted from original version by Chris Mechinech, UW-Stevens Point Groundwater Center.

"Water's Wonders." Trees for Tomorrow Lesson Plan. Eagle River, Wisconsin.

Appendix A
Water Quotes

"When the well is dry we know the worth of water."
- Benjamin Franklin

"To stick your hands into the river is to feel the cords that bind the earth together in one piece."
- Barry Lopez

Water is life's mater and matrix, mother and medium. There is no life without water."
- Albert Szent-Gyorgyi, Hungarian biochemist and Nobel Prize Winner for Medicine.

"In an age when man has forgotten his origins and is blind even to his most essential needs for survival, water along with other resources has become the victim of his indifference."
- Rachel Carson

"Civilization has been a permanent dialogue between human beings and water."
- Paolo Lugari (founder of the Gaviotas Community in Colombia)

"Water is the most basic of all resources. Civilizations grew or withered depending on its availability."
- Dr. Nathan W. Snyder, Ralph M. Parsons Engineering

"If we could ever competitively, at a cheap rate, get fresh water from saltwater, ..(this) would be in the long-range interests of humanity which could really dwarf any other scientific accomplishments."
- John F. Kennedy

"Throughout the history of literature, the guy who poisons the well has been the worst of all villains..."
- Author unknown

"Thousands have lived without love, not one without water."
- W.H. Auden

"If there is magic on this planet, it is contained in water"
- Loran Eisley (Anthropologist), The Immense Journey, 1957

"The frog does not drink up the pond in which he lives."
- American Indian Saying

"Water links us to our neighbor in a way more profound and complex than any other."
- John Thorson

"In every glass of water we drink, some of the water has already passed through fishes, trees, bacteria, worms in the soil, and many other organisms, including people... Living systems cleanse water and make it fit, among other things, for human consumption."
- Elliot A. Norse, Animal Extinctions

"Water is the driver of Nature."
- Leonardo da Vinci

Appendix B
Water Cycle Vocabulary

aquifer: the geologic formation of sand, soil and gravel where groundwater is stored.

biodegradable: capable of being broken down by living things like microorganisms and bacteria.

compost: fertilizing material consisting of organic, decaying matter.

condensation: stage of the water cycle when water transforms from a gas into a vapor and becomes suspended in the atmosphere, visually represented by clouds.

conservation: not wasting, using something wisely

contamination: an impurity in air, soil or water that can cause harm to human health or the environment

depletion: occurs when water is used faster than it is replaced; can cause a shortage

discharge: to expel; water that naturally moves from an aquifer to a surface stream or lake

drought: an extended period of dry weather

evaporation: stage of the water cycle when water transforms from a liquid into a gas

fertilizer: any chemical used to improve soil and promote plant growth

groundwater: water contained under the ground's surface, between particles of and in the cracks of sand, soil and gravel; a common source of water for drinking and irrigation

groundwater flow: the movement of groundwater beneath the earth's surface

hazard: something that is dangerous; unsafe

hydrologic cycle: see water cycle

infiltration: see recharge

irrigation: to supply water to crops, parks, golf courses and lawns

landfill: a low area of land that is filled in with layers of garbage and soil

overuse: using more than necessary; wasteful

permeable: any material that allows water to penetrate through

pollution: see contamination

precipitation: stage of the water cycle when water vapor molecules become too large and heavy to remain in the atmosphere and fall to the ground in the form of rain, snow, sleet, hail, etc.

quality: to be at a high degree of excellence; something that is good or well done

recharge: to increase the amount of groundwater through precipitation or surface water that absorbs into the aquifer, also called infiltration

recycle: to produce a new item from an old item; to reuse parts of

runoff: water that does not become absorbed by the earth but flows across the surface of the land into a stream or lake

saturation zone: the area where water fills the spaces between soil, sand and rock underground

seepage: to leak from

septic system: underground pipes and tanks that store and dispose of human waste

storage tank: container that stores potentially hazardous chemicals above or below ground

water cycle: the never-ending movement of water through the atmosphere, ground and back again; also called the hydrologic cycle

water table: the top of the saturation zone

well: a hole or shaft drilled into the earth to pump water to the surface

Appendix C
Water Facts

- 75 % of the earth is covered with water.
- 97 % of earth's water is in the oceans. Only 3 % of the earth's water can be used as drinking water. 75 % of the world's fresh water is frozen in the polar ice caps.
- Although a person can live without food for more than a month, a person can only live without water for approximately one week.
- The average person in the United States uses 80 to 100 gallons of water each day. During medieval times a person used only 5 gallons per day.
- It takes 2 gallons to brush your teeth, 2 to 7 gallons to flush a toilet, and 25 to 50 gallons to take a shower.
- It takes about 1 gallon of water to process a quarter pound of hamburger.
- It takes 2,072 gallons of water to make four new tires.
- Sources of water pollution include: oil spills, fertilizer and agricultural run-off, sewage, stormwater, and industrial wastes.
- Ancient Egyptians treated water by siphoning water out of the top of huge jars after allowing the muddy water from the Nile River to settle.
- Hippocrates, known as the father of medicine, directed people in Greece to boil and strain water before drinking it.
- In the 1950's scientists began to suspect that water might carry diseases. Although earlier treatment of water could make the water safer, it was mainly done to improve the taste, smell or looks of the water.
- The first United States water plant with filters was built in 1872 in Poughkeepsie, New York..
- In 1908, Jersey City, New Jersey and Chicago, Illinois were the first water supplies to be chlorinated in the United States.
- The Safe Drinking Water Act (SDWA) of 1974 represents the first time that public drinking water supplies were protected on a federal (national) level in the United States. Amendments were made to the SDWA in 1986 and 1996.
- One gallon of water is equal to 3.785 liters of water.
- One cubic foot of water is equal to 7.48 gallons of water.
- Water boils at 212^{o} Fahrenheit or 100^{o} Celsius.
- Water freezes at 32^{o} Fahrenheit or 0^{o} Celsius.

How much do we depend on groundwater?

- 22% of all freshwater withdrawls
- 37% of agricultural use (mostly for irrigation)
- 37% of the public water supply withdrawals
- 51% of all drinking water for the total population
- 99% of drinking water for the rural population

All Water on Earth

Oceans	97.24%
All ice caps/glaciers	2.14%
Groundwater	0.61%
Freshwater lakes	0.009%
Inland seas/salt lakes	0.008%
Soil Moisture	0.005%
Atmosphere	0.001%
All rivers	0.0001%
Total	100%

Useable Freshwater on Earth

Groundwater	0.61%
Freshwater lakes	0.009%
Rivers	0.0001%
Total	0.6191%
Adding ice caps/glaciers	2.14%
Total	2.7591%