Water On and Under the Farm: Where does it come from and how is it used?

Lesson: 2

National Science Education Standards for Grades 9-12

Content Standard C: Life Science: The Interdependence of Organisms

- *Human beings live within the world's ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology and consumption.*

Content Standard D: Earth and Space Science: Geochemical Cycles

- *Each element on earth moves among reservoirs in the solid earth, oceans, atmosphere and organisms as part of geochemical cycles.*

Content Standard F: Science in Personal and Social Perspectives: Natural Resources

- *Human populations use resources in the environment in order to maintain and improve their existence. Natural resources have been and will continue to be used to maintain human populations.*
- *The earth does not have infinite resources; increasing human consumption places severe stress on the natural processes that renew some resources, and it depletes those resources that cannot be renewed.*

Student Learning Objectives

2.1 Define surface water and groundwater characteristics.

2.2 Illustrate how local water sources are part of a watershed.

2.3 Broadly define who uses water in their agricultural community and for what purposes.

Teacher Info Table Time

Instruction time for this lesson: 75 minutes if no remedial activity is used (additional 90 minutes).

Resources, Tools, Equipment and Supplies

2.1. Define surface water and groundwater characteristics

Supplies

Make enough copies of SW.2.1.A.AS so there are enough for students to work in groups of 4-5. See SW.2.1.A.AS for sort packet preparation instructions.

Equipment

Internet connection

Computer

LCD projector screen or light colored wall

2.1.a. The Story of Groundwater

Resources

- *The Story of Groundwater* animation http://www.groundwater.org/kc/groundwater_animation.html

Equipment

Internet connection

Computer

LCD projector screen or light colored wall

Resources, Tools, Equipment and Supplies

2.1.b. Build a Groundwater Model Activity

Supplies

Groundwater Model handout, available at http://www.epa.gov/region07/education_resources/teachers/activities/wateractivity1.htm

One 20 ounce clear plastic tumbler

12 inches of clear plastic tubing

A small piece of nylon fabric to cover the end of the tubing

Masking tape

Small pebbles

Clean sand

Filter paper (e.g. a section of a coffee filter)

Pump-type sprayer (e.g. from window cleaner)

A disposable syringe

Red food coloring

A clear glass container

2.2. Local Water Sources

Resources

- Students' watershed maps from activity 1.2.a or watershed models from activity 1.2.b

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2.3. Brainstorming Activity

Resource

- Slide SW.2.3.TM.A –How do we use water in the United States?

Equipment

Computer

LCD projector screen or light colored wall

Inventory Homework Activity

Make copies of the Drinking Water Inventory Homework Activity (SW.2.HW.AS) as needed (one/student or one/group)

Key Terms

Aquifer
Brackish
Evaporation
Groundwater
Impervious surface
Infiltration
Low point
Polluted runoff
Pollution
Surface water
Tributaries
Water cycle
Watershed
Watershed divide

SUMMARY OF CONTENT AND TEACHING STRATEGIES:

A. Sources of drinking water

1. Surface water
    a. Water from rivers, lakes, ponds, wetlands, estuaries and reservoirs
    b. Often pumped and treated by a public water system for drinking
    c. Used for livestock, irrigation, and a variety of other uses
    d. Can be fresh or brackish (salty)
    e. May flow slowly or quickly
    f. More people drink from surface water systems because many larger cities utilize surface water sources for drinking water

2. Groundwater
    a. Groundwater – water found underground
    b. Aquifer – a underground geologic formation of porous rock (such as sandstone or limestone) containing water or of less porous rock with cracks, which fill with water
    c. Water pumped from wells drilled into underground aquifers
    d. Water that comes out of the ground through natural springs or artesian wells
    e. Shallow wells – 50 feet or less; Deep wells – 100 feet or greater
    f. Can be fresh or brackish (salty)
    g. Moves slowly
    h. People in rural areas tend to depend on groundwater for drinking water

B. Local water sources are part of a watershed.

1. Watershed – the land area from which water drains into a stream, river or reservoir

2. Basic components
    a. Headwater of the body of water
    b. Watershed divide (boundary; hills, mountains, etc.)
    c. Tributaries (smaller bodies of water)
    d. Low point (stream, lake, river, etc.)
    e. Groundwater

3. All shapes and sizes; cross county, state and national boundaries

C. Source water

1. Sources of drinking water can be streams, rivers, lakes, reservoirs or underground aquifers.
2. Provides public drinking water as well as water for livestock, wildlife and human activities such as irrigation and recreation
3. Provides water for homes, schools, businesses and others from private wells.
4. Some treatment may be necessary; however, costs along with risks to human health can be reduced by protecting source water from contamination in the first place, reducing the need for treatment at the public water system.

D. Land use effects on drinking water: Each time the use of a land area changes, it can affect the hydrologic makeup of the landscape

1. Agricultural
    a. Cropland – nitrogen and phosphorous from fertilizer, pesticide runoff
    b. Livestock and poultry facilities – sources of nutrients, pathogens, and pharmaceuticals from manure, litter and dust
2. Residential
    a. Development runoff
    b. Nitrogen and phosphorous from lawn fertilizer
    c. Pesticide runoff
    d. Paved and impervious surfaces
3. Forest land: sediment and attached petroleum materials related to harvesting

INTEREST APPROACH:

Students expand their understanding of basic drinking water concepts to include groundwater and surface water as they explore the source of local drinking water. A sort packet and brainstorming activity involve students in collaborative, out-of-seat learning. Identifying local water sources on their models or diagrams carries the interest forward.

GETTING STARTED:

Hold up a clear glass of water

The most basic molecules in this glass of water may have been consumed by a dinosaur, may have fallen in a deluge during Hurricane Katrina or may have watered the grass in (*state a nearby or widely known sports)* stadium.

But what's its recent history? Where has this water been in the last several weeks?

What is the specific source of the water that I get when I turn on the faucet here at school? Drinking water systems draw from surface water or groundwater resources and today we will discover where this water entered our water system, and whether that is the same source for our water at home and in other places in our community.

Let's get right into it by matching some watershed definitions in small groups. *Distribute sort packets to groups of four to five students and allow a brief period for matching terms and definitions. Review the terms by a discussion of local examples of each.*

OBJECTIVE BY OBJECTIVE:

Activity Outline and Teacher Support Information:

Water On and Under the Farm: Where does it come from and how is it used? – In this lesson students explore groundwater and surface water and their uses as drinking water sources. A remedial activity is provided for students needing more experience to understand groundwater.

2.1. Define surface water and groundwater characteristics

2.1.a. VOCABULARY SORT

Students familiarize themselves with the vocabulary by participating in a sort activity.

Follow the instructions at the top of SW.2.1.A.AS. Divide the class into groups of four to five students. Give each group a SORT PACKET.

When you say, *SORT*, each group's task is to categorize strips of paper that have information on them regarding different types of water. Give students about 90 seconds to complete this task.

EXAMPLE OF SORT RESULTS

Sources of Drinking Water

1. **Surface water**
   a. Water from rivers, lakes, ponds, wetlands, estuaries and reservoirs
   b. Often pumped and treated by a public water system for drinking
   c. Used for livestock, irrigation and a variety of other uses
   d. Can be fresh or brackish (salty)
   e. May flow slowly or quickly

2. **Groundwater**
   a. Groundwater – water found underground
   b. Aquifer – a underground geologic formation of porous rock (such as sandstone or limestone) containing water or of less porous rock with cracks, which fill with water
   c. Water pumped from wells drilled into underground aquifers
   d. Water that comes out of the ground through natural springs or artesian wells
   e. Shallow wells – 50 feet or less; Deep wells – 100 feet or greater
   f. Can be fresh or brackish (salty)
   g. Moves slowly

Have each group compare results with another group and have students capture information on notepaper. Allow five minutes for groups to complete task, record their results in a box drawn on the blackboard as prompted by students. The information you record should capture the points shown in the box below.

Depending on their experience and grasp of content in the first activity, students either participate in a short REVIEW activity (2.1.a) or the more in-depth groundwater model activity (SW.2.1.C.AS) to create new or better understanding of surface and groundwater concepts (REMEDIAL).

2.1.b. ANIMATED WATER REVIEW
Students will review surface and groundwater characteristics by viewing an animation at http://www.groundwater.org/kc/groundwater_animation.html

This musical animation (3 minute, 43 seconds) illustrates the importance of groundwater to living things, including people, and suggests how to help protect this hidden resource. The *Groundwater Story* is designed for a younger audience, but high school students will find it useful for reviewing key concepts about the water cycle and groundwater. [King County, Water and Land Resources Division, 206-296-6519]

After students view the video once, then ask them to watch it again to identify vocabulary terms (water cycle, watershed, surface water, groundwater) and concepts of importance that are illustrated in the video such as evaporation, infiltration, aquifer, polluted runoff, impervious surfaces, water conservation, water users. Have them pay particular attention to what is happening in the background, behind the animated dancers.

2.1.c. GROUNDWATER MODEL

In the *Groundwater Model Activity*, SW.2.1.C.AS, students build a groundwater model to reinforce their understanding about groundwater. (REMEDIAL)

2.2. Illustrate how local water sources are part of a watershed.

2.2.a. SOURCE WATER WATERSHED COMPONENTS
After reviewing watershed component terms in activity 2.1, students will locate and label source water components (lakes, streams, rivers, ponds, wetlands, estuaries) in their watershed diagram or model from Lesson 1.

2.2.b. LOCAL GROUNDWATER: INTERNET EXPLORATIONS
Have students examine the U.S. Geological Survey (USGS) Groundwater Watch site: http://groundwaterwatch.usgs.gov/ to explore information about groundwater resources close to their school and/or home. See Local Groundwater:

Internet Explorations, SW.2.2.B.AS, for a list of instructions that can be distributed to students on how to navigate the site and for a list of what data they should collect. After they have completed the worksheet, discuss findings as a group. Some counties may have numerous well sites, others may have none. Make a list of the sites examined by the students. If no sites were found, talk with students about why that might be the case. Contact a local water resource expert to provide some insight on that discovery.

Ask students to determine if the well site(s) they studied are within the watershed(s) they identified in Lesson 1.

Discuss the information they collected regarding: well depth, soil composition and depth to water. How do soil, water depth, and well depth affect groundwater (source) water quality? Does it make it more or less vulnerable to contamination? If students found multiple sites, have them compare that data and decide if the county sites were fairly uniform or not; ask them to note similarities and differences.

2.3. Broadly define who uses water in their agricultural community and for what purposes.

Set up a brainstorming activity in which students offer examples of drinking water users within these four categories:

1) municipal, public, commercial water users

2) industrial and mining water users

3) agriculture water users

4) thermoelectric water users

Take four pieces of blank 8.5 x 11 paper. Using a wide-line marker, write one of the four categories of water use on each paper in large print. Tape each sheet on a separate wall in the room. Divide the class into groups of three to four students. Give each group a pad of sticky notes. Ask the groups to brainstorm what water uses might fit under each category. Have them write their ideas on sticky notes and then paste those notes under the appropriate label. Review the responses with the class; ask them to organize the responses, deleting duplicates and consolidating like answers. Show the slide SW.2.3.TM.A. Ask students to review the bullets under each category and decide if they've captured all the information during their activity. If not, they should add that information to their responses. Have each student make a master list of all the ideas in his/her journal.

Which of the uses, not listed under agriculture, might also occur in the agricultural or rural communities in your county? In your state? Which uses did you consider?

REVIEW / SUMMARY:

Ask students to respond to the following questions in their journals:

- In today's activity you identified a body of water, which is located in our watershed. Have you ever seen that body of water?
- What are some activities that you have participated in that involved this body of water?
- Do you have any memories of this body of water from your childhood?
- Describe your thoughts and feelings about the body of water. Do you think it may be susceptible to pollution, and if so what kinds? Why is it important to protect it from current and future pollution?

APPLICATION:

Drinking Water Inventory Homework Activity (SW.2.HW.AS)

The source of drinking water can vary from place to place in a community. This homework assignment and the follow-up activity in Lesson 3 provide an overview of local water systems, introducing students to the concept of a public drinking water system vs. private well.

Students will complete an inventory of their household drinking water source. Give each student a copy of the inventory (SW.2.HW.AS) to take home. This exercise will take students 30-60 minutes depending on the amount of help they receive from family members or the water utilities online information.

EVALUATION AND ANSWERS:

EVALUATION

Name _____

1. Write the correct word on each line provided in parts *a* and *b* below. (1 point each)

a. Which type of water is acquired from aquifers?

_____

b. Which type of water is acquired from rivers and streams?

_____

2. More people drink from surface water systems even though there are more groundwater systems in use in the United States. True or false? Explain your answer. Your response should include at least two sentences. Take approximately two minutes to respond to this item. Correct grammar and spelling are expected. (2 points)

Answers to Evaluation

1.a. groundwater

1.b. surface water

2. Student responses should reflect the following statement:

More people drink from surface water systems because many larger cities utilize surface water sources of drinking water such as rivers, lakes and reservoirs. People in rural areas tend to depend on groundwater for drinking water.

ACTIVITY WORKSHEET(S) – AS NEEDED:

SW.2.1.A.AS: VOCABULARY SORT

Instructions: Print off enough copies so there is one sheet for each group. Prior to the class session, cut out each item (total of 10 items) and secure with a paper clip to create a "sort packet" for each group.

Surface Water	**Rivers, streams, lakes, reservoirs**
Surface Water	**Ponds, wetlands, estuaries**
Surface Water	**Can be fresh or brackish (salty)**
Surface Water	**May flow slowly or quickly**
Surface Water	**Drinking water used by larger cities/more people**
Surface Water	**Pumped from intakes**

SW.2.1.A.AS: VOCABULARY SORT *(continued)*

Groundwater	**Moves very slowly**
Groundwater	**Can be fresh or brackish (salty)**
Groundwater	**Used for drinking water more often in rural areas**
Aquifer	**Underground geologic formation containing water**
Shallow well	**≤ 50 feet deep**
Deep well	**≥ 100 feet deep**

SW.2.1.C.AS *(continued)*

Groundwater Model[1]

Objective Students will demonstrate, through building a model, how aquifers are formed and groundwater becomes polluted.

Setting Classroom

Duration One 1 1/2 hour period

Subject Science

Skills Observation, analysis, discussion, experimenting, media construction, comparing similarities and differences

Materials ***For each model***

- Groundwater Model handout (this document)
- One 20 ounce clear plastic tumbler
- 12 inches of clear plastic tubing
- A small piece of nylon fabric to cover the end of the tubing
- Masking tape
- Small pebbles
- Clean sand
- Filter paper (e.g., a section of a coffee filter)
- Pump-type sprayer (e.g., from window cleaner)
- A disposable syringe
- Red food coloring
- A clear glass container

Procedure Define groundwater and aquifers. Discuss with students the importance of groundwater in the United States. Divide class into small groups to build the model, or each student might build the model individually if there are enough materials. Have students follow the steps 1-11 on the next page.

1 From EPA, Region 7, Groundwater Model: http://www.epa.gov/region07/education_resources/teachers/activities/wateractivity1.htm

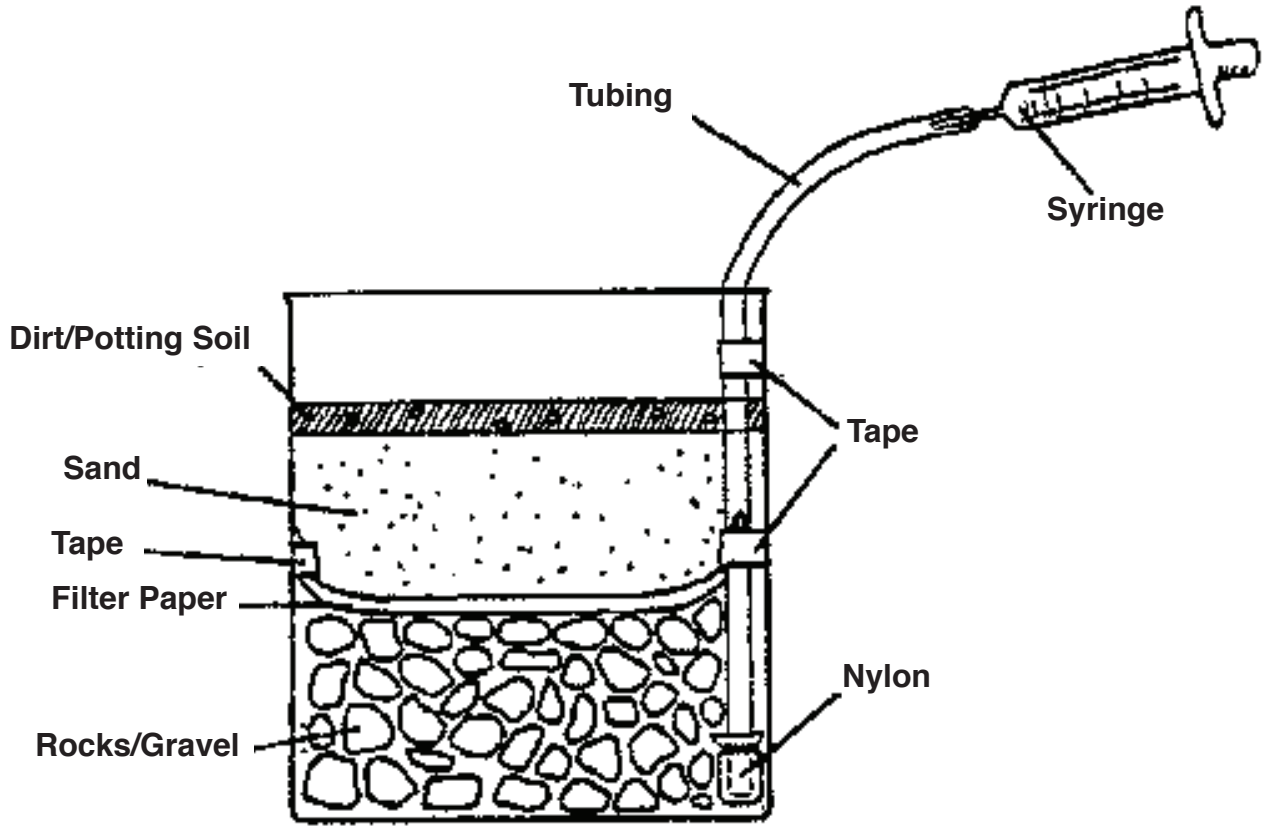
SW.2.1.C.AS *(continued)*

The diagram below can be used as a guide.

1. Secure nylon fabric over one end of the plastic tubing with masking tape or a rubber band.
2. Tape the tubing to the inside of the tumbler so that the nylon covered end of the tubing *almost* touches the bottom of the tumbler.
3. Fill about one-third of the tumbler with pebbles.
4. Cut the filter paper into a circle with a diameter slightly larger than the diameter of the inside of the tumbler. Place the filter paper on top of the pebbles and tape it securely to the sides of the tumbler.
5. Fill the rest of the tumbler with sand. Note: A shallow layer of potting soil can be added on top of the sand to represent the Earth's crust.
6. With the sprayer, apply water to the sand until it is saturated. The water will filter down into the pebbles.
7. Put the end of the syringe into the tubing and make sure the connection is tight.
8. Pull back the plunger of the syringe to create a vacuum. Water will be drawn from the pebbles/sand into the tubing and ultimately into the syringe. Discuss with students that this represents how groundwater is pumped from aquifers.
9. Add a few drops of red food coloring to the sand. Explain to the students that the red food coloring represents a pollutant. Discuss what kinds of substances can pollute groundwater, such as nitrate from fertilizer running off lawns or farm fields or salt used for de-icing in snowy weather running off roadways.
10. Apply more water to the sand.
11. Continue "pumping" water from the tumbler with the syringe. When the syringe fills with water, remove it from the tubing and pour the water into the clear glass container. Refasten the syringe to the tubing and continue "pumping" water. Ultimately, the water in the clear glass container will have a reddish hue. Discuss with students how the "pollutant" applied at surface level has "contaminated" the "groundwater" in the experiment.

SW.2.1.C.AS *(continued)*

Groundwater model



SW.2.2.B.AS

Local Groundwater: Internet Explorations

The purpose of this activity is to use the U.S Geological Survey (USGS) website, *USGS Groundwater Watch*, to explore data about a groundwater resource near your home and/or school. You will need a computer with Internet access and a printer or a notebook to record data.

1. Go to the USGS Groundwater Watch homepage: http://groundwaterwatch.usgs.gov/. Read the two paragraphs at the top of the page to learn about the site and the data that is stored onsite. Locate the "National Networks" map in the middle of this page.
2. Use the National Networks map to find a local groundwater resource. Click anywhere on the map to go to the next page, http://groundwaterwatch.usgs.gov/default.asp. Read the "Explanation" key to the information on this map, which is located underneath the map. Using terms like upper Midwest or south or northwest, answer the following questions in your journal:
    a. Which area(s) of the country are experiencing groundwater levels that are "much above normal"?
    b. Which area(s) of the country are experiencing groundwater levels that are "much below normal"?
3. On the *Active Groundwater Level Network* map, click on your state. Underneath the map of your state you will see a list of counties and data for each county.
    a. Look at the bottom of the counties list. How many active wells are in your state?
    b. Write your county's name (where your home or school are located) in your journal. Click on your county's name.
    c. On the county map, find the site symbol (triangle, circle or square) that is nearest your home and/or school. (The key to the symbols is located on the right side of the *Explanation* key.) What does the color of the well symbol indicate about the water level in that well? See the Explanation key below the map for help. Click on the well symbol you chose.
    d. Write down the well site number or ID. Collect the following data in your journal: Well depth, hole depth, well soil composition for national aquifer, and most recent value of depth to water level.
    e. Is there anything that strikes you as surprising or interesting about the data presented for this particular location?

SW.2.HW.AS

Drinking Water Inventory Homework Activity

In this activity you will complete a drinking water inventory at home, which will help you describe your drinking water resource and delivery system in great detail.

INVENTORY DATA

1. Does your drinking water come from a municipal utility (water company) or a private well?

_____

a. If you get your drinking water from a private well:

How many people are served by this well?_____

_____

If possible, find out how deep the well is: _____

_____

When was the last time the well was tested?_____

_____

What tests were done? _____

_____

Did the test results indicate a problem with contaminants? Yes No

If yes, what were the contaminants?_____

_____

How was the water issue treated?_____

_____

b. If you get your drinking water from a public utility:

How many people are served by this public utility? _____

What is the source of the water utility's drinking water supply?
Surface water or groundwater? *Circle one.*

SW.2.HW.AS *(continued)*

If surface water, name the body of water (i.e., Lake Michigan)_____

_____

If groundwater, where is the public well is that serves your site? _____

_____

Consumer Confidence Reports

The Consumer Confidence Rule requires public water suppliers that serve the same people year round (community water systems) to provide consumer confidence reports (CCR) to their customers. Community water systems are public water systems that have at least 15 service connections or regularly serve at least 25 year-round residents. CCRs are also known as annual water quality reports or drinking water quality reports. The remaining public water systems in the U.S. are not required to provide CCRs, because they do not serve the same people on a day-to-day basis throughout the year. Local drinking water information available at: http://cfpub.epa.gov/safewater/ccr/index.cfm

The CCR summarizes information regarding sources used (i.e., rivers, lakes, reservoirs, or aquifers), any detected contaminants, and compliance and educational information. The reports are due to customers by July 1 of each year.

Do you receive a Consumer Confidence Report annually, which provides data on water quality and issues? Yes No

Can you access a CCR from your utility online? Yes No

If you have access to the CCR for your site, list three contaminants that are treated by the utility (i.e., bacteria, nitrates).

_____

_____

_____

POWERPOINT SLIDES – AS NEEDED:

SW.2.3.TM.A

How do we use water in the United States?

- Municipal/Public/Commercial Water Users
  - Refers to the use of water, including drinking water, for cities, towns, domestic and public service enterprises.
  - Included are industries that provide direct services to the cities and towns through the use of water.
  - Examples of use: Sprinklers, wastewater treatment plants, public restrooms, water fountains, drinking water for homes and schools, households (showers, dishwashers, clothes washers).

- Industrial and Mining Water Users
  - Industrial use refers to the use of water for construction and processing.
  - Smelting facilities, petroleum refineries and industries producing chemical products, paper products, food and drink.
  - Mining water use includes: Extraction of minerals, including solids such as coal and ores, liquids such as crude petroleum, and gases such as natural gas.

SW.2.3.TM.A *(continued)*

- Agriculture Water Users
  - Includes the watering of all forms of domestic livestock and crops.
  - Irrigation accounts for a third of all freshwater use in the United States.
  - Extreme importance lies with the proper storage and use of pesticides, fertilizers, manure and wastewater.
  - Includes water uses for food processing.

- Thermoelectric Water Users
  - Refers to the use of water to create electricity.
  - Fifty two percent of freshwater withdrawals are for once-through cooling at power plants.
  - Can be used to measure temperature, or to heat or cook objects. Thermoelectric devices make very convenient temperature controllers.