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Groundwater Model Building Instructions

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An interactive model has been designed to educate students about the geologic structure and properties of aquifers, the movement of groundwater, and the methods by which geologists recognize point- and non-point sources of pollution. The model was constructed using gravel, modeling clay, and medium-grained sand. A gravel aquifer sits atop a "basement" constructed from plastic floral foam and modeling clay and is designed to resemble crystalline rock. A basement dip of approximately 45° permits down slope movement of the water. The gravel aquifer is approximately 10 cm thick and composed entirely of 2mm-sized pea-gravel. An overlying 2-3 cm thick clay layer completely confines the gravel aquifer. Above the confining layer sits a 30 cm layer of medium-grained sand. A second discontinuous clay layer interrupts this sand, creating both an unconfined and perched aquifer. Five plastic tubes, sealed at the bottom and perforated with holes near the base, serve as wells permitting students to saturate the aquifers, measure artesian flow in downdip wells, and track acidic "pollutants" throughout the system.

The model components are as follows:

- Plastic file folder (12" long, 8" wide, and 11" high)
- Ceramic Tile and Crayola Model Magic (Basement)
- Kwik Seal Caulk (Basement sealant)
- Pea gravel (Gravel aquifer)
- Medium-grained sand (Sand aquifer)
- Bentonite clay (Continuous and discontinuous confining layers)
- Five plastic tubes, perforated and sealed (wells)
- Two smaller perforated tubes (drains)

This model provides a cost-effective way for middle school teachers to demonstrate groundwater and aquifer properties to students. Models available for purchase can cost hundreds of dollars, which most teachers cannot afford, especially if multiple models are necessary. The drawback to the construction of models is the time necessary for completion. However, if many models are to be constructed at once, the teacher may opt to complete the first few steps on his/her own and then bring the models into school for the class to complete. A second drawback is the relatively slow drainage time. This only becomes a major problem if pollutants are introduced into the system. They may be slow to drain from the model and make the activity less effective in later classes. A solution to this problem may be to stagger the days on which the activity will be completed or to use a model through which only fresh water has passed.

OBJECTIVES

This model was designed to incorporate eighth-grade science objectives as defined by the North Carolina Standard Course of Study. Specifically, the model addresses the following Competency Goals and Objectives:

- **Competency Goal 1—The learner will build an understanding of the hydrosphere**

Objectives

1.01 Explain the composition, properties, and structure of the hydrosphere

1.04 Assess human impact on water quality

1.05 Evaluate the effects of point and non-point sources of pollution on North Carolina water

- **Competency Goal 2—The learner will build an understanding of population dynamics**

Objectives

2.01 Evaluate data related to population growth, along with problems and solutions

- Resource availability

2.02 Conclude that some ecosystem resources are finite

2.04 Analyze practices that affect the use, availability, and management of natural resources:

- Land Use
- Urban Growth
- Manufacturing

METHODS AND MATERIALS

All materials for the corrected and reconstructed models can be purchased at national chain stores (e.g. Wal Mart, A.C. Moore or Michaels craft stores) with the exception of the aquarium tubing, which can be purchased at most pet stores.

MATERIALS:

- Aquarium tubing, cut to the following lengths: 6.5” (Well #1), 8.0” (Well #2), 4.5” (Well #3), 7.0” (Well #4), 9.5” (Well #5), and two 2.5” drains
- Plastic filing box (this model is 12” long, 8” wide, and 11” high)
- Plastic floral foam, cut slightly smaller than length and width of bottom and approximately 4” high
- 5 lb. block of modeling clay (this is enough for one model)
- Plastic wrap
- Caulk
- 1 bag of pea gravel

- 1 bag of sand (any size available)
- "Grass" doormat, cut to model dimensions (optional)
- Utility knife
- Power drill (if available)
- Large pushpin
- Tape
- Rubber bands (optional)
- Marker
- Ruler

METHODS:

1. Cut aquarium tubing to specified lengths
2. Using the large pushpin, punch 20-25 holes at the bottom of each tube
3. Cover the bottom of the five longest tubes with tape
4. Using utility knife (or power drill, if available) cut two holes in side of plastic container. The holes should be the diameter of the tubing and approximately 2" and 5" from the base of the model. If a drill is available, additional drain holes may be drilled into the underside of the container
5. Insert the two smallest tubes halfway into the holes and caulk (the tubes may be further secured with rubber bands, if desired
6. Mark the center of the long side of the foam and connect this point to the corners of the foam, bisecting the corners and creating a 45° angle
7. Cut the foam with the utility knife
8. Cover the foam with the modeling clay
9. Place the covered foam into the container, adding more clay around the edges to create a seal
10. Cover with plastic wrap and caulk (Note: Most caulk takes about 24 hours to set)
11. After caulk has set, pour gravel on top of basement. The gravel layer should be of uniform thickness and thick enough to allow students to see the water move through the aquifer
12. To create the confining layers, mold clay into two sheets. The first should be the length and width of the container in order to confine the gravel aquifer. The second aquiclude should also be the width of the container, but approximately one-third of the length. This will allow for construction of the perched aquifer
13. To make deconstruction easier, cover the confining layers with plastic wrap. Remember, however, that two tubes must penetrate this layer. Holes may be cut or punched into the plastic wrap in the correct areas to allow the tubes to penetrate.
14. Add sand approximately halfway up the remainder of the container.

15. Add the second layer of clay to the side of the container closest to the drains. The clay should stop before it reaches the end of the container to allow water to percolate down to the drain
16. Add sand almost to top of container
17. Insert the three remaining tubes in the correct locations
18. Label all five wells with the tape and marker
19. If desired, place "grass" doormat on top of sand, with five holes cut out for tubes

ACTIVITY SUGGESTIONS

Once the models are complete, there is a variety of activities that can be performed.

1. Copy the diagram of the aquifer model. Ask students to predict the direction of movement and the driving mechanism (gravity).
2. Discuss porosity and permeability. Have students predict through which aquifer the water will move fastest. Add different colored water into wells #1 and #2 simultaneously and measure the amount of time it takes for the water to reach the drains.
3. Discuss the properties of saturated and non-saturated aquifers and artesian flow. Cap lower drain with cork and saturate gravel aquifer. Measure water levels in well #2 and well #5.
4. Discuss point and non-point sources of pollution, and how they are identified. Cap drains and add water to each aquifer. Make students look away or leave room and "pollute" one well with an acidic solution. Bring students back and uncap drain. Using pH paper and long swabs (or skewers with sponges attached to end), ask students to determine the source of pollution. Copy diagram and ask students to track the migration over time. Discuss contaminant plumes.

DRAINAGE AND DECONSRUCTION

The models should be either drained or deconstructed after use to prevent mold and bacteria growth. This may be accomplished by adding a dilute bleach and water solution to the wells or by pouring out the sand and gravel. The sand and gravel may be reused, but should be washed and partially dried before reuse. If drain holes are drilled into the underside, remember to place a pan underneath the models before water is added.