# The Pucker Effect

■ **Grade Level:**
Middle School, High School

■ **Subject Areas:**
Environmental Science, Earth Science, Health, Government

■ **Duration:**
Preparation time: 90 minutes

Activity time: 50 minutes

■ **Setting:** Classroom

■ **Skills:**
Gathering information (observing, measuring, recording); Organizing (mapping, manipulating materials); Analyzing; Interpreting (translating)

■ **Charting the Course**
The concept of pH is discussed in the activity "Where Are the Frogs?" To gain an understanding of ground water, students should participate in "Get the Ground Water Picture." The activity "A Grave Mistake" should follow "The Pucker Effect"; it provides students the opportunity to use skills learned in this activity to solve a real problem.

■ **Vocabulary**
ground water, point source pollution, plume

*People in your town are suffering from contaminated drinking water and are experiencing the "pucker effect"—pursed lips and sour dispositions. Your mission is to discover the source of the contamination.*


**Summary**
Students observe how ground water transports pollutants, and simulate ground water testing to discover the source of contamination.


## Objectives

Students will:

- describe how underground point source pollutants move through ground water.
- analyze data from test wells they have "drilled" to identify point source contamination.

## Materials

- *Cup of sand* (Mix grape-flavored powdered drink into the sand and poke holes in the bottom of the cup.)
- *1 clear baking pan*
- *Unsweetened grape-flavored powdered drink mix*
- *Misting bottle*
- *Water*

Each group will need the following:

- *Aluminum baking pans or fast-food salad containers*
- *Unsweetened lemonade-flavored powdered drink mix*
- *Small objects to raise end of tray one inch (2.5 cm)* (e.g., blocks of wood, books)
- *Sand* (enough to fill baking pan; an alternative is to use soil, but the results are not as dramatic)
- *Copies of* ***How to Hide and Seek Your Contaminant***
- *Copies of* ***Project Pucker Effect: Background, Procedures, and Data Sheet***
- *Straws*
- *13 pH papers*
- *Misting bottle*
- *Beaker of water*

## Making Connections

Students may have been personally affected by contaminated drinking water or have heard of an incident within their communities. The media often report news of polluted ground water. Learning about the possible effects of point source pollution may prompt students to assume a more active role in protecting ground water in their communities.

## Background

Throughout history, waste has been stored in dumps, deposited in the ocean, burned, and buried. Many years ago it became a practice to bury storage tanks underground. These tanks were used, and continue to be used, to store petroleum products (gas and oil), chemicals, and chemical waste products for manufacturers, industries, and businesses. However, many underground storage tanks have eroded, leaking their contents into ground water. When a pollutant is identified as coming from a single source, it is referred to as point source pollution.

Point source pollution of ground water can originate from a variety of situations. These include leaking pipes, faulty landfills, above-ground dumpsites, and underground storage tanks. (See *Ground Water Contamination: A True Story* sidebar on page 340.)

When contaminants dissolve in or are carried by ground water, they move in

the direction of ground water flow. If a well is pumping near the pathway of the flowing contaminants, the pollutants are likely to be drawn up into the well along with the water.

Contaminants seeping underground from concentrated masses are called plumes. These plumes resemble the smoke from a chimney, only underground. The concentration of the pollutant is high near the source of the contamination, and dilutes as it spreads further from its origin. The shape and size of these plumes are influenced by several variables, including the physical and chemical properties of the contaminant, the rate at which materials are added to the contaminating source, the action of wells pumping or withdrawing ground water, and the rate water moves through the substrate.

When it was discovered that pollutants from leaking underground storage tanks had been affecting ground water supplies, new legislation was established to regulate existing tanks and strengthen environmental protection criteria for new tanks. For example, the use of underground tanks requires extensive leak-monitoring equipment and less corrosive tank materials. In many instances, old tanks are removed and replaced with updated tanks (sometimes above ground), and monitoring equipment is installed along with the tank. This is done for liability purposes; it costs far less to replace tanks than to clean up after one has leaked. Millions of dollars are currently being spent to clean many sites of leaking underground tanks.

However, leaking underground storage tanks are not the only threat to ground water quality. Septic tank systems, hazardous waste sites, sanitary landfills, and wastewater disposal ponds also pose threats.

Not all contaminants have an odor. They can go undetected in a drinking water supply if it is not regularly tested. City water is frequently tested for contaminants. People who use private wells must have their water supply tested regularly.

## Procedure

### ▼ *Warm Up*

Show students a cup of sand mixed with grape-flavored drink mix and ask if it appears to be clean. Pour water onto the cup and allow water to filter through; it should pick up the drink mix and turn purple. Have students ever heard of a situation where water in the ground got contaminated? How was the source of the contamination detected? Tell students that sometimes clues help to locate the origin of underground pollutants.

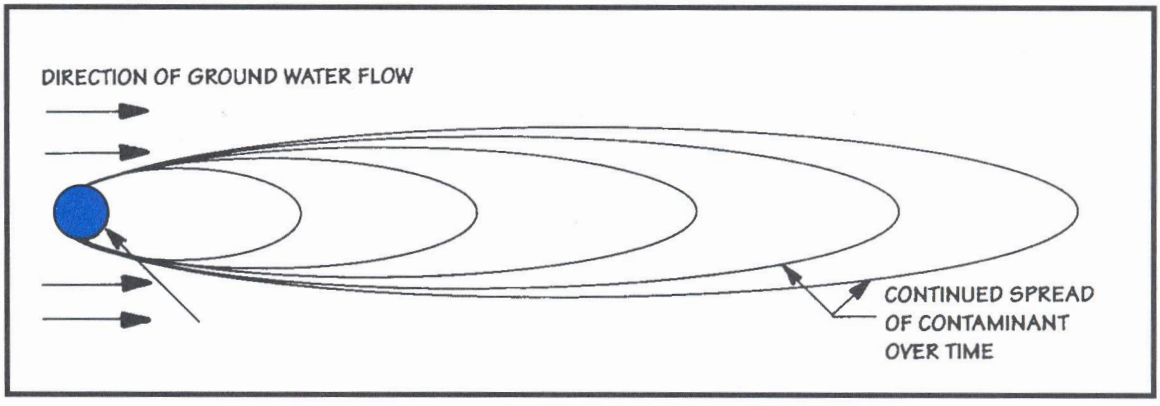
Fill the clear baking pan with sand to a depth of 1.2 inches (3 cm) and elevate one end of the pan 2.4 inches (6 cm). Make a small hole in the sand at the elevated end of the pan and bury a small pile of grape-flavored powder in the hole. Tell students the powder represents a substance that has been stored underground. Ask students to predict what will happen when you spray water on the pan. List reasons for their predictions on the board.

Represent years of rainfall by gently spraying the pan with water for 5 to 10 minutes (or until the sand is saturated). Lift the pan and show the bottom. A streak of purple should originate from the source and follow the flow of water as it filters downhill. Discuss student observations. Explain that the streak of "contaminant" is called a plume. Tell students that since the source of the contamination can be identified, the pile of powder is known as point source pollution. What if a community well field or homes with private wells were pumping water from the formation through which the plume was traveling? Discuss how drinking water could be affected by the underground contaminant.

### ▼ *The Activity*

1. **Ask students to form small groups. Each group is a well-drilling company (team) that tests ground water quality. Give each team an aluminum cake pan filled with 2.4 inches (6 cm) of sand. Have each group mark the outside of one end of the tray with an "X."**

2. **Tell students to bury a small pile of lemonade-flavored pow-**



**dered drink mix somewhere in the sand. (See *How to Hide and Seek Your Contaminant.*) Have them sketch a map showing where they have hidden the contaminant, then switch pans with another team.**

### Ground Water Contamination: A True Story

People in a community noticed the smell of gas in their basements and in their well water. The fire department was notified because residents feared an explosion would occur in their homes. (A few days earlier, a manhole cover was blown off by ignited gas vapors.) Because this was an obvious public health threat, an intense effort was made to locate the source of the petroleum. Was it a leaking pipeline? Old diesel fuel tanks in the basement of a neighbor's abandoned house? The gas station at the end of the block? These were among the many possible sources of gas leaks. The health department limited the possible sources by mapping places that had identified gas odors and by determining the intensity of the fumes. They knew that as the concentration of gas smells increased, they were likely getting closer to the source. They narrowed the search further by drilling test wells to measure the gas content in ground water. After a few weeks of testing and systematic elimination of potential sources, officials located the origin: an abandoned underground gas tank. Apparently, the tank had been leaking for more than a decade before the plume reached the sewer systems and basements. The plume, flowing in the direction of ground water, was approximately one mile long, several feet wide, and several feet deep. An engineering company was contracted to clean the ground water. The process was time consuming and costly.

3. **Distribute the *Project Pucker Effect Background, Procedures, and Data Sheet*. Have students complete the investigation and record their results. Each team should compare their results to the maps made by the teams that hid the contaminant.**

## ▼ *Wrap Up*

Ask students to share what they observed. How did they use the results of the pH tests to locate the contaminant? Ask students if they had enough pH test papers to pinpoint the source of the contaminants. If they were given an unlimited supply, could they guarantee that the source could be accurately located? In a real situation, would testers have unlimited time and resources?

Explain that in reality underground storage tanks can contain fuel oil or radioactive materials. Discuss what problems could arise if these materials leaked into water supplies. What challenges do students think there could be to cleaning ground water?

Students may be interested in researching what steps their community is taking to avoid ground water contamination from storage tanks, septic tank systems, sanitary landfills, chemical landfills, or wastewater disposal ponds.

## Assessment

Have students :

- simulate ground water testing methods (step 3).
- identify a source of contamination using simulated ground water testing methods (step 3).
- cite challenges to locating and cleaning underground contamination (***Wrap Up***).

Upon completing the activity, for further assessment have students:

- illustrate and describe the formation of an underground plume.

## Extensions

Students can also compare the length and size of plume formations.

Prepare five clear baking pans as follows:

**Pan #1:** 1-inch (2.5 cm) depth of sand (this pan remains level)

**Pan #2:** 1-inch depth of sand (elevate one end about 1 inch)

**Pan #3:** 1-inch depth of sand (elevate one end about 2 inches [5 cm])

**Pan #4:** 1-inch depth of gravel (elevate one end about 1 inch)

**Pan #5:** 1-inch depth of a mixture of equal amounts of sand and gravel (elevate one end about 1 inch)

Make a small hole in the sand at the elevated end of each pan, and bury a small pile of grape-flavored powder in the hole. Ask students to predict what will happen when you spray water on each pan. List reasons for their predictions on the board. Spray each pan with water and discuss student observations. Ask them to summarize how the size and shape of sand particles and slope influence the shape and size of the plume.

Have students investigate the real costs of drilling test wells. Why would these costs vary among regions (depth of water table, hardness of substrate, access to site, etc.)?

Have students collect newspaper articles that convey information about ground water contamination within their own community, region, or state.

## Resources

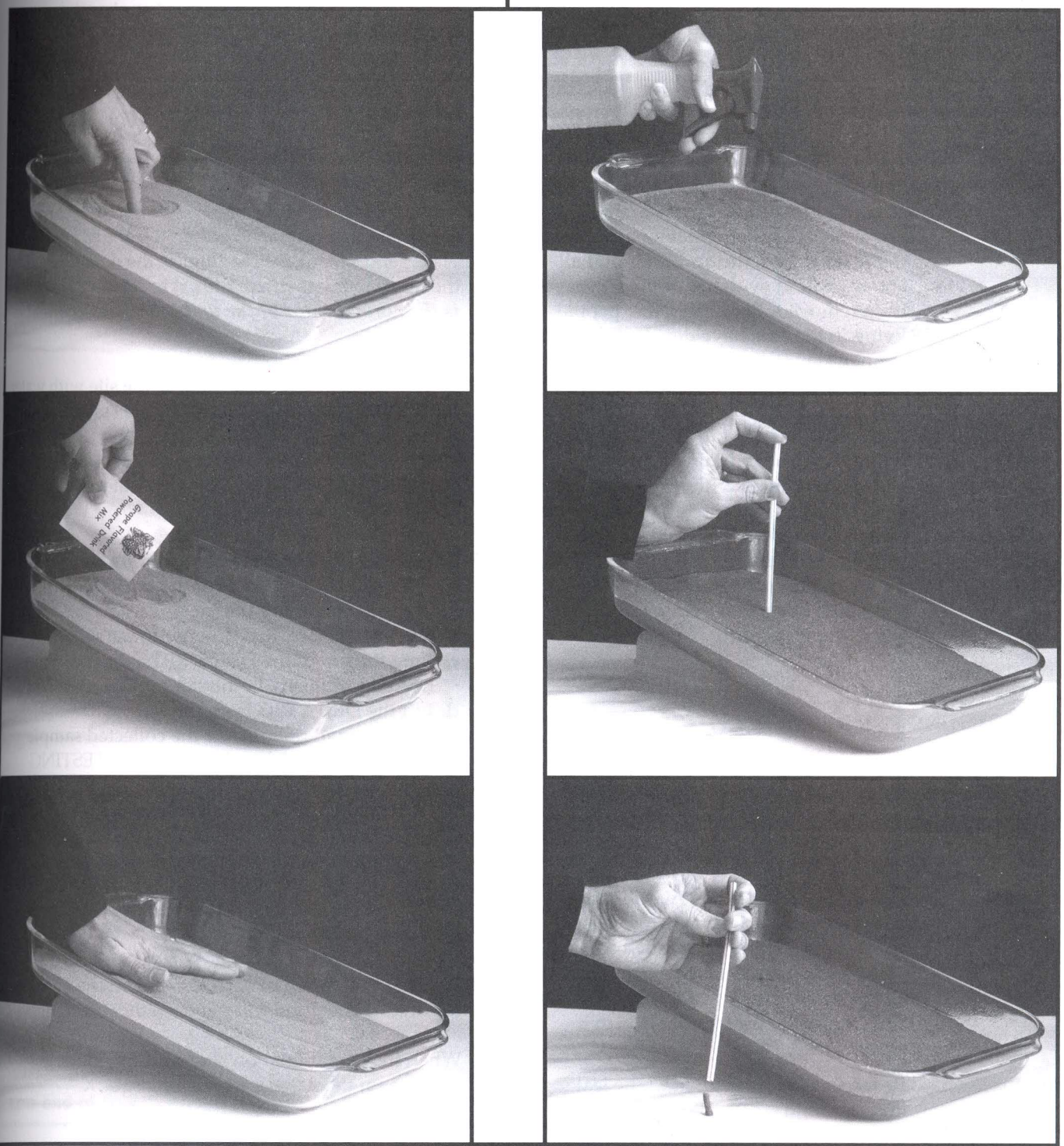
Daley, Robert B. 1986. Earth Science, *A Study of a Changing Planet*. Newton, Mass.: CEBCO.

Harte, John. 1991. *Toxics A to Z*. Berkeley, Calif.: University of California Press.

Jorgensen, Eric P. 1989. *The Poisoned Well*. Washington, D.C.: Island Press.

# How to Hide and Seek Your Contaminant

| HIDING THE CONTAMINANT | SEEKING THE CONTAMINANT |
| --- | --- |



# Project Pucker Effect:

## Background

**Your Task:** Conduct water quality tests and locate the leaking underground storage tank in your community.

**Background:** In the fall of 1981, the ACME Lemonade Corporation closed its manufacturing facilities. This action took place amid allegations that the company had secretly been producing a highly toxic unsweetened brand of lemonade. Since the plant closed, the buildings and all above-ground evidence of the site have been removed. Recently, a few people living in the area have developed strange symptoms—puckered lips leading to sour dispositions.

**The Challenge:** The ACME Lemonade Corporation is suspected of abandoning a large storage tank filled with a vile, unsweetened lemonade product that has leaked into the local drinking water supply. With limited resources, you must track down and describe the extent of the spreading chemicals before the *pucker effect* strikes full force.

**The Tools:**

An environmental
TESTING DRILL RIG (a straw)

The Hygiene-O-Matic
SANITATION STATION (a beaker of water)

A multi-million dollar
TESTING LABORATORY (pH test paper)

**Hints:** The chemical leaked by ACME produces a telltale acidity when combined with water. Acidity can easily be measured by using a system of pH values. Ordinary tap water will leave test paper blue, while the contaminants turn it green.

**WARNING:** **Resources are limited**. Find the leaking underground storage tank with your allotted number of test papers or risk the pucker effect for every citizen.

## Procedures

1. Write the name of your team and students' names on the data sheet.
2. Elevate the end of the pan that is marked with an "X" 1 inch (2.5 cm).
3. Sketch a picture of the pan on the data sheet, top view.
4. Fill a misting bottle with water, test the pH of the water, and record the reading on the data sheet. After the test paper has dried, affix it to the data sheet. ***This is the normal color of the water without contamination.***
5. Simulate a gentle rain by misting the site with water for 5–10 minutes. MIST SLOWLY; no surface runoff should occur.
6. Fill SANITATION STATION with water. Rinse DRILL RIG with water.
7. **Begin collecting and testing as follows:**
   a. Place the DRILL RIG over the most likely location of the contaminant plume.
   b. Press the DRILL RIG down into the soil.
   c. Plug the top of the DRILL RIG with your finger. (Avoid losing any of the sample!)
   d. Lift the DRILL RIG from the soil.
   e. Place a **small** quantity of the collected sample onto the **edge** of the pH test paper (TESTING LABORATORY).
   f. Observe and record the test results.
   g. Rinse (sterilize) the DRILL RIG to eliminate contaminating the next sample.
   h. Repeat steps **a** through **g** until you have used all of your pH test papers or until you think you have found the contamination site.
8. Record the location of each test site on the data sheet by affixing the dried test paper to the location.
9. When the contamination site is found, mark the location on the data sheet with a large "X."

# Project Pucker Effect:

## Data Sheet

Team Name _____ Teacher: _____

Team Members _____ Date: _____

Misting Water pH Value: _____ Affix Paper Here

### SITE MAP

Raised end of tray (marked "X")

Low end of tray