HYDROSPHERE

The activities in this guide, created by the Center for Inquiry-Based Learning (CIBL), are designed to deepen students' understanding of science concepts and processes. Materials for activities are available from CIBL with professional development. This guide is under development. Please provide feedback at cibl@ciblearning.org or our website, http://www.ciblearning.org. This unit is part of the following series:

6th Grade Modules	7th Grade Modules	8th Grade Modules
Cycling of Matter & Population Dynamics	Atmosphere	Cell Theory and Microbiology
Earth's Crust	Bodyworks	Chemistry
Energy Transfer and Transformation	Thrill Ride	Change Through Time
The Solar System	Genetics	Hydrosphere

The activities in this guide can be used to teach about properties of water, dilution, water purity, water pollution, water testing, and ocean currents. The contents of this guide align with the following North Carolina Essential Science Standards:

8.E.1 Understand the hydrosphere and the impact of humans on local systems and the effects of the hydrosphere on humans.

8.E.1.3 Predict the safety and potability of water supplies in North Carolina based on physical and biological factors, including:
- Temperature
- Dissolved oxygen
- pH
- Nitrates and phosphates
- Turbidity
- Bio-indicators

8.E.1.4 Conclude that the good health of humans requires:
- Monitoring of the hydrosphere
- Water quality standards
- Methods of water treatment
- Maintaining safe water quality
- Stewardship

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How Many Drops

Overview

Students will determine how many drops of water, rubbing alcohol, and vegetable oil can be placed on a penny before the liquid spills over. In the process of comparing this quality of the three liquids, students learn about cohesion, adhesion, polarity, and surface tension. Students will propose an explanation and a test for their explanation. It is not necessary for them to explain that water's greater cohesion accounts for more drops of water than the other liquids on the pennies (you'll get to that later). However, students are asked to propose testable explanations and reasonable tests. They won't have to execute the tests because many tests would be too difficult, but they do have to explain how and why their test would work. You will question them to determine whether their test could confirm or refute their explanation.

Background

Water molecules form bonds of attraction, and they form some of those bonds *between each other*. The bonds are electrical, like the static electric attraction between a balloon and the wall. The attraction is between electric charges unevenly distributed around the smallest bits of water called molecules. The hydrogen parts of the molecule have a bit of extra positive charge, and the oxygen part has a little extra negative. These parts are like positive and negative "poles." That's why water is called **polar**. Each end of a water molecule is attracted to the oppositely charged end of another water molecule. This is called **hydrogen bonding**. The hydrogen bonds make water tend to stick to itself, a quality called **cohesion**. Cohesion shapes the way water behaves. It causes water to form drops. It also produces the skin-like surface on top of water called surface tension. When insects walk on water, they walk on surface tension. The static charges can also make water stick to other things (like glass), a quality called **adhesion**.

Oil is not polar, so it attracts itself very little. Because of this, oil spreads out on a penny to form a thin layer. Rubbing alcohol molecules are slightly polar, with a weak attraction between molecules. On a flat surface, a drop of rubbing alcohol forms a flatter and smaller drop than water. The difference in 'polarness' among the three liquids makes them behave differently when you drop them carefully on the surface of a penny. You can pile water into a dome shape before it spills over. You can also pile up rubbing alcohol, but it spills over before it forms much of a dome. Oil will barely pile up at all. As a result, you can put much more water on a penny.

Materials

*Materials to be supplied by the teacher or the students are marked with an asterisk.

Materials for the whole class

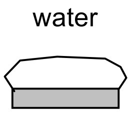
- 1 bottle rubbing alcohol
- 1 bottle vegetable oil
- *water
- *paper towels

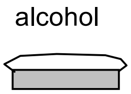
Materials for small groups (groups of 2)

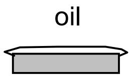
- 3 disposable pipettes
- 1 penny
- 1 9-oz cup containing about 1/4 inch of water
- 1 9-oz cup containing about 1/4 inch of rubbing alcohol
- 1 9-oz cup containing about 1/4 inch of oil
- 3 paper towels

Preparation

- Pour three 9-oz cups for each group: one with about 1/4 inch of water, one with1/4 inch of rubbing alcohol, and one with 1/4 inch of vegetable oil.
- Set out the remaining materials for each group of 2
- Be ready to insist that students draw table-level views of the pennies and liquids. Students will skip this step if left to their own devices, but they gain from observing and drawing. Their drawings might look like this:





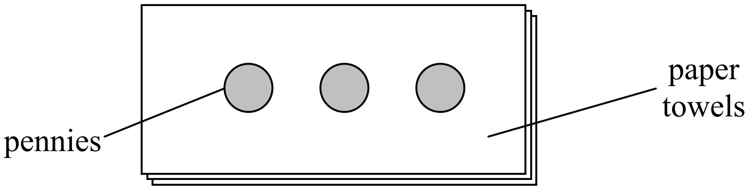


Procedure for a team of 2 students

[There is a black line master of these instructions at the end of this section.]

1. Put a pipette in each of the 3 plastic cups with the three different liquids. During the activity, keep each pipette with its own liquid and do not use it with any other liquid.

2. Keep your paper towels folded and pile them in a neat stack, smoothed flat. Set the 3 pennies a few inches apart in the middle of the paper towel. In your notebook, record how you arrange the heads and tails of the 3 pennies. Same sides up? Which sides? Different sides up? Why?



[An alternative could be to require all students to set up their pennies exactly the same way—all heads up or all tails up—and to label each penny with the liquid it will get. This would reinforce the notion of uniformity and labeling in experimental design. On the other hand, a discussion of the variability of results might bring out the same points.]

3. In your notebook, predict a) which of the three liquids will allow you to put the most drops on a penny, and b) which of the three liquids will allow you to put the fewest drops on a penny. Give your reasons for each prediction.

4. Drop one of the liquids on a penny slowly and gently. Note how far you are dropping from. Is it near the penny or higher up? How high? Count the drops. Stop when a drop makes the liquid overflow the edge of the penny and don't count the drop that caused the overflow. Record the number of drops and the liquid used. Wipe off the penny and repeat 2 more times. Record the number of drops for all 3 trials and circle the middle number. On the last trial, before the liquid overflows, place your eye at table level. View the penny and liquid from the side. Draw what you see in your notebook. Label the drawing with the name of the liquid used.

5. Repeat step 4 with a second liquid. Again record the number of drops for 3 trials. Circle the middle number from the 3 trials. On the last trial, view the penny and liquid from the side at table level, draw what you see in your notebook. Label the drawing and the number of drops with the name of the liquid used.

6. Repeat step 4 with the third liquid. When finished, your notebook should contain a record of all 3 trials of each liquid with the median indicated. It should also contain labeled drawings of the three pennies with liquids as seen from table level.

7. When you are done, use clean spots on the paper towels to wipe up any liquid that has soaked through to the tabletop.

Reflection/Discussion

Teams of 4 Students Discuss and Report in Notebooks

1. Which liquid had the highest median number of drops on the penny? Lowest? In between?
2. As a team, discuss why you think the medians are different. Try to explain so that everyone in the group agrees. Write the explanation you agree upon. If you don’t agree, record all of the explanations.
3. Design a way to test your explanation. You won’t have to do the test, so it can include materials not on hand. However, the test should show if your explanation makes sense.
4. Designate someone in your team to report the explanation and test to the class.

Reflection/Discussion (for the teacher)

Ask the class which aspects of the procedure are controlled and which are not (there are many of each). Aspects such as coin type, side of coin used, temperature, humidity, time of day, liquids used, types of pipettes, etc., are usually controlled. Condition of pennies, dropping techniques, and cleanliness of pipettes, etc., are usually uncontrolled.

Put a chart on the board like the one below and ask recorders from each group to fill it in. Ask reporters questions about their explanations and proposed tests as necessary. Check that 1) their explanations are consistent with their data, and 2) their tests fit the explanations.

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	Median # of drops				
Team Name	Water	Alcohol	Oil	Hypothesis	Test of Hypothesis

Debriefing

Students are unlikely to know about hydrogen bonds, cohesion, or surface tension. They might say the “heaviest” liquid comes off the penny with the fewest drops. They might want to weigh the liquids. If so, ask them to weigh the same volume of each liquid. This could lead to a good discussion of density. If they say that oil is densest, so the penny holds less of it, they might test this by layering the three liquids. If oil were densest, it would be on the bottom. On the contrary, it will be on top. This doesn’t support the explanation, but the test does shed light on the explanation, so it is a success.

Students may also say that oil is more viscous, so it oozes off the penny. They can test viscosity by timing the descent of a BB through equal columns of the liquids, or racing drops down an inclined plane.

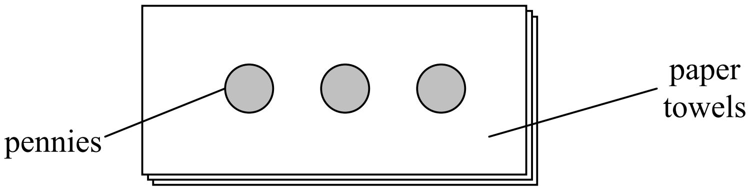
Other teams might explain that drops of different liquids are different sizes, and test this by counting drops needed to fill a small graduated cylinder to the 5 ml mark.

If students correctly explain that cohesion allows more water drops on the penny, a reasonable test would use detergent to disrupt hydrogen bonds. Few students know that detergents do this, but if someone proposes it, they could add a few drops of detergent to water before dropping it on the penny, decreasing the number of drops the penny will hold. With a good supporting argument, the test could support the hypothesis.

How Many Drops

Procedure for a Team of 2 Students

1. Put a pipette in each of the 3 plastic cups with the three different liquids. During the activity, keep each pipette with its own liquid and do not use it with any other liquid.
2. Keep your paper towels folded and pile them in a neat stack, smoothed flat. Set the 3 pennies a few inches apart in the middle of the paper towel. In your notebook, record how you arrange the heads and tails of the 3 pennies. Same sides up? Which sides? Different sides up? Why?



3. In your notebook, predict a) which of the three liquids will allow you to put the most drops on a penny, and b) which of the three liquids will allow you to put the fewest drops on a penny. Give your reasons for each prediction.
4. Drop one of the liquids on a penny slowly and gently. Note how far you are dropping from. Is it near the penny or higher up? How high? Count the drops. Stop when a drop makes the liquid overflow the edge of the penny and don't count the drop that caused the overflow. Record the number of drops and the liquid used. Wipe off the penny and repeat 2 more times. Record the number of drops for all 3 trials and circle the middle number. On the last trial, before the liquid overflows, place your eye at table level. View the penny and liquid from the side. Draw what you see in your notebook. Label the drawing with the name of the liquid used.
5. Repeat step 4 with a second liquid. Again record the number of drops for 3 trials. Circle the middle number from the 3 trials. On the last trial, view the penny and liquid from the side at table level, draw what you see in your notebook. Label the drawing and the number of drops with the name of the liquid used.
6. Repeat step 4 with the third liquid. When finished, your notebook should contain a record of all 3 trials of each liquid with the median indicated. It should also contained labeled drawings of the three pennies with liquids as seen from table level.
7. When you are done, use clean spots on the paper towels to wipe up any liquid that has soaked through to the tabletop.

Parts Per Million

Overview

Water dissolves tiny amounts of some things. For example, water may dissolve a small amount of the copper pipes that carry it through your school. The amount of copper in the water is measured in “parts per million.” A million is such a huge number that we can’t picture what a part in a million might be. Can you taste a few parts per million of something in drinking water? Can you see it? Can it make you sick? In this activity, students get some answers.

Materials

*Materials to be supplied by the teacher or the students are marked with an asterisk.

Materials for the whole class

- 4 dropper bottles of red dye
- 2 column “Million – Millionth” transparency (from black line master below)
- Powers of Ten transparency (from black line master below)
- Chemplate® Wells transparency (from black line master below)

Materials for groups of 2

- 1 Chemplate® with white paper under it and clean water in the large well
- Access to 1 dropper bottle with red dye
- 9-oz cup of rinse water
- *paper towels

Procedure (for the Teacher)

1. Show the 2-column “Million – Millionth” transparency and ask students for concrete examples of a million things. Also, ask for concrete examples of a millionth of something. Write these into the columns. Some examples:
   - A million people would fill 10 stadiums.
   - Work out how high a stack of a million sheets of paper would be: 1 ream (500 sheets) is 2 inches high. 1000 sheets are 4 inches high. A million sheets are 4,000 inches high. 4,000 inches is 333 feet. That’s as high as a 28 story building.
   - One second is a millionth of about 12 days (and a billionth of more than 30 years).
   - One inch is a millionth of about 16 miles.
   - If a singer sells a million copies of her CD, then a single CD is 1 part per million (1 ppm).
2. Discuss which is larger, 1 million or 1 billion? 1 millionth or 1 billionth? (Use the Powers of Ten transparency.)
3. Explain how 10 ml of a 10 % solution by volume of red dye is made. [1 ml of pure red dye and 9 ml of water.] Students typically think that it is 1 ml of red dye

and 10 ml of water. Discuss why it's 9 ml of water and not 10. The red dye supplied in the kit is a 10% solution.

4. Add 6 drops of red dye to well #1 on the Chemplate.® Move a drop of this to well #2. Rinse the pipette in a cup of clean water, and then add 9 drops of clean water from the large well on the Chemplate® to well #2. Stir with the pipette tip.

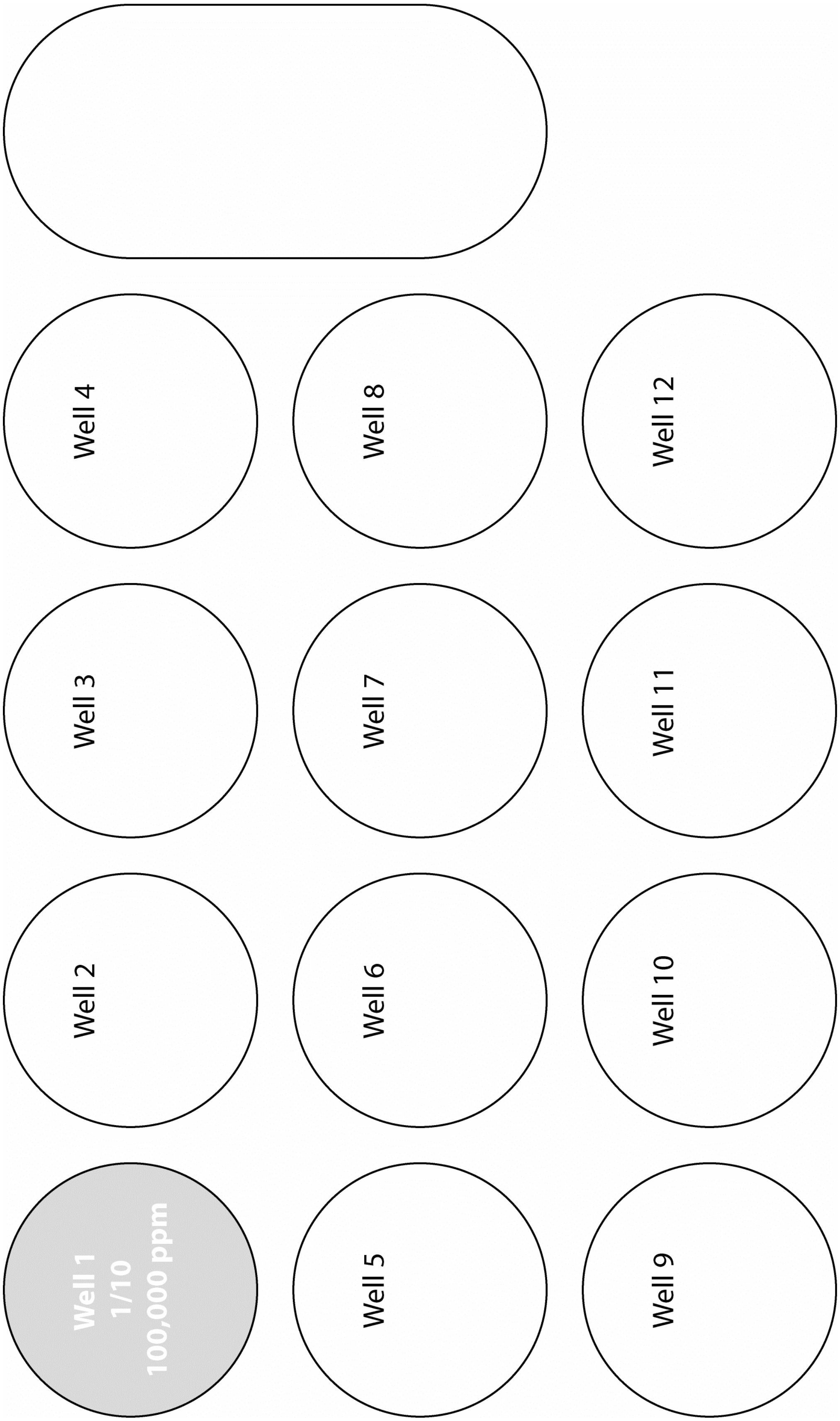
   [Demonstrate this whole procedure for students. Show them how to use the pipette—hold it vertically, avoid air bubbles, and don't let fluid get into the bulb.]

5. Repeat by taking 1 drop from well #2, placing it in well #3, rinsing the pipette, and adding 9 drops of water. Tell students they'll continue this procedure until they can no longer see any color in the water.
6. Tell students to record in their notebooks the concentration in parts per million of red dye in the first 7 wells.
7. After students finish, use the Chemplate® transparency and overhead projector (see Chemplate® black line master) to fill in the concentration of red dye in each well for the whole class. The concentration of red dye in well #1 is 10% (this is the concentration of red dye provided). How many parts per million is a 10% solution? [100,000 ppm] Ask students the concentration of red dye in well #2. How many parts per million? [10,000 ppm] Proceed through all of the wells until you reach the concentration where no red dye is apparent (usually 1 ppm).
8. Discuss **observing results** versus **inferring** from this evidence that red dye is present. *We do not observe any red dye, but we can infer that some red dye must be there*.

One Million	**One Millionth**

NAME	NUMBER	# OF ZEROES	EXPONENT	FRACTION	PARTS PER
1 billion	1,000,000,000	9	10^{9}	1,000,000,000/1	
100 million	100,000,000	8	10^{8}	100,000,000/1	
10 million	10,000,000	7	10^{7}	10,000,000/1	
1 million	1,000,000	6	10^{6}	1,000,000/1	
100 thousand	100,000	5	10^{5}	100,000/1	
10 thousand	10,000	4	10^{4}	10,000/1	
1 thousand	1,000	3	10^{3}	1,000/1	
hundred	100	2	10^{2}	100/1	
ten	10	1	10^{1}	10/1	
one	1	0	10^{0}	1/1	
tenth	0.1	1	10^{-1}	1/10	
hundredth	0.01	2	10^{-2}	1/100	
1 thousandth	0.001	3	10^{-3}	1/1,000	1 ppt
10 thousandth	0.0001	4	10^{-4}	1/10,000	100 ppm
100 thousandth	0.00001	5	10^{-5}	1/100,000	10 ppm
1 millionth	0.000001	6	10^{-6}	1/1,000,000	1 ppm
10 millionth	0.0000001	7	10^{-7}	1/10,000,000	100 ppb
100 millionth	0.00000001	8	10^{-8}	1/100,000,000	10 ppb
1 billionth	0.000000001	9	10^{-9}	1/1,000,000,000	1 ppb

- **Names**: Note how the names decrease 100, 10, 1 and then increase 1, 10, 100.
- **Number**: Nice pattern when you line up the decimal points.
- **# of Zeroes**: By including the 0 in front of the decimal, this value goes from 9 to 0 to 9.
- **Exponent**: For numbers > 1 the exponent is the same as the number of zeroes.
  To fit the pattern, 1 is defined as 10^{0}.
  For numbers < 1, the exponent is defined as the negative of the number of zeroes (counting the 0 in front of the decimal point).
- **Fraction**: Kind of artificial (though legitimate) to write the whole numbers as n/1, but it makes the point that the number of zeroes rule works here as well.
- **Parts per**: ppt = parts per thousand, ppm = parts per million, ppb = parts per billion


Well 1
1/10
100,000 ppm
Well 2
Well 3
Well 4
Well 5
Well 6
Well 7
Well 8
Well 9
Well 10
Well 11
Well 12

Fruitvale

Overview

Students try to solve a water pollution mystery in an imaginary town. Use the Fruitvale teacher's guide and the transparencies in it to work through this activity. The Fruitvale kit contains many excellent activities not covered in this Hydrosphere Teachers Guide. We encourage teachers to explore the kit beyond what we present here. The whole Fruitvale kit is included in the Hydrosphere textbook supplement. The Fruitvale teachers guide **MUST** be returned with the other non-consumable materials.

Background

Background is in the Fruitvale teachers guide starting on page 1, Activity 1, *The Fruitvale Story, Part I.* We recommend using all 12 lessons in Fruitvale in 14-20 class periods, but recognize that few teachers devote that much time to this topic. Of necessity, the workshop that comes with the Hydrosphere textbook supplement compresses 10 of the Fruitvale activities into several activities. You may choose to compress activities for your students, also in the interest of time, but this diminishes the power of the kit. For example, the workshop and this guide skip Activity 2, *Understanding Groundwater*, Activity 4, *Interpreting Maps*, and Activity 5, *Modeling Groundwater Contamination*. All of these are excellent and valuable. If you have time, we recommend doing them. The procedure below is for teachers who choose to compress activities.

Materials

Materials for the whole class

- 40 well samples in dropping bottles
- 4 dropper bottles of universal indicator
- Paper towels and sponges
- *Street Map of Fruitvale*, *Transparency 1.1*, p. 11
- *Topographic Map of Fruitvale*, *Transparency 4.1*, p. 55
- *Geologic Cross Section of Fruitvale, Transparency 4.2*, p. 56
- *Map of Fruitvale's Wells, Transparency 7.1*, p. 95
- *Rules for Drawing Isomaps*, *Transparency 9.1* p. 111
- *Map of Fruitvale's Groundwater Contamination*, *Transparency 10.1*, p. 123
- Transparency from *Fruitvale's Pesticide Plume*, *Student Sheet 10.1*, p. 121

Materials for groups of 2

- 1 *The Mystery of Fruitvale's Water* handout pp. 7-9
- 1 *Street Map of Fruitvale* handout *Student Sheet 1.1,* p. 11
- 1 *Topographic Map of Fruitvale* handout *Student Sheet 4.1,* p. 55
- 1 *Geologic Cross Section of Fruitvale* handout *Student Sheet 4.2,* p. 56
- 1 *Pesky Pesticides* handout, pp. 91-92
- 1 *Well Testing Results and Pesticide Testing Key*, *Student Sheet 8.1*, p. 103
- 1 *Map of Fruitvale's Wells*, handout *Student Sheet 7.1,* p. 95
- 1 *Fruitvale's Pesticide Plume, Student Sheet 10.1*, p. 121

- 1 *Making Isomaps*, *Student Sheet 9.1a and 9.1b*, p. 109
- 1 clean Chemplate®
- Access to the well samples and universal indicator (the teacher sets these out)
- *Paper towels and sponges

Preparation

Set out the well samples and universal indicator and setups for student groups. Read *The Mystery of Fruitvale's Water* and *Pesky Pesticides* from the Fruitvale teachers guide, pages 7-9 and 91-92. You might want to make copies of these to hand out to teams so that the teams can take turns reading the story aloud.

Procedure (for teachers who choose to compress the activities)

The following steps can take 3-5 class periods. Read through and determine break points before doing the activity.

1. Read *The Mystery of Fruitvale's Water*, pp. 7-9, aloud as a class, a paragraph at a time. Ask students each, in their own notebooks, to make three columns: one for information learned from the story, one for unanswered questions, and one for steps to find the answers to questions. Pause after each paragraph to give students time to put something in each column. Ask them to write a few paragraphs about the situation and what they would do to investigate it. Afterward, discuss the story as a class for a few minutes. At this point, students do not know the nature of the pollutant, but they will find out later. If students do not mention groundwater movement and topography, try to direct their attention to these factors.

2. Hand out a copy of *Street Map of Fruitvale, Topographic Map of Fruitvale, and Geologic Cross Section of Fruitvale* to each team. With the whole class, examine these 3 maps for more clues about Fruitvale's water pollution problem. Depending upon your knowledge and other resources, this process could take a full class period or several class periods. You might use these maps one-at-a-time. These topics are covered for a class period or more each in the Fruitvale teachers guide. They are Activity 2, *Understanding Groundwater*, Activity 4, *Interpreting Maps*, and Activity 5, *Modeling Groundwater Contamination*.

3. Read *Pesky Pesticide*, pp. 91-92, aloud as a class, a paragraph at a time. Afterward, ask teams to decide: 1) Which 3 locations on the map are the most likely sources of pesticide? Why did you pick each one? 2) What more would you like to know about Fruitvale and its water supply? Ask students to write reasons in their notebooks for the first three wells they have chosen to test.

4. Give students the *Map of Fruitvale's Wells, Student Sheet 7.1*, and ask them to make a testing plan. When they have a plan, ask them to write it in their notebooks (with reasons for their choices). Follow directions in the Fruitvale teachers guide from *Testing for Pesticide Concentrations*, Activity 8, pp. 97-100. Ask students to test samples from test wells 3-at-a-time and fill in *Well Testing Results and Pesticide Testing Key, Student, Student Sheet 8.1*. When they have

completed all 12 tests and recorded results on *Student Sheet 8.1*, ask them to transfer the hazard levels for the 12 locations they have tested to the appropriate circles on *Fruitvale's Pesticide Plume, Student Sheet 10.1*.

5. Explain to students that they will use their recorded results on the *Fruitvale's Pesticide Plume*, *Student Sheet 10.1* to draw the underground contaminant plume that is creeping under Fruitvale.

6. Hand out *Making Isomaps*, *Student Sheet 9.1a and 9.1b*, and ask students to try the exercise. Show *Rules for Drawing Isomaps*, *Transparency* 9.1 and explain the rules to students. Tell them that this is practice for the plume they are about to draw on the *Fruitvale's Pesticide Plume*, *Student Sheet 10.1.*
7. Ask students to use the isomap procedure to draw the plume on their sheet. When students are finished, their plumes will differ. Compare several maps and use the differences to discuss the fact that many actions are taken under conditions of uncertainty. Afterward, take data from the whole class to fill in circles on a transparency made from *Fruitvale's Pesticide Plume, Student Sheet 10.1*. From that, draw the whole-class version of the plume. Depending on test results, the class map might not exactly match the one from the Fruitvale teachers guide, *Map of Fruitvale's Groundwater Contamination*, *Transparency* p. 123. Decide whether to show this transparency. In this case, the "correct answer" is not particularly important.

Testing Water Samples

Overview

In this activity, students test water from 4 local sources to determine its purity.

Background

As the ‘universal solvent,’ water dissolves lots of things, including some things that make it less useful for washing or drinking. Some water impurities can even corrode pipes. Common measures of dissolved compounds include ‘hardness’ (calcium and magnesium salts), acidity or alkalinity (low or high pH), chlorine (added to kill bacteria), iron, copper from pipes, or coliform bacteria. Although a particular type of coliform bacterium may not be dangerous, the presence of coliform bacteria in a water sample indicates that other potentially dangerous organisms may be present. Any sample that tests positive for bacteria should not be consumed.

EPA recommendations for limits on water contamination are summarized below:

- Alkalinity – should be < 180 ppm
- pH – should be between 6.5 and 8.5
- Hardness – should be < 50 ppm
- Iron – should be < 0.3 ppm
- Copper – should be < 1.3 ppm
- Total Chlorine – should be < 4 ppm

Materials

*Materials to be supplied by the teacher or the students are marked with an asterisk.

Materials for the whole class

- 4 sterile collecting bottles for collecting water samples
- *4 water samples in bottles from different locations, labeled by location
- 4 bacteria tests
- 1 pair of rubber gloves
- 1 pair of safety glasses
- *10 % chlorine bleach solution (teacher wearing rubber gloves and safety glasses should make this)

Materials for small groups (Groups of 2)

- 1 hardness test strip
- 1 pH test strip
- 1 chlorine test strip
- 1 iron test strip and sulfite tablet
- 1 copper test strip
- 1 1-oz cup containing a water sample labeled with the location from which it was taken
- an empty 1-oz cup to collect used test strips
- 1 Water Analysis Test Instructions sheet
- *paper towels

Preparation

- Collect water samples from 4 different locations. Try to include samples from outdoors, such as a pond or stream, and some from drinking water sources. Take care when collecting samples not to pollute them by touching the inside of the cap or bottle. Do not let your hand touch water that may go into the collecting bottle.
- The bacteria test takes 48 hours, and even a strong positive may appear negative for the first day. However, it retains its positive color for several days after the 48 hours. Once sealed for the test, the vials should only be opened for disposal. Discard all completed bacteria tests as biohazards by disinfecting as follows:
  - Fill a container with a 10% chlorine bleach solution (1 part bleach to 9 parts water).
  - Empty the contents of each bacteria test vial into the bleach.
  - Immerse each vial and cap in the bleach.

Be sure that students have learned a little about bacteria in water, including how potentially harmful bacteria can get into water and what problems these bacteria can cause. Let students see you put water samples in the bacteria test vials. Follow the instructions with the vial. Let students know that the class will read the test in 2 days.

Procedure (for students)

Notes to Students about the Test Strips

These tests are very sensitive, so be careful not to touch anything that comes in contact with your sample. Note the following peculiarities with these test strips:

- Each strip can be used only once.
- Follow directions on the Water Analysis Test Instructions sheet for each test strip. Pay attention to how long you dip the strip in the sample before removing it. Don't shake off excess water. Hold the strip level (parallel to the floor), and read the results after the amount of time specified.
- The **pH test** looks reddish before use, and it appears not to change very much in a liquid of pH 4. However, the color strip *is* accurate, and that reddish color indicates pH ≤ 4. Pure neutral pH (7) water placed on the strip turns it brownish.

The group does the following steps in this order:

1. Test the sample *1-test-at-a-time*. In your notebook, record the name of the sample (location from which it was taken), the type of test, and the result in ppm. Use the table below to note whether you think any action should be taken.

   EPA recommendations for limits on water contamination are summarized below:
   - pH – should be between 6.5 and 8.5
   - Hardness – should be < 50 ppm
   - Iron – should be < 0.3 ppm
   - Copper – should be < 1.3 ppm
   - Total Chlorine – should be < 4 ppm

2. Do all of the following tests, and record the results of each in ppm. After each test, place the used strip in the empty 1-oz cup.
   - pH test strip
   - hardness test strip
   - iron test strip and sulfite tablet
   - copper test strip
   - chlorine test strip

Water Sample Riddle

Overview

In this activity, students test 4 water samples to determine their contents. Students can use many different methods to arrive at the answer to this logic puzzle.

Materials

*Materials to be supplied by the teacher or the students are marked with an asterisk.

Materials for the whole class
- Stock supplies of water samples numbered 1, 2, 3, and 4.
- 1 permanent marker

Materials for small groups (groups of 3 are recommended)
- 2 **hardness** test strips
- 2 **pH** test strips
- 2 **chlorine** test strips
- 2 **nitrate/nitrite** test strips (only the nitrate pad is used—see below)
- 1 empty 1-oz cup to collect used test strips
- 1 photocopy of the *Directions for Students*
- 1 *Water Analysis Test Instructions* sheet
- *paper towels

If teacher labels and pours the student sample cups:
- 4 1-oz cups, labeled 1, 2, 3, and 4, containing the respective water samples

If students label and pour their own sample cups:
- 1 permanent marker for each group
- 4 1-oz cups
- Access to the four stock supplies of water samples labeled 1, 2, 3, and 4

Preparation

- Label 4 1-oz. cups per team with a permanent marker. Label them 1, 2, 3, and 4. If students are working in groups of 3, fill each cup about ¾ full of the corresponding sample. (Sufficient solutions are provided for 120 students. If students are working in pairs, fill each cup ½ full in order to have enough for all classes.)
    - *Alternate setup*: Sample bottles can be set up at stations and students can label and fill their own cups.
- The non-toxic mystery water samples are provided in the kit, but if you need to make more, recipes are as follows. We suggest you wear rubber gloves and safety glasses to make these samples.
    - Water Sample #1: Add 1 ml chlorine bleach to 1 L water.
    - Water Sample #2: Add 2 ml chlorine bleach and 0.1 g washing soda (Na_2CO_3) to 1 L water.
    - Water Sample #3: Add 1 ml chlorine bleach, 0.26 g Epsom salt ($MgSO_4$), and 0.26 g Calcium Chloride ($CaCl_2$) to 1 L water.

    - Water Sample #4: Add 0.26 g Epsom salt ($MgSO_4$), 0.26 g Calcium Chloride ($CaCl_2$), 0.26 g sodium nitrate fertilizer ($NaNO_3$), and 0.008 g Calcium Hydroxide ($Ca(OH)_2$) to1 L water.
- Set out materials at each work place sufficient for 3 students.
- Make photocopies of the *Directions for Students*. They will use the chart on this sheet to plan and record their strategies.

Key for the Teacher:

- #1: Blooming Botanical Gardens.
- #2: Josiah J. Jones household.
- #3: Carbondale Community Center.
- #4: Feline Fitness Facility.

Procedure

1. Hand out *Directions for Students*.
2. Tell students that there are many different ways to solve this problem, some longer and some shorter. It has been solved in just 3 or 4 tests, though some luck was involved.
3. Before making any tests, teams must first develop a plan of attack, record their plan in a notebook with a reason for each step, and then raise their hands. **Do not** let teams start testing until they show you a complete plan supported by reasons. Teams may alter their plans during the testing, but at least they will have thought through the problem beforehand.
4. Let students begin testing after you see their plan. Tell them not to taste or drink any of the water samples.

Directions for Students

At Befuddled Testing Corp., a new worker correctly tested a group of water samples and found the following:

- The sample from the Carbondale Community Center has chlorine, hardness ≥ 120 ppm, and pH near neutral (near 7).
- The sample from the Blooming Botanical Gardens water supply has chlorine and pH near neutral (near 7).
- The sample from the Feline Fitness Facility has nitrates, hardness ≥ 120 ppm, and pH near neutral (near 7).
- The sample from the Josiah J. Jones residence has chlorine and pH ≥ 9.

Unfortunately, the new worker labeled the samples 1, 2, 3, and 4, but forgot to write down which sample went into each 1-oz cup. This person also kept no records. The new worker was immediately fired. You were hired as the replacement and told to sort out the mess.

Your boss says that you must match the identity of each sample (1-4) to its correct source. You may use a total of 6 tests, but a maximum of two of any particular test. (The tests are very expensive.) For example, if you use 2 chlorine tests, you can't test for chlorine again. Which sample (1-4) is in each 1-oz cup?

Use the table below to help you keep track of your work. Try to plan your strategy before you begin. In your notebook, record your testing sequence and the reasons for each step.

Notes About the Test Strips

- Each strip can be used only once.
- The **chlorine test** strip may turn the sample slightly yellow or green. This will not affect the results.
- On the **nitrate/nitrite test** strip, ignore the nitrite test pad and read the nitrate test. (See the color comparator sheet for the position of each pad.) The nitrate square may take up to 60 seconds to develop. Read it then because the color may change.
- When wet, **the hardness test** becomes slightly shiny, and may appear positive even at low hardness. The color comparator is accurate.

Water Sample Riddle Table

	Sample 1	Sample 2	Sample 3	Sample 4
Nitrates				
Hardness				
Chlorine				
pH				

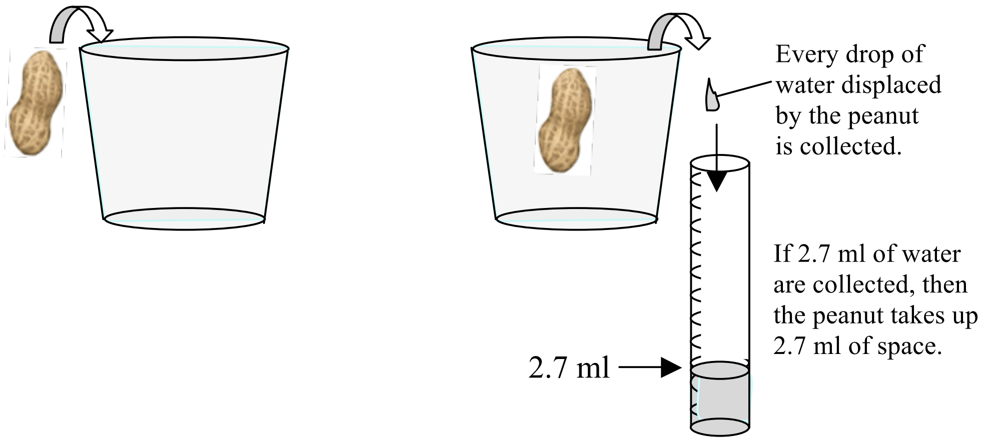
Flinkers

Overview

In this activity, students explore density and its relationship to buoyancy by making an object that neither floats nor sinks; we call it a flinker. It flinks because it has the same density as water. Students are challenged to add exactly the right amount of sand to a small tube to make it flink. They'll try to get the tube to flink by trial and error, trying their flinker repeatedly in a cup of water. Students will be surprised by the tiny amount of weight that makes the difference between floating, sinking, and flinking. They'll also predict whether their flinker in plain water will also flink in salt water. Students can apply these concepts to understand how tiny differences in density can drive ocean currents and cause lakes to "turn over" in the fall.

Background (Making Sense of Dense and Buoyant)

The amount of weight in a given amount of space is called **density**. You can measure the space that something takes up by measuring the amount of fluid it displaces when it is submerged. If you completely submerge a peanut in a glass full *to the brim* with water, water overflows. If you catch every drop of overflow water and measure its volume, that volume of water is pretty close to the volume of the peanut.



If you weighed the water that the peanut displaced and also weighed the peanut, you'd be weighing two things of about the same volume. If the peanut weighed less than the water it displaced, it would be less dense than water. Objects that are less dense than the fluid they are in float. If both weighed the same, they would have the same density. Objects of the same density as the fluid they are in neither float nor sink. They flink (a made-up word combining floating and sinking). If the peanut weighed more than the water it displaced, it would be denser than water. Objects that are more dense than the fluid they are in sink.

Archimedes said that a fluid exerts an upward "buoyant force" on whatever is in it. The upward force is equal to the weight of fluid that the object displaces. Think of the water that was pushed aside by the object. It has weight. That weight is trying to get back into the space it was pushed out of. The only force it has to exert is its weight. In this case, that weight pushes up. It pushes up the way squeezing a slippery watermelon seed between your fingers can shoot the seed straight up into the sky. That's the buoyant force.

Whatever is in the fluid is also pushing down according to its weight. So, there are two forces – one pushing down and one pushing up. It's a pushing match where the greater force wins. If the thing sitting in the fluid weighs less than the buoyant force, it floats. If the thing weighs more than the buoyant force, it sinks. If the thing sitting in the fluid and the amount of fluid displaced weigh the same, it's a tie. There is no net force either way. In that case, the thing doesn't rise up or sink down. It flinks.

In a lake or an ocean, the thing that's floating or sinking doesn't have to be solid. It can be a liquid. Less dense liquids like oil float in denser liquids like water. Even water that's warmer than the water around it will rise. Warmer water has expanded. The same weight takes up a little more space than the colder water it's displacing. So, it rises. The same goes for water with more or less salt. A cup of salty water is a little heavier than a cup of fresh water, so salty sinks in fresh, and vice versa. These differences are the main forces driving ocean currents.

Materials

*Materials to be supplied by the teacher or the students are marked with an asterisk.

Materials for the whole class

- 15 tubes 1.5 cm in diameter, 3 cm long, with water-tight caps
- 15 9-oz cups
- 15 metal scoops
- 16 1-oz cups
- sand
- salt
- 8 50-ml graduated cylinders
- 1 electronic balance accurate to 0.1 gram
- *newsprint to cover work areas

Materials for small groups (groups of 2)

- 1 small plastic tube 3 cm long, with a water-tight cap
- 1 9-oz cup ¾ full of water
- 1 metal scoop
- 1 plastic forceps
- 1 food tray of sand
- 1 1-oz cup of salt
- 1 50 ml graduated cylinder
- access to an electronic balance

Preparation (by the teacher)

1. Fill one 9-oz cup ¾ full of water for each group of 2 in your class
2. Fill one 1-oz cup ¾ full of sand for each group
3. Fill one 1-oz cup ¾ full of salt for each group
4. Set out all of the remaining materials for groups of 2
5. Place electronic balances where groups can use them efficiently. Plug them in and make sure they are zeroed. Avoid jams at the balances by letting each group know which balance to use.
6. Be sure that students either have newspaper to cover their work areas, or that you have covered the work areas with newspaper.

Procedure (for the teacher)

1. Ask students to fill their tubes *almost full* of sand (2 mm from the top) and cap them. When they have done this, ask them to fill their graduated cylinders about half way with water. Tell them NOT to put the tube in the graduated cylinder.
2. Ask students to predict in their notebooks what will happen when they put their tube in the graduated cylinder. Ask them to draw the graduated cylinder before and after.
3. Ask students to record the volume of water in the graduated cylinder and drop the capped tube full of sand into it. What is the change in volume? Ask students how much space they think the tube full of sand takes up. Ask if the tube would take up more space if more sand were put into it? Have students completely fill the tube and drop it into the graduated cylinder. Would the tube take up less space if sand were taken out of it? (No need to try this one; the answer is “no” and most students should see this.)
4. Challenge students to make a flinker. Give them 10 minutes. Say, “Using only sand to weight the tube, make a tube that neither floats nor sinks in the cup of water. Take care that no bubbles are on or under the tube.” Students will not achieve neutral buoyancy on their first attempt. Nearly all tubes will sink or rise fairly quickly. Students will eventually be adding or subtracting just a few grains of sand, and trying their flinker over and over again.
5. Once a group has a flinker, ask that group to find the volume of the flinker in the graduated cylinder. Ask them to record that volume in their notebooks. Ask students to predict (estimate) the mass of the flinker in grams, then weigh it on the balance. What is the density of the flinker in grams per cubic centimeter?
6. Ask students: what do they think is the density of water in grams per milliliter? How would they find out? Ask students to devise a way to find out and try it. Give students 10 minutes to do this.
7. Ask students to put the flinker back in the cup. They might need to adjust it a little to get it to flink as well as before. Once they’ve got it, tell them you’re going to

ask them to add the salt from the 1-oz cup into the cup of water with the flinker. Ask them to predict in their notebooks what will happen, and to give a reason why, then have them add the salt.

8. Ask students to adjust the flinker to flink in the salt water. Ask them to predict its density in their notebooks. Tell them to again find the flinker's density. What do they see? Ask them to write an explanation in their notebooks.

Reflection/Discussion

1. Ask: What made it difficult to get the tube to flink? Do you think that 1 grain of sand is enough to make the difference between floating and sinking? Why do you think that? (The answer is "Yes.")

   Look at the table of water density vs. temperature. What's the difference in density between water that feels cold (41 °F) and water that feels cool (59 °F)? This is a spread of 18 °F. The cool water will strongly rise up in the cold water even though the difference in density between the two is only 0.00081 g/cm^3. That's far less than a grain of sand's worth in a flinker tube, but it's enough to drive ocean currents.

Water Density by Temperature

Temperature	Density		Temperature	Density
°F	g/cm3		°F	g/cm3
32.0	0.99982		66.2	0.99849
33.8	0.99989		68.0	0.99829
35.6	0.99994		69.8	0.99808
37.4	0.99998		71.6	0.99786
39.2	1.00000		73.4	0.99762
41.0	1.00000		75.2	0.99738
42.8	0.99999		77.0	0.99713
44.6	0.99996		78.8	0.99686
46.4	0.99991		80.6	0.99659
48.2	0.99985		82.4	0.99631
50.0	0.99977		84.2	0.99602
51.8	0.99968		86.0	0.99571
53.6	0.99958		87.8	0.99541
55.4	0.99946		89.6	0.99509
57.2	0.99933		91.4	0.99476
59.0	0.99919		93.2	0.99443
60.8	0.99903		95.0	0.99408
62.6	0.99886		96.8	0.99373
64.4	0.99868		98.6	0.99337

2. Review Archimedes' principle. The buoyant force is equal to the mass of the fluid displaced. For every cubic centimeter of cool water, 1 gram of cold water is pushing up and only .99919 grams are pushing down. The result of this little pushing match is that .00081 more grams are pushing up than pushing down on every cubic centimeter of the cool water. A grain of sand weighs a lot more than that. However, because there are a gazillion cubic centimeters of warm water out there, it adds up, and it's enough to move the whole body of warm water upwards.

Home Water Use Study

Overview

In this activity, students find out how much water their family uses in a week. They use that information to make stacked bar graphs that compare usage for different purposes. The process has 4 steps: 1) identify and locate the home fixtures and appliances that use water, 2) determine how fast water flows from each fixture or appliance, 3) put a record sheet at each appliance or fixture for all family members to record the duration of water usage, and 4) multiply each time by flow rate and add up the amounts each fixture uses. Students then make a stacked bar graph from a week's data. A teacher who used this lesson found that her 1999 class's families used an average of 1,308 gallons per family per week (gfw). Her 2000 class averaged 1,475 gfw. Her 2002 class averaged 894.2 gfw. You might see weekly family water use in this range.

The activity can take a few weeks. It works best if you help the class arrive at their own method for gathering data. For that reason, the data analyses, tallies, and record sheets with this activity are intended as guides for the teacher in leading the class to find their own methods for data gathering.

Background

One way that people affect water resources is to use them up. Urbanizing areas of North Carolina face possible shortages of water during the next few decades. The growing populations in these areas are too large for the ground and surface water supplies, especially during droughts. Additionally, the average American uses more water than the average citizen of any other country. Maybe your students' families are typical American families in this regard and maybe not. In this activity, students might find out. They might also see how their family could use less water if this resource became scarce.

Materials

Materials for the whole class

- Water Source Inventory transparency
- Water Flow Rate transparency
- Water Use Record Sheets transparency
- Water Use Tables transparency
- Water Use Stacked Bar Graph transparency

Materials for small groups (Groups of 2)

- Water Source Inventory Handout
- Water Flow Rate Handout
- Water Use Record Sheets handout
- Water Use Tables Handout
- Water Use Stacked Bar Graph Handout

Preparation

Have all handouts and transparencies ready.

Procedure

1. Talk to students about how they might go about learning how much water their family uses. How would they go about it? What steps would they take?
    - If students don't come up with it on their own, ask them to list all of the things in the house that use water.
    - Next, ask them how much water each thing uses each time it's used.
2. SAY: "We also need to know how much water is used throughout the house." Try to get the class to come up with ways, given what has been discussed, to represent the different uses for each household *and* for the whole class. For example, how would we know what proportion of water is used for flushing toilets?
3. Either have the class make up a water source inventory sheet (best option), or go over the Water Source Inventory transparency and give out the Water Source Inventory Handout (no inquiry).
4. Either have the class make up a technique for determining water flow rate (best option), or go over the Water Flow Rate transparency and give out the Water Flow Rate Handout (no inquiry).
5. Either ask the class to determine how they will record water use rate by fixture or appliance (best option), or go over the Water Flow Rate transparency and give out the Water Flow Rate Handout (no inquiry). Some combination of these options might work.
6. Either have the class devise a technique for recording water use at each fixture (best option), or go over the Water Use Record Sheets transparency and give out the Water Use Record Sheets handout (no inquiry).
7. Either have the class decide how they will assemble all of their water use records into data tables (best option), or go over the Water Use Tables transparency and give out the Water Use Tables handout (no inquiry).
8. Ask students to make a stacked bar graph showing water use in their households. To make the graphs comparable, ask them to use a scale of 1 cm = 50 gallons. Show the Water Use Stacked Bar Graph transparency and give out the Water Use Stacked Bar Graph Handout.

Water Source Inventory

How many do you have?

Water-Using Item	Number in your house
Toilets	
Bathroom sinks	
Showers	
Bathtubs	
Kitchen Sinks	
Ice cube maker (in refrigerator)	
Refrigerator door water	
Dishwashers	
Washing Machines	
Garden Hose Spigots	
Other (specify)	
Other (specify)	

Water Flow Rate

TOILETS, SINKS, BATHTUBS, SHOWERS, HOSES, etc.: How could you find out how fast water flows from a faucet or shower head? Think about:

1. How do we usually express how fast water flows?
   - in the American system, flow rate of a liquid is given in gallons per minute
   - in the metric system, the flow rate of a liquid is given in liters per second

1. What tools will you need?

2. What will you do, one step at a time?

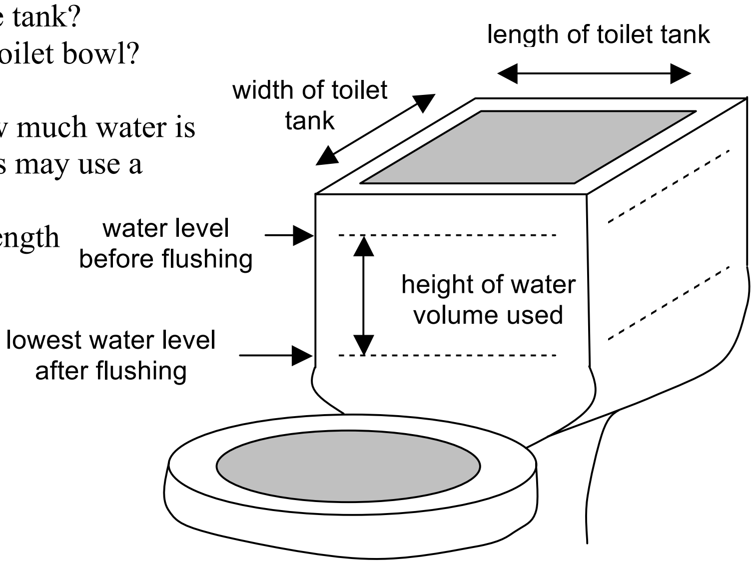
3. Who will do what?

TOILETS:

1. What happens when you push the handle? (look inside the back and find out)
2. What makes water empty out of the tank?
3. What makes water stop filling the toilet bowl?
4. What does the float do?
5. Here's one method to calculate how much water is used in one flush? Low flow toilets may use a different mechanism.
   - Measure the inside width and length of the toilet tank in INCHES.

     Record here. Length:_______

     Width: _______



   - Use a pencil to mark the water level in the tank before flushing and after flushing and measure the distance between the two lines.

     height of water volume used: ______

   - Convert your measurements to decimal numbers (e.g. 3/4 inch = 0.75 inch)

- Multiply length of toilet tank times width of toilet tank times height of water volume used.

  length of toilet_______x width of toilet_______x height of volume used________

  Volume of water used = ________________cubic inches

- 1 gallon = 231 cubic inches. How many gallons were used?

  Record your answer______________

If you have multiple toilets, use the following table to calculate the volume for each:

toilet location	length	width	height of volume used	volume in cubic inches	volume in gallons

WASHING MACHINES – Typically use about 40 gallons each use. Check the instruction manual if you have it.

DISHWASHERS – Typically use about 14 gallons each use. Check the instruction manual if you have it.

Flow Rates

SINKS — Use a small bucket, cooking pot, or other container, along with a second hand on a watch, to determine the flow rates of all sinks. IMPORTANT: Do this with the water turned on at a *medium* rate – not fastest or slowest, but in the middle.

Collect water flowing from the faucet for 10 seconds. Then, measure the water you have collected to the nearest quarter of a cup. Do three trials for each sink. Fill in the data in the table below. You have the # of cups/10 seconds. How do you find the # of cups/minute if flow remains constant? How many cups are in one gallon? What is the flow rate in gallons/minute?

sink location	cups per 10 seconds			gallons per minute			avg. gal. per minute
	trial 1	trial 2	trial 3	trial 1	trial 2	trial 3	

SHOWERS — Fill the table using the procedure for sinks, but use the flow rate that most shower takers in the family use (not necessarily the middle amount).

shower location	cups per 10 seconds			gallons per minute			avg. gal. per minute
	trial 1	trial 2	trial 3	trial 1	trial 2	trial 3	

TUBS — Cut the top off an empty gallon milk or water jug just below the neck. Make the hole just big enough to fit around the bath tub spigot. Find out how long it takes to fill the jug. Then find out how long it takes to fill the tub. Record the number of gallons it takes for one bath.

tub location	# seconds to fill a 1 gallon jug	# of seconds to fill the bath tub	gallons for one bath

HOSES — Fill the table using the procedure for sinks.

hose location	cups per 10 seconds			gallons per minute			avg. gal. per minute
	trial 1	trial 2	trial 3	trial 1	trial 2	trial 3	

REFRIGERATOR DOOR WATER
Do this by the number of glasses people drink (call each glass 1 cup).

ICE MAKERS
Melt 10 ice cubes and determine how much water is in an ice cube; then keep track of the number of ice cubes used in a week.

Check Sheet for placing water use record sheets

______Bathroom sinks – all that are in use

______Showers – all that are in use

______Tubs– all that are in use

______Toilets – all that are in use

______Kitchen sink

______Refrigerator water (if people get water from the refrigerator door)

______Ice cubes (for automatic ice cube makers only (on door or in freezer)

______Dishwasher

______Clothes washer

______Any other sinks (e.g. laundry, bar, garage)

______Hoses– all that are in use

______Other

BLANK WATER USE RECORD SHEETS

Cut these sheets along dotted lines and place at appropriate fixtures or appliances.

Sink (kitchen, bathroom, utility, or other) Record Sheet

Directions: make one hash mark for every 12 seconds the sink runs. 𝍸 = 1 minute

Sink location	Day 1	Day 2	Day 3
	Day 4	Day 5	

Sink (kitchen, bathroom, utility, or other) Record Sheet

Directions: make one hash mark for every 12 seconds the sink runs. 𝍸 = 1 minute

Sink location	Day 1	Day 2	Day 3
	Day 4	Day 5	

Sink (kitchen, bathroom, utility, or other) Record Sheet

Directions: make one hash mark for every 12 seconds the sink runs. 𝍸 = 1 minute

Sink location	Day 1	Day 2	Day 3
	Day 4	Day 5	

Shower Record Sheet

Directions: make one hash mark for every 12 seconds the shower runs.

Shower location	Day 1	Day 2	Day 3
	Day 4	Day 5	

Shower Record Sheet

Directions: make one hash mark for every 12 seconds the shower runs.

Shower location	Day 1	Day 2	Day 3
	Day 4	Day 5	

Bathtub Record Sheet

Directions: make one hash mark for every bath taken.

Bathtub location	Day 1	Day 2	Day 3
# of gallons used per bath =	Day 4	Day 5	

Bathtub Record Sheet

Directions: make one hash mark for every bath taken.

Bathtub location	Day 1	Day 2	Day 3
# of gallons used per bath =	Day 4	Day 5	

Toilet Flush Record Sheet

Directions: make one hash mark each time the toilet is flushed.

Toilet location	Day 1	Day 2	Day 3
# of gallons used per flush =	Day 4	Day 5	

Toilet Flush Record Sheet

Directions: make one hash mark each time the toilet is flushed.

Toilet location	Day 1	Day 2	Day 3
# of gallons used per flush =	Day 4	Day 5	

Toilet Flush Record Sheet

Directions: make one hash mark each time the toilet is flushed.

Toilet location	Day 1	Day 2	Day 3
# of gallons used per flush =	Day 4	Day 5	

Refrigerator Water Record Sheet

Directions: make one hash mark for each glass of water taken.

Refrigerator	Day 1	Day 2	Day 3
	Day 4	Day 5	

Ice Use Record Sheet (automatic ice makers only)

Directions: make one hash mark for each ice serving taken.

# of cups of water per avg. ice serving (e.g., melted ice cubes or crushed ice) =	Day 1	Day 2	Day 3
	Day 4	Day 5	

Dishwasher Record Sheet

Directions: make one hash mark for each time the dishwasher is run.

Use 14 gallons of water per operation of the dishwasher (unless otherwise specified)	Day 1	Day 2	Day 3
	Day 4	Day 5	

Clothes Washer Record Sheet

Directions: make one hash mark for each time clothes are washed.

Use 40 gallons of water per operation of the washing machine (unless otherwise specified)	Day 1	Day 2	Day 3
	Day 4	Day 5	

Hose Record Sheet

Directions: make one hash mark for each 5 minutes the hose is run.

Hose location	Day 1	Day 2	Day 3
	Day 4	Day 5	

Hose Record Sheet

Directions: make one hash mark for each 5 minutes the hose is run.

Hose location	Day 1	Day 2	Day 3
	Day 4	Day 5	

Water Use Tables

Use these data tables to calculate the total number of gallons used by each water source.

TOILETS	# of flushes	Gallons per flush	Gallons Used
Toilet 1			
Toilet 2			
Toilet 3			
		Total gallons used by all toilets:	

SHOWERS	minutes run	Gallons per minute	Gallons Used
Shower 1			
Shower 2			
Shower 3			
		Total gallons used by all showers:	

BATHTUBS	# baths	Gallons per bath	Gallons Used
Bathtub 1			
Bathtub 2			
Bathtub 3			
		Total gallons used by all bathtubs:	

SINKS (write location)	minutes run	Gallons per minute	Gallons Used
Sink 1______________			
Sink 2______________			
Sink 3______________			
Sink 4______________			
		Total gallons used by all sinks:	

DISHWASHER	# of uses	Gallons per use	Gallons Used
		14	
		Total gallons used:	

WASHING MACHINE	# of uses	Gallons per use	Gallons Used
		40	
		Total gallons used:	

HOSES	minutes run	Gallons per minute	Gallons Used
Hose 1			
Hose 2			
Hose 3			
		Total gallons used:	

OTHER (describe)	minutes run	Gallons per minute	Gallons Used
		Total gallons used:	

GRAND TOTAL OF ALL WATER USED FOR THE WEEK______________________

Stacked Bar Graph Practice Sheet

Ann gathered the data shown below after a week of measuring her family's water use.

SOURCE	GALLONS USED
toilets	175
laundry	150
showers	250
bathtubs	150
sinks	85
hoses	40

Questions:

1. How many gallons of water did the family use for the week?

2. What *percent* of the family's water was used for toilets for the week?

3. What *fraction* of the family's water was used for sinks for the week?

Use the data given to make a stacked bar graph showing how Ann's family used water. Use a scale of 1 cm = 50 gallons. Make your graph on the back of this sheet. How many cm tall will the whole stacked bar graph be?

Stacked Bar Graph of Ann's Family's Water Use for 1 Week

(850 gallons total)