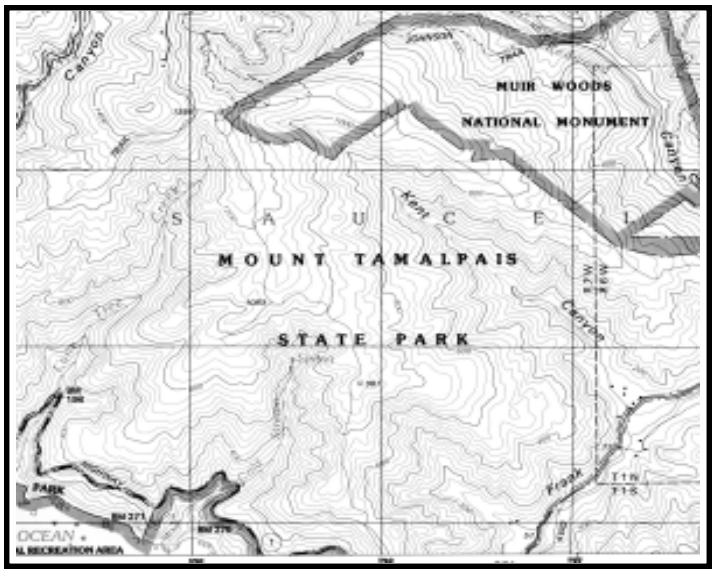
Three Ways to be 3-D

Understanding Topographic Maps

TEACHER'S PAGES

Overview

These three activities are designed to help students visualize how contour lines on a topographical map relate to three-dimensional landforms. In the first activity, students will use a three dimensional model of a landform to create a two dimensional image. In the next two activities, students use an enlarged portion of a topographical map to create accurate three-dimensional models of landforms within the San Francisco Bay watershed. (Note: the second two activities are interchangeable.)



USGS Topographical Map

Estimated Time

Each Part of the activity takes 1 to 1 ½ hours. It is recommended to conduct Part I in one class session and then conduct either Part II or Part III in another class session.

Objectives

Students will be able to:

- Understand contour lines on a topographical map
- Learn to relate contour lines to field elevations
- Use a three-dimensional model to create a two-dimensional representation of a landform
- Use a topographic map to create a three dimensional model of a landform within the San Francisco Bay watershed

Materials

Part I:

For each group of three to five students:

- Photocopy of student pages
- Work surface (table or counter)
- Dough ingredients:
  1 ½ c. table salt
  3 c. all purpose flour
  1 ½ tsp. Vegetable oil
  1 c. water
  mixing bowl
  OR 1 large bag of modeling clay
- washbin or plastic dishpan, preferably with high sides
- masking tape
- food coloring
- water jug or pitcher
- paper
- waterproof marker
- ruler

Additional Resource: USGS: What do maps show?
http://interactive2.usgs.gov/learningweb/teachers/mapsshow_guide.htm

Materials (continued)

Part II

For each group of two to three students:

- Photocopy of student pages
- Topographic map with contour lines, enlarged if necessary so that landforms are 3-4 inches in diameter (there are examples attached).
- Permanent markers
- 8-12 stackable clear food/salad plastic containers approximately 7" by 7" with the lids removed (the lids can also be used if they are clear and stackable). These can be collected at salad bars and cleaned for reuse or purchased at stores such the Center for Creative Reuse or Smart and Final.
- White Paper

Part III

For each group of two students:

- Photocopy of student pages
- Enlarged pieces of a topographic map, 2 photocopies of each (examples attached)
- Thick cardboard or foam core
- Utility knife
- Glue
- Modeling clay
- Pen or pencil

California Science Content Standards

Grade 6

Standard Set 7.f: read a topographic map and a geologic map for evidence provided on the maps, and construct and interpret a simple scale map.

Grade 9 – 12

Investigation and Experimentation

Standard h: read and interpret topographic and geologic maps.

Background

(Written by Ellen P. Metzger, from *The Best of BAESI*, a collection of 19 hand-on lessons modeled by teacher-participants in the BayArea Earth Science Institute.)

Topographic maps are used extensively by a variety of people including geologists, field biologists, and hikers. A topographic map is the representation, on a flat surface, of part of the Earth's surface drawn to scale.

The features shown on topographic maps may be divided into three groups: (1) relief, which includes hills, valleys, mountains, etc.; (2) water features, including lakes, ponds, and streams; and (3) cultural features, man-made features like bridges, canal, buildings, and roads.

Relief is the difference in elevation between any two points. Where relief is low, the area appears to be relatively flat as in river valleys or broad, flat uplands. When relief is high, the area is steep, as in rugged mountainous terrains. Relief determines the contour interval, which is the difference in elevation between adjacent contour lines. A contour line is an imaginary line on the Earth's surface connecting points of the same elevation. Contour intervals may be large for rugged terrains (80 or 100 feet) or they may be small in areas of low relief (10-20 feet). Contour intervals are consistent for a given map, though they may change from map to map. Usually every fifth contour line (an index contour) is printed heavier than the others and bears the elevation above sea level.

In addition to contour lines, heights of many points occur on the map, such as road intersections, summits of hills, lake shorelines, etc. These are spot elevations and are accurate to within the nearest foot or meter. More precisely located and more accurate in elevation are bench marks, points marked by brass plates fixed permanently on the ground. On a topographic map, bench marks are represented by crosses and the elevation, preceded by the letters "BM", is printed in black on the map.

Rules of Contour Lines.— Some basic rules or facts about contour lines are listed below.
1. Where a contour line crosses a stream or valley, the contour bends to form a "V" that

points upstream or valley. In the upstream direction the successive contours represent higher elevations.
2. Contours near the upper parts of hills form closures. The top of a hill is higher than the highest closed contour.
3. Hollows (depressions) without outlets are shown by closed, hatched contours. Hatched contours are contours with short lines on the inside pointing downslope. The bottom of the hollow is lower than the lowest closed contour.
4. Contours are widely spaced on gentle slopes.
5. Contours are closely spaced on steep slopes.
6. Evenly spaced contours indicate a uniform slope.
7. Contours do not cross or intersect each other, except in the rare case of an overhanging cliff.
8. All contours eventually close, either on a map or beyond its margins.
9. A single higher elevation contour never occurs between two lower ones, and vice versa.
10. A change in slope direction is always determined by the repetition of the same elevation either as two different contours of the same value or as the same contour crossed twice.

Scale: Scale expresses the relationship between distance on the map and the true distance on the Earth's surface. This is generally expressed as a ratio or a fraction, such as 1:24,000 or 1/24,000. The numerator, usually 1, represents map distance, and the denominator, a large number, represents ground distance. Thus, 1:24,000 means that a distance of 1 unit on the map represents 24,000 such units on the ground. The unit here is not important - it could be meters, feet, or inches. What is important is the relationship between the map distance and the true ground distance.

Colors and Symbols.— Each color on a topographic map has significance as follows:
Blue = water features;
Green = woodlands, orchards, etc.;
Red = urban areas, important roads, public-land boundary lines, civil boundaries;
Black = man-made works;
Brown = contour lines.
Purple = new additions in revised versions; usually man-made features

Teacher Procedure
1. Construct the activities you want to do with the students ahead of time so you will have an example to show the students. The activities will run much more smoothly if students can see an end product before they make their own maps and models.
2. Students should be introduced to the concepts of relief, scale, and contour intervals before beginning this activity, using the background information and demonstrating on a transparency of a topographical map.
3. Hand out the materials and photocopies of student pages to small groups of students, and assist them with the creation of their topographical models.

Modifications for Activity III:
To increase the challenge:
1) select a landform near the school with which the students are familiar;
2) select a canyon rather than a hill, or;
3) select a large, complex series of hills and canyons, split up the area between groups in the class to create a 3-D model of a large area. Once models are assembled, cover with paper mache or clay and paint, then add the man-made structures for a more realistic representation of the area modeled.

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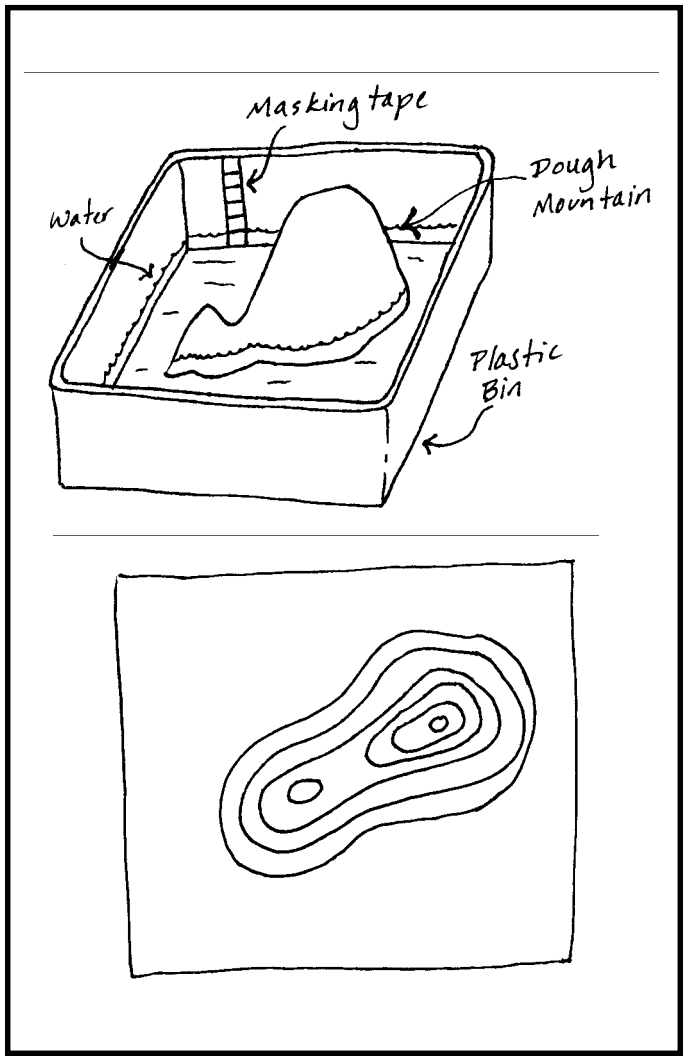
Student Pages

Part I
Making A Topographic Map

INTRODUCTION

Topographic maps show shapes and features of the Earth's surface using contour lines. A contour line shows places on the map which have the same elevation. You can make a topographic map of a model landscape by using colored water to show the shape of the land at different elevations.



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MATERIALS

Dough ingredients:

- 1 ½ c. table salt
- 3 c. all purpose flour
- 1 ½ tsp. Vegetable oil
- 1 c. water
  OR 1 large bag of modeling clay
- washbin or plastic dishpan
- masking tape
- food coloring
- water jug or pitcher
- paper
- waterproof marker

PROCEDURE

1. Prepare the model-making dough. Mix flour, salt, and oil together and slowly add enough water to produce a stiff dough. Knead dough to distribute water thoroughly. If mixture is not used immediately, store in an airtight container.
2. On a strip of masking tape, mark off 1cm. intervals. Place end of tape with zero mark at bottom inside edge of basin and stretch tape up to top of basin. (See illustration).
3. Press dough into the bottom of the basin, leaving an area around the "tape measure" clear of dough. Mold landforms such as mountains, valleys, islands, and stream corridors.
4. Sketch what you expect your contour map of the "landscape" to look like.
5. Fill jug or pitcher with water and add 3 to 4 drops of food coloring to make water more visible.

PROCEDURE (continued)

6. Gently pour water into the basin until it is even with the first centimenter mark on the tape.
7. Look straight down at the model and on a piece of paper draw the shape formed where the water line circles your dough landscape. This is your one inch contour line.
8. Add water again to your next tape mark, the 2 inch line. On the same map that you just started to create, draw the contours at the waterline of the same landscape. What changes are you seeing?
9. Continue to add water to the next mark, and draw in shapes of "land" at the water line. When this activity is completed, you will have developed a topographic map of your landscape.

QUESTIONS

1. Compare your final map to your initial one. Are there any differences between your predicted and final maps? What have you learned about how contour lines work?

2. Have you drawn your maps to scale? To verify your answer, take a series of measurements on both your model and your map and then compare them to see whether the proportions between model and map are always the same.

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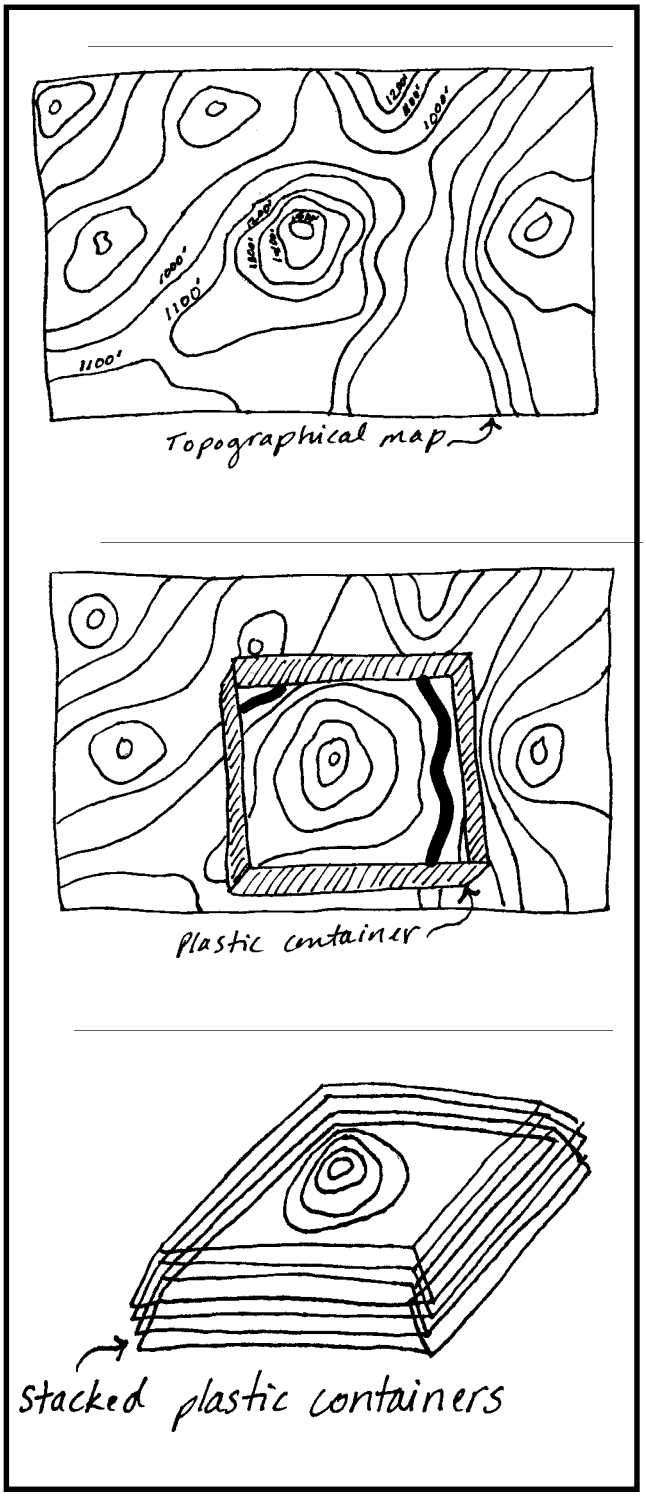
Part II
Drawing a 3-D Topographic Model

INTRODUCTION
Topographic maps show the shapes and features of the earth's surface using contour lines. Contour lines show places on the map that have the same elevation. By drawing the contour lines of a landform on layers of clear plastic, you can create a 3-D representation of that landform.

MATERIALS
- Topographic map with contour lines, enlarged if necessary so that landforms are 3-4 inches in diameter.
- Permanent markers
- 8-12 clear food/salad containers, lids removed
- Piece of white paper

PROCEDURE
1. Examine your map. On a separate piece of paper, draw or write a description of the landscape.
2. Place a salad container on the map and center the container over a landform.
3. Trace the outline of the container onto the map with a pencil (making a rectangle on the map to mark the spot)
4. With a permanent marker, trace the lowest contour line of the landform onto the plastic container. Set aside.



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PROCEDURE (Continued)

5. Place another container on the rectangle outline on the map. Trace the next highest contour line onto the container (note: If your landform has a number of closely spaced lines, draw only the index contours, which are the lines in bold print). Stack this container on top of the first one.
6. Continue tracing contour lines onto separate plastic containers and stacking them on top of each other until you have traced the highest elevation.
7. Cut a piece of white paper to fit inside the container on the bottom. Using the map, trace creeks, rivers, or other landmarks onto the paper. Tape the paper into the bottom container. Now you should be able to see a 3-D image of your landform!

QUESTIONS

1. Compare your initial description of the landscape to your model. Were your predictions accurate? If you predicted anything incorrectly, what did you learn about contour lines from this exercise?

2. Look at the location of creeks and rivers in your landscape. Which topographical features help guide the flow of water? Which features may have been formed by flowing water?

3. How might your area be affected by these different scenarios: heavy rain, agriculture, urban development, deforestation, reforestation, drought? How would these scenarios affect the water that flows to the Bay?

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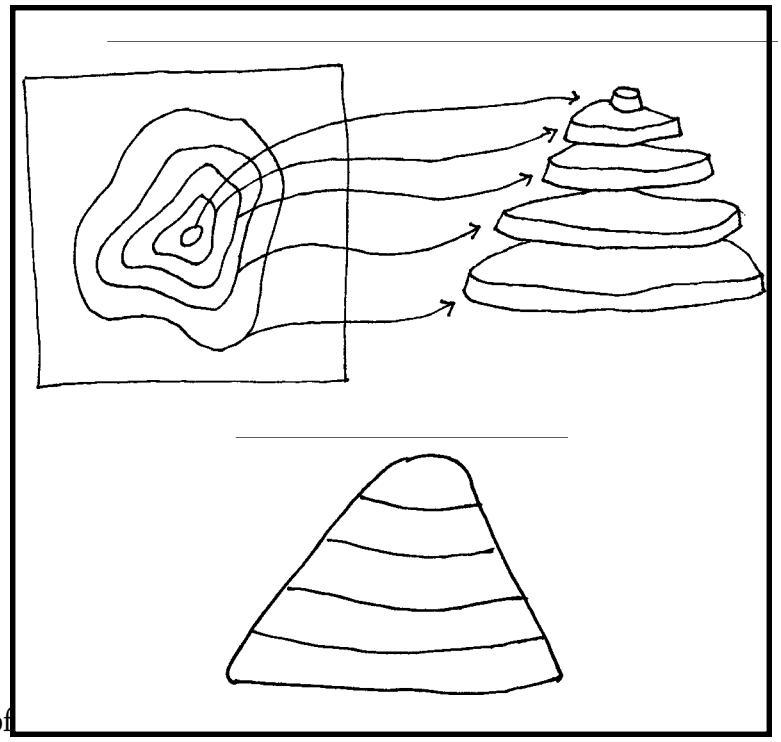
Part III
Building a Topographic Model

INTRODUCTION
Topographic maps show the shapes and features of the Earth's surface using contour lines. Contour lines show places on the map that have the same elevation. Using contour lines as a guide, you can build a three dimensional model of a landform.

MATERIALS
- Enlarged pieces of a topographic map, 2 photocopies of each
- Thick cardboard or foam core
- Utility knife
- Glue
- Modeling clay
- Pen or pencil



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PROCEDURE
1. Examine your map. On a separate piece of paper, draw or write a description of the landscape.
2. Cut along the outermost contour line on your enlarged map.
3. Use this as a template to cut a piece of cardboard of the same shape and size.
4. Cut along next inner contour line and use it as a template to cut the next piece of cardboard.
5. Continue this process, stacking the progressively smaller pieces of cardboard.
6. Glue stacked shapes together, then compare them to an uncut version of the map.
7. To smooth the steps between contours, cover edges with modeling clay.
8. Use the map to find the location of creeks and rivers in your landform. Mark them on your model by carving them into the clay with a pencil or by using colored clay or markers.

QUESTIONS

1. Compare your initial descriptions of the landscape to your model. Were your predictions accurate? If you predicted anything incorrectly, what did you learn about contour lines from this exercise?

2. Look at the location of creeks and rivers in your landscape. Which topographical features help guide the flow of water? Which features may have been formed by flowing water?

3. How might your area be affected by these different scenarios: heavy rain, agriculture, urban development, deforestation, reforestation, drought? How would these scenarios affect the water that flows to the Bay?