Thank visitors
Don't forget to thank visitors for coming to the exhibit and sharing their learning experience with you. Remind visitors not to forget items they put down or hung up around the exhibit.

F. Inquiry-based Investigations

Activities and suggested dialogue for inquiry investigations are detailed below for a variety of subject areas: topography and contour lines; geology and landforms; and hydrology and human impacts. More background information is provided at the beginning of each section and in the glossary.

This guide was not written with the intention that facilitators cover all learning goals or activities. **Instead, it was designed so that facilitators can focus on a targeted subset of the activities.** Choose the focus based on base knowledge of the visitors, local geographic context, recent current events, and relevance to visitors' lives, experiences, and interests.

Topography and Contour Maps

Background
Topographic maps can be difficult for both children and adults to understand. The sandbox can be used to create a model that represents real topography and can help visitors connect an abstract map to actual topography and explore landform evolution and ecosystem processes.

Topographic maps provide a way of showing a 3-dimensional landscape on a 2-dimensional surface. **Contour lines** are the main feature of topographic maps. Every point on a single contour line represents the same elevation or height above a reference point (usually sea level). If you were to walk along a contour line, you would not climb up or down, but stay at the same elevation at all times.

The **contour interval** represents the vertical distance between two adjacent contour lines. Moving from one contour line to the next represents a rise or drop in elevation. The closer together the lines, the steeper the terrain.

Topographic maps are most commonly used for navigation so that hikers and travelers can get a sense of the terrain. They are also used by scientists to explore how earth processes and properties vary with topography.

Primary Activities

- **Think out loud together and explore the concept of elevation.** Ask visitors what they notice about the sandbox and the projected visualization. Ask visitors to consider how the colors and lines change as they construct different features in the land surface.

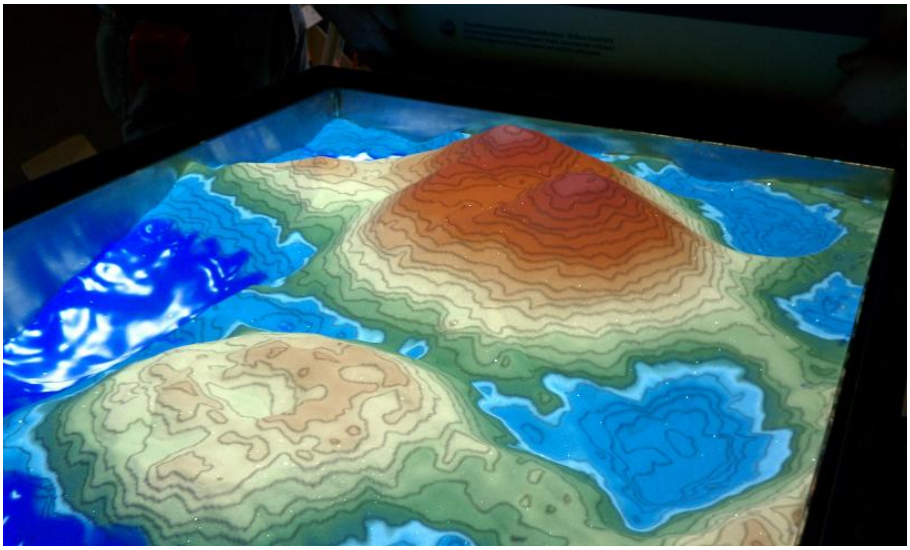
  "What color is the top of the mountain? On the sides of the hill, the sand is a different color. If you dig a hole, the color will change again. Different colors are representing different heights. Geologists call different heights above sea level elevation. The model shows different elevations as different colors."

- **Introduce the concept of a topographic map**. Tell visitors that when scientists study watersheds and ecosystems it is useful to know how the land dips and rises – where the hills, valleys, ridges, stream beds, and plains are. Most maps don't tell us this information. They may show cities, roads, and rivers, but not valleys, ridges, and mountains. Topographic maps are a special type of map that *do* show how the land rises and falls.

- **Introduce contour lines.** Many visitors (including adults) are not familiar with contour lines. There are several ways you can help them understand the concept.

  1. First, ask visitors to choose a line in the sandbox and trace their finger along it.
  "The whole line you just traced is the exact same distance above the floor in this room [or another useful reference point]. Everywhere on that line is the same height in the sandbox. These are called contour lines because they contour to the surface at the same height. That is, if you were to walk along a contour line, you would not climb up or down, but stay at the same elevation at all times."

  *Note that depending on where the contour line being traced is located relative to the visitor, the student's arm or body might inadvertently create rain. If that's the case the facilitator can use a laser pointer to trace the contour line, being careful not to point the laser in anyone's eye.



Visitors can explore how contour lines work by observing, in real-time, how the lines and color projections change as the topography changes. (Photo Credit: Travis Cook)

Alternatively, you can ask visitors to find the **color** which represents the highest elevation in your sandbox (most commonly, this is white or brown). Then ask them to point out other places that the color is found in the watershed. Next, ask visitors about the next color in the elevation scale (the one lower than the peak color). Help visitors make the connection between where the colors are observed and the pattern of lines.

"Scientists use contour lines to show what the landscape looks like on flat maps. Different spacings and shapes of lines indicate three-dimensional features on the surface of Earth. Moving from one contour line to another always indicates a change in elevation. The contour interval is the vertical distance between two adjacent lines and is exactly and always the same between each contour line on a given map."

2. Second, you can also ask visitors to **read the first panel of the sandbox graphic** to show how the lines relate to landforms. Explain that contour lines are used to show what the landscape (e.g., a mountain in the graphic) looks like on a flat map. Show visitors, for instance, that the points on the mountain that are 300 feet above sea level are represented by the smallest (300') circle on the contour map.

3. You can also hold a **large white posterboard** above the sand - the lines and colors are clearer on the posterboard so visitors can get a better understanding of what is being projected on the sand.

- **Build different shapes to explore the properties of contour lines.**
  "Build a mountain with steep sides. Notice the distance between the contour lines on your mountain. Now build a low, gentle hill, and notice how the spacing of the lines is different. Which of your landforms would be easier to walk up? What do the lines look

like in a valley? What do the lines look like on a flat plain? The closer that contour lines are to one another, the steeper the slope is in the real world (e.g. mountains). Contours that are spaced further apart represent a shallow to flat slope (e.g. floodplain).

What do you notice about how contour lines interact with one another? Every contour line must eventually connect at its ends. Contour lines can never cross one another; each line represents a separate elevation."

- **Explore how water flows in relation to the contour lines.** Focus on the rule that contour lines point upstream. Ask visitors to predict which way water will flow based on the pattern of contour lines. Then ask them to make it rain and test their prediction. Point out how the water eventually settles along a contour line.

Extension Activities

- **Compare the sandbox visualization with real topographic maps.** Explaining contour lines can also be facilitated by showing visitors an actual map to convey how they are used in real life.

  1. Find topographic maps of interest to your visitors and in line with your educational goals. It can be helpful to trim **smaller maps** from larger maps or print 8 x 11" maps from the internet so each visitor can look at a map and to avoid the complication of hard-to-manage larger maps. Choose maps with **minimal labeled built features** (no roads or cities) and possibly present the map next to a **photograph** of the same area. Visitors often engage with maps of the **local area** so using a map that includes a region near or encompassing your science center may be also useful.

  - Order United States Geological Survey (USGS) topographic maps (pdf or paper) here: http://tinyurl.com/TopographicMaps82

  - Landform shaded relief imagery, 3D geologic features and other visualizations can be ordered here: http://tinyurl.com/TopoViz

  2. Explore the properties of topographic maps. Give visitors sample topographic maps. Ask them what they notice.

  Ask them to **identify features**: a steep slope, a gentle slope, and a valley. Hills can be identified by concentric circles that grow smaller and smaller until you reach the peak of a hill. Topographic maps also show other features in the landscape, including bodies of water such as streams, rivers, and lakes. Depressions such as a dried out pond or the crater of a volcano are generally shown with hatched contour lines.

Use the maps to review the **general rules of contour lines**: (1) they do not cross or break apart, (2) closely spaced contours represent steep slopes and widely spaced contours indicate gentle slopes, and (3) contour lines form a "V" or a "U" where they cross a stream in a valley.

Calculate elevation. Ask visitors to find a stream, river, pond or lake on their topographic map. **"**What is its elevation? Compare this with the elevation of a nearby peak. Hint: look at the contour lines nearby to determine the elevation.

The numbers written on contour lines indicate the elevation of the lines. The elevation of unlabeled contour lines can be determined using the contour interval (usually written at the bottom of the map). The contour interval tells the vertical distance between neighboring lines.

By counting the number of contours from a labeled line, and multiplying by the contour interval, you can calculate the elevation of any contour line. For points located between contour lines, you can estimate the elevation by examining the distance to the two closest contours."

3. Challenge visitors to build sandbox landforms which closely resemble the maps. Ask visitors to predict what their topographic map would look like in 3 dimensions and then encourage them to create a model of their map.

For instance the following topographic map of Angel Island (located in the San Francisco Bay) is a relatively easy starting place, with distinct features and clear contour lines. See how similar the sandbox creation can get to the topographic map. http://online.wr.usgs.gov/outreach/images/topo_map_angel_island.pdf

For those on the east coast, try the map of Mount Philo (located in Vermont): http://i.imgur.com/hbQxfak.png

Or Pease Mountain: http://i.imgur.com/vBAlkvZ.png

For those in the Sierra Nevada mountain region, use the map of Herlan Peak: http://i.imgur.com/7TnpFNF.jpg

Additional Resources for Topography Lessons

- Making sense of topographic maps http://learningcenter.nsta.org/product_detail.aspx?id=10.2505/4/ss05_029_02_34
- 27 ideas for teaching with topographic maps http://education.usgs.gov/lessons/teachingtopomaps.html
- Linking topographic maps to 3D models http://www.mysciencebox.org/map2model