Title: “How steep are those hills?”

Engineering
Grade: 10-12
Estimated Time: 3 hours (2 days)
Groups: 3 to 4 students

Synopsis: Students will be able to understand the concept of surveying and mapping ground elevations by analyzing a fabricated data set in multiple ways and eventually constructing a model of what this region would look like in reality. This experiment will be for groups of 3 to 4 students. Students should be in grades 10-12.

Purpose: Students will be able to understand the importance and complicated nature of ground surveying. They will also be able to question how the creation of graphs, charts and models can be used to determine water flow, soil erosion, road and building construction and other important factors.

Next Generation Science Standards:

Students who demonstrate understanding can:

HS-ESS1-5.	Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. [Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust increasing with distance away from a central ancient core (a result of past plate interactions).]
HS-ESS2-1.	Develop a model to illustrate how Earth’s internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. [Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).] [*Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth’s surface.*]
Science and Engineering Practices	**Developing and Using Models** Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). Develop a model based on evidence to illustrate the relationships between

	systems or between components of a system. (HS-ESS2-1) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (HS-ESS1-6)
HS-ESS3-1.	Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

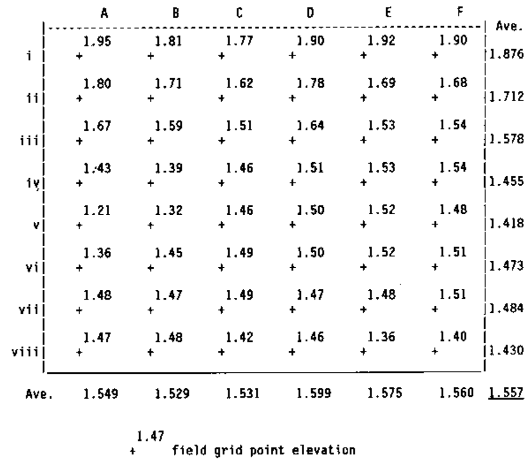
Objectives:

- Be able to create maps, graphs and a 3-D model out of limited information
- Be able to think critically and connect how the visuals they create can be used to determine various information in real life
- Improve teamwork to prepare for collaboration in the professional setting

Introduction/ Instructor Background Information: Surveying is a necessary step in any construction, water pattern analysis or land mapping project. Without an understanding of the site that is going to be analyzed, worked on or built upon, it would be extremely difficult, risky or impossible for any project or research to be completed. This lab will allow for students to retain a basic understanding of the tools utilized and ways to portray findings and information that can be derived from the results. The surveying tools used today to find the elevation data points are very expensive, fragile and complicated instruments. For this reason the students will be provided with a fabricated set of data points to work with; however, teaching the students about these instruments would be helpful and interesting. For more information (for the instructor) on the instruments used you can go to: http://www.landsurveyors.com/tools/land-surveyor-tools/ **15 Minutes**

Materials:

- Pencil
- Paper with initial data points (Figure 1.0)
- 2 pieces of graph paper (for section views)
- Ruler
- Tape (to keep papers still while creating section view graphs)
- 1' X 1' piece of cardboard (base for model)
- Clay (for 3-D model)
- Small cup of water (to wet and mold clay)
- Plastic knife (to help cut and smooth clay)



	A	B	C	D	E	F	Ave.
i	1.95	1.81	1.77	1.90	1.92	1.90	1.876
ii	1.80	1.71	1.62	1.78	1.69	1.68	1.712
iii	1.67	1.59	1.51	1.64	1.53	1.54	1.578
iv	1.43	1.39	1.46	1.51	1.53	1.54	1.455
v	1.21	1.32	1.46	1.50	1.52	1.48	1.418
vi	1.36	1.45	1.49	1.50	1.52	1.51	1.473
vii	1.48	1.47	1.49	1.47	1.48	1.51	1.484
viii	1.47	1.48	1.42	1.46	1.36	1.40	1.430
Ave.	1.549	1.529	1.531	1.599	1.575	1.560	1.557

Figure 1.0: http://www.fao.org/docrep/t0231e/t0231e08.htm

Vocabulary: 5-10 Minutes

- *Surveying*- collecting data and characteristics of a piece of land and creating maps, charts and models out of that information
- Section cut- a view of a specific slice of the interior of an object or collection of objects.
- *Section plan*-a two-dimensional depiction of a specific slice of the interior of an object or collection of objects.
- *Topographic map*-a detailed map portraying the contours of the surface of a landscape. They are often very detailed.
- *Elevation*- height above sea level
- *Peak*-The highest point
- *Slope*- an incline. Can be calculated by rise/run. Often shown as a percentage.
- *3-dimensinal model*- a representation with height, depth and width.

Prerequisite Knowledge:

- Geometry
- Understanding of various types of graphs

Career Connection: 5-10 Minutes

- *Surveyor/ Cartographer*
  - Education:
    - BS Degree in related field and/or Apprenticeship
  - Responsibilities:
    - record, map and survey sites
    - Create maps, models and charts
    - Work with cartographers
    - Relay information to planners
- *Architect/ Landscape Architect / Civil engineer*

- Education:
  - Bachelor's Degree and Certification
- Responsibilities:
  - Design buildings including: homes, schools, office buildings, pavilions, etc.
  - Design gardens, parks and other outdoor spaces
  - Design construction projects, often roads, bridges, buildings, etc.
  - Create models and graphs, both by hand and through computer programs

- *Urban/Regional Planner*
  - Education:
    - Master's Degree and Certification
  - Responsibilities:
    - Collect the local residents opinions and ideas through surveys, town meetings and forums
    - Construct and write comprehensives plans
    - Analyze regional factors such as population, demographics, income, etc. over time

Show students at the end of the lesson: http://www.bls.gov/ooh/architecture-and-engineering/surveyors.htm#tab-7

Questions to Engage the Students/Analysis:

- If a designer were to create a model of a site for after the project was completed, how could this process be reversed so changes could be implemented?
  - Would have to measure the model on the scale it was built on and convert the measurements to feet. Then you could create your topographic maps and the section views.
- How could surveying be used to record change on a given site? How could the change be shown visually?
  - Any changes over time would be evident in elevation changes. Could show this change by overlaying graphs and maps or using computer programs to overlay information.
- Is surveying used for reasons other than construction projects? What are some examples?
  - To observe land changes (i.e. erosion. To separate pieces of property, both private and public. To create large scale maps for any purpose. Etc.

Setting up the lab: lay out all materials at each group's station. You can give every group the same set of data points to work with so you can compare at the end, or give them separate data points to allow for varying results.

Procedure:

1. Using the given elevation points on the piece of paper that has been handed out, find the highest elevation point on the grid. With the pencil, place a point at this spot and label it with its height. This tells you the highest point on your site. **5 Minutes**

2. After labeling the peak, create rings of matching elevation height starting with the largest whole integer below the peak. For example, if the peak is at 865.43 Ft., then the first ring would be connecting where the elevation is at 865 Ft. Label the height within the ring. Continue to create continuous rings for every descending foot. Make the rings as accurate as possible. Figure 1.1 demonstrates an example. *Hint: There may be more than one hill on the site.* **15-20 Minutes**

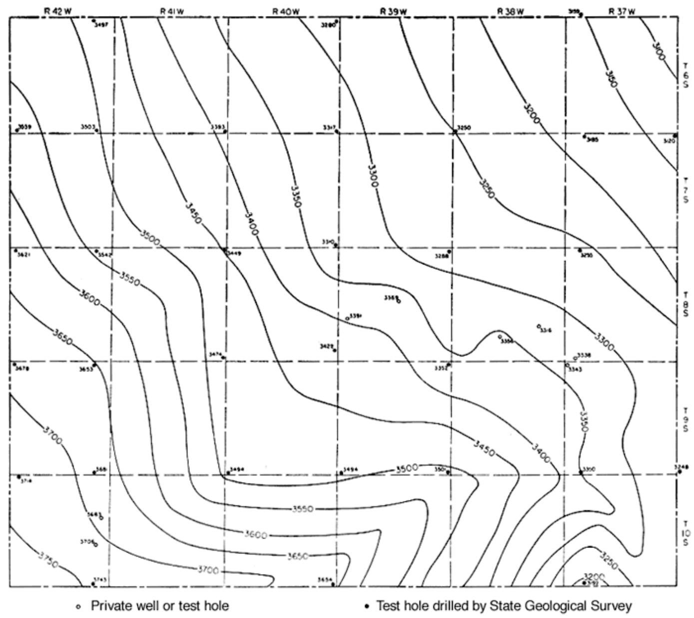


Figure 1.1: http://www.kgs.ku.edu/General/Geology/Sherman/04_rock.html

3. Once all of the rings have been connected and all of the peaks have been labeled for the site, it is time to create a section cut graph for a better understanding of the site. A section cut of an object is a view of the object as if it is being sliced through with a knife. This allows for the viewer to get an understanding of the inside of one specific section of the inside of an object. The most effective place to slice through a surveyed site would typically be a landmark, a peak or a valleys bottom. In this case, the most effective place to slice through would be the hill peak(s).
Use Figure 1.2 as a guide.
25-30 Minutes
    a. First, pick the highest peak on the sight. With a ruler, create a horizontal dashed line through the paper. On one end of the line label it Section 1.
    b. Next, using the tape provided, attach the site map to the table horizontally. Be sure to leave room for second sheet of paper below it. Directly below the site map, tape a sheet of the blank graph paper. The edge of the graph paper should be in line with the section line drawn on the site map.

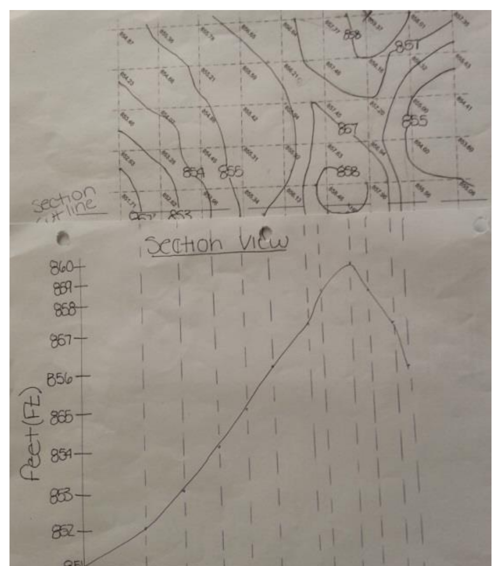


Figure 1.2: LARC160, University of Maryland, College Park

c. Once both sheets are taped down, it's time to create the section view. Using the ruler, draw dashed vertical lines for every ring that crosses with the section line onto the graph paper. Do the same for the peak.
d. Along the edge of the graph, draw a sold straight line and label it: elevation (Ft.). Draw a horizontal line about an inch from the bottom of the graph paper and ensure these two lines cross in the bottom left hand corner of the paper. Determine the lowest elevation through the cut line and make the next lowest integer the bottom number on the vertical line. At the top of this vertical line, write the next integer above the peak's elevation. In between these two numbers, create a dash for each foot. Make sure there is an equal distance between the numbers. (see Figure 1.2)
e. Finally, draw a point where each vertical dashed line intercepts with its given elevation and connect the lines. Label this piece of paper Section 1.
f. Repeat all of step 3, but create a vertical section cut through the peak. Make sure to label it section 2.

4. The section view graphs that have now been completed give the viewer a more comprehensive understanding of the site. If needed, there could be infinite section views created for the site; however, when more than a couple section cuts become necessary, a 3-D model is typically a more useful way to portray the information collected. With the clay provided, create a 3-D model of what the site would look like in reality. Make the clay model on the piece of cardboard and use the water and knife provided to mold the clay as needed. *Hints: Use the maps that were created in the previous steps and measure with the ruler when necessary. Think about using the same scale as the site map to simplify the task. This is not meant to be a perfect reconstruction; the goal is to make the 3-D model as accurate as possible with the information provided.* **90-120 Minutes**

Discussion Material: **15 Minutes**

- What are some unique properties of water? How can this be applied and used in analyzing a site?
  - Water is a liquid and follows the path of least resistance. From the map, graphs and model created, a prediction of where water would flow from a hill peak can be made.
- How would a designer (Architect, Civil Engineer, etc.) use this information when creating a construction project?
  - This information can determine the best placement of structures and any changes they need to make. Shows what the designer has to work with. Students can connect back to water (you don't want water flowing into a building or causing erosion around foundation).
- How could a section view be used to communicate even more if additional information on the soil, rock and water makeup of the site was given?
  - With a detailed section view any underground water, sinkholes, mineral deposits etc. can be seen. This would make determining how strong the ground on the site is much easier.
- Why is the 3-D model necessary if the same information is on the actual site? What are some advantages of a smaller scale?
  - It is very hard to imagine a plan on such a large scale when first starting. Makes it easy to alter and make changes so you can see how the site would look with various changes made. The most comprehensive way to pitch a plan to a prospective buyer.

Student Sheet:

Name: Date:

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1.47 + field grid point elevation

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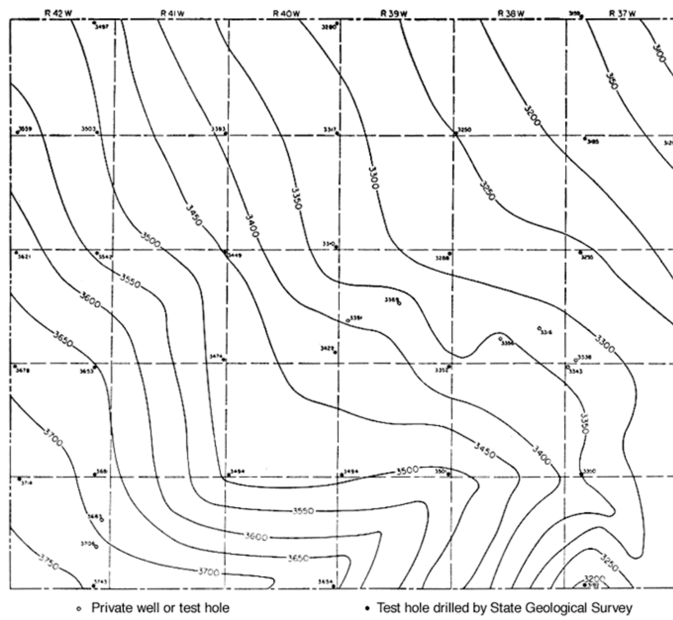

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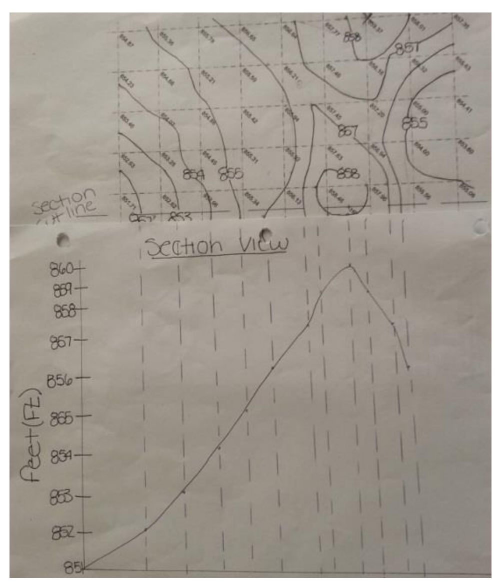

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Discussion Material:

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3. How could a section view be used to communicate even more if additional information on the soil, rock and water makeup of the site was given?

4. Why is the 3-D model necessary if the same information is on the actual site? What are some advantages of a smaller scale?