Using a Surveyor’s Level to Generate a Topographical Map

This application note describes the process of using a surveyor's level for generating a topography (topo) map. The site survey described below uses San Francisco's Yerba Buena Gardens as a site for recording relative elevations over a specific area. With these relative elevations organized into a grid, a topographical map can be created.

Equipment: (most available from Tool Lending Library):
- Surveyor's Level
- Level Tripod
- Leveling Rod
- Compass
- 100’ Tape Measure
- Notebook and Pencil

Procedure:
- Step 1: Find a Reference Point (Benchmark Elevation)
- Step 2: Set up the Surveyor's Level
- Step 3: Reading the Leveling Rod
- Step 4: Taking Readings
- Step 5: Make a Grid Over the Chosen Plot
- Step 6: Making Sense of the Collected Data
- Step 7: Drawing Topography Lines

Step 1: Find a Reference Point (Benchmark Elevation)

1. **Establish a reference point, also known as the benchmark elevation.** A list of official benchmark elevations in San Francisco is available from the Bureau of Street Use and Mapping. (located at 875 Stevenson Street, Room 460 // San Francisco, CA. 94103 /// 415.554.5810). The nearest benchmark to the plot is the intersection of 4th and Mission Street. (Figure 2).
The benchmark on the list in Figure 2 is a fire hydrant with the word "OPEN" on top. The elevation is 26.295 feet above sea level at the top of the letter "O". For this survey, it will be the reference point (Benchmark 1).

2. Project official elevation to the target location in the park (Figure 4). Set up the surveyor's level at a convenient and safe location (Station 1 in Figure 4) where the benchmark and the target plot within the park are visible (see Step 2 below for setup instructions). In this exercise the direct view to the target plot was not available so the elevation from Benchmark 1 was read at Station 1 and projected to Benchmark 2. Station 2 is a point near the target plot where the elevation at Benchmark 2 can be read.
Step 2: Set up the Surveyor's Level

1. **Extend the legs of the tripod and adjust the height by using the levers on the legs for extension.**
   - Place the tripod on stable ground. Since *Station 2* is on a grass surface, each leg should be anchored by stepping on the foot pegs and pushing the end points into the grass.
   - Keep the top of the tripod level.
   - Adjust the top of the tripod so it is above both sight points.

2. **Screw the level onto the tripod.**
   On the underside of the level are four leveling screws. Each screw should be touching the plate at the top of the tripod. If not, extend the leveling screws until they all touch the plate. *(Figure 6)*

1. **Adjust the level by turning the telescopic sight to align with opposite pairs of screws.**

2. **Turn the screws until the bubble on top of the level is centered.** *(See Figures 7 & 8.)*

3. **Turn the telescopic sight to align with the other pair of screws and center the bubble as shown in the step above.**

*Figure 6: Screwing the level onto the tripod.*

*Figure 7. “The Golden Rule for quick and simple leveling is THUMBS IN, THUMBS OUT. Turn BOTH screws equally and simultaneously. Practice will help you get the feel of the screws and the movement of the bubble. It will also help to remember that the direction your left thumb moves is the direction the bubble will move.” Drawn images shown for Step 2 are from the David White Owner's Manual #8814-802.*
Step 3: Reading the Leveling Rod by Using Sight Level

1. **Leveling rods are approximately 7-9 feet in length and are extendable to twice their collapsed length.** The face of the rod is usually marked in feet subdivided in eighths of an inch (*Figure 10*). Two people are needed for this step because there are two roles, the rod holder (holder) and the instrument reader (reader).

2. **The holder places the leveling rod on a chosen spot, and turns the numbered side of the rod toward the reader.** The holder slowly rocks the rod back and forth. This assures that the rod is held vertically when reading is taken. In *Figure 9*, the reading is 4’ 10-1/8”.

3. **The number is read at the crosshair when it points to the lowest number.** The measurement is in feet, inches, eighths of inches. (*Figure 10*)

4. **The reader looks through the eyepiece and locates the rod in sight (**Figure 11**) and adjusts the focusing knob.** For closer focus, turn the knob clockwise. (*Figure 12*). For farther focusing, turn counterclockwise.
Step 4: Taking Readings

1. The elevation of Benchmark 1 is 26.295'.

2. The instrument set up at Station 1 backsights or plus (+) sights the leveling rod held at BM (Benchmark) 1.

   Height of Instrument = Elevation + Backsight
   27' 3" (H.I.) = 26' 3.5" + 11.5"

3. The telescopic sight is revolved to sight the rod at BM2. This second reading is called foresight or minus (-) sight.

   Elevation 2 = H. I. – Foresight
   27' 0.75" (BM2) = (H.I.) 27' 3" - 2.25"

4. Set up instrument again at Station 2, near the plot to be surveyed and backsight BM2.

   (H.I. = Elevation 2 + Backsight)
   35' 11.75" = 27' 0.75" + 8'-11"

5. Here are the readings:

<table>
<thead>
<tr>
<th>Stations</th>
<th>Backsight</th>
<th>Instrument Height</th>
<th>Foresight</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark 1</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>26' 3.5&quot;</td>
</tr>
<tr>
<td>Station 1</td>
<td>11.5&quot;</td>
<td>27'3&quot;</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Benchmark 2</td>
<td>---</td>
<td>---</td>
<td>2.25&quot;</td>
<td>27' 0.75&quot;</td>
</tr>
<tr>
<td>Station 2</td>
<td>8' 11&quot;</td>
<td>35' 11.75&quot;</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

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*Figure 13: Benchmark and Station Plan*

*Figure 14: Benchmark and Station Section Diagram of plan in Fig. 10*

*Figure 15: Benchmark and Station Readings*
Step 5: Make a Grid Over the Chosen Area

1. Take measurements with long tape measure every 10'-0" over a 50'-0" x 50'-0" area.
2. One person is the anchor for the tape measure and will direct the other person while looking through the compass or surveyor's transit.
3. The other person marks the measurement 50'-0" away along the axis. Stakes are helpful to mark the points of the grid in the grass.
4. Read and record the elevation of each point as described as in Step 6.

*Figure 16:* Grid plotted from which points measurements were taken. Sections along gridlines C and 5 shown in Figure 17 & 18.

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Step 6: Making Sense of Collected Data

1. Each grid-point measurement is a foresight reading from the instrument set up at Station 2. Elevation of Grid Point = Height of Instrument - Foresight
   List of Grid Point Measurements and Adjusted Elevations
2. A cross section of the landscape is plotted from the points that we surveyed. (*Figs. 17 & 18*)
Step 7: Drawing Topography Lines

1. **Plot the elevation at each point on the grid.** Even-foot values occur between the grid points. Approximate and connect the points where even values occur. These lines are the topography (topo) lines. (The location and diameter of all the trees were also determined and plotted in this example, see Figure 19.)
Figure 19: Topography of a plot in Yerba Buena Gardens, San Francisco