12. Vertical Positions

A **vertical position** is the height of a point relative to some reference surface, such as mean sea level, a geoid, or an ellipsoid. The roughly 600,000 vertical control points in the U.S. National Spatial Reference System (NSRS) are referenced to the North American Vertical Datum of 1988 (NAVD 88). Surveyors created the National Geodetic Vertical Datum of 1929 (NGVD 29, the predecessor to NAVD 88), by calculating the average height of the sea at all stages of the tide at 26 tidal stations over 19 years. Then they extended the control network inland using a surveying technique called **leveling**. Leveling is still a cost-effective way to produce elevation data with sub-meter accuracy.

Figure 5.13.1 A leveling crew at work in 1916.

Credit: Hodgson, 1916

The illustration above shows a leveling crew at work. The fellow under the umbrella is peering through the telescope of a leveling instrument. Before taking any measurements, the surveyor made sure that the telescope was positioned midway between a known elevation point and the target point. Once the instrument was properly leveled, he focused the telescope crosshairs on a height marking on the rod held by the fellow on the right side of the picture. The chap down on one knee is noting in a field book the height measurement called out by the telescope operator.

Figure 5.13.2 A level used for determining elevations.

Leveling is still a cost-effective way to produce elevation data with sub-meter accuracy. A modern leveling instrument is shown in Figure 5.13.2, above. Figure 5.13.3 illustrates the technique called differential leveling.

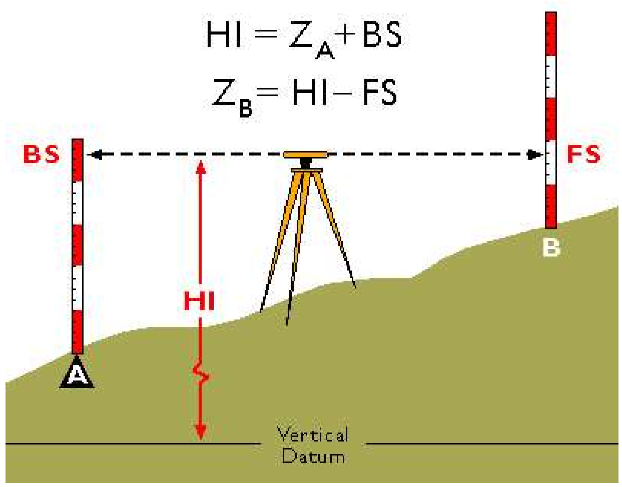

Figure 5.13.3 Differential Leveling.

Credit: Adapted from Wolf & Brinker, 1994

This diagram illustrates **differential leveling**. A leveling instrument is positioned midway between a point at which the ground elevation is known (point A) and a point whose elevation is to be measured (B). The height of the instrument above the datum elevation is HI. The surveyor first reads a backsight measurement (BS) off of a leveling rod held by his trusty assistant over the benchmark at A. The height of the instrument can be calculated as the sum of the known elevation at the benchmark (Z_A) and the backsight height (BS). The assistant then moves the rod to point B. The surveyor rotates the telescope 180°, then reads a foresight (FS) off the rod at B. The elevation at B (Z_B) can then be calculated as the difference between the height of the instrument (HI) and the foresight height (FS).

Former student, Henry Whitbeck, (personal communication, Fall 2000) points out that surveyors also use total stations to measure vertical angles and distances between fixed points (prisms mounted upon tripods at fixed heights), and then calculate elevations by trigonometric leveling.

Heights

Surveyors use the term **height** as a synonym for elevation. There are several different ways to measure heights. A properly-oriented level defines a line parallel to the geoid surface at that point (Van Sickle, 2001). **An elevation above the geoid is called an orthometric height.** However, GPS receivers cannot produce orthometric heights directly. Instead, GPS produces heights relative to the WGS 84 ellipsoid. **Elevations produced with GPS are therefore called ellipsoidal (or geodetic) heights.**

‹ 11. Trilateration up 13. Global Positioning System ›

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