

The equipotential surface most commonly known and understood is mean sea level which serves as the reference datum for the National Geodetic Vertical Datum of 1929 (NGVD29). The vertical distance from mean sea level to each bench mark is its *orthometric height* determined by applying an "orthometric height correction" to the elevation differences observed along a given line of precise levels.

It is easy to accept orthometric height as the vertical distance from mean sea level to the equipotential surface until one considers that the orthometric height of the water surface at the south end of Lake Huron (in Michigan) is 5 centimeters higher (further from mean sea level) than the same equipotential surface at the north end. How can the same water surface have two heights when a loop of precise levels around the lake shows no difference in elevation?

Another way to visualize the apparent discrepancy is to note in the leveling diagram that the elevation difference observed along Route A is greater than that observed along Route B. A loop from Point 1 to Point 2 along Route A and back along Route B will fail to close mathematically (observational errors aside) because the equipotential surfaces are not parallel.

Modern geodesy accommodates this apparent discrepancy (Zilkowski 1991) by adopting a system of geopotential numbers for equipotential surfaces (having no hydraulic head). The orthometric height is obtained by dividing a geopotential number by the appropriate value of gravity. The North American Vertical Datum of 1988 (NAVD88) is published as Helmert orthometric heights where gravity is computed using the Helmert height reduction formula. Persons concerned with hydraulic head and working, for example, along the Great Lakes use a system of dynamic heights which are obtained by dividing the same geopotential numbers by the normal gravity at 45° latitude. The geopotential numbers are just scaled by normal gravity to make them look like elevations. So, on NAVD88, use orthometric heights in the same way you would have used NGVD29 elevations (different numbers of course) but if your application is very precise and requires computation of accurate hydraulic head over long distances, use dynamic heights as recommended by NGS.

If the mass distribution throughout the earth were uniform as assumed by Newton, the equipotential surfaces would be very regular. However, due to irregular mass distribution within the earth, the local plumb bob hangs wherever it will and the local level surface "slopes" accordingly. That means the geoid (mean sea level) undulates from the mathematical ellipsoid by up to 100 meters on a global scale and that gravity, and physical geodesy, are important considerations locally. That is especially true as GPS data are used to estimate elevations. A better understanding of the underlying concepts is important.