

## REFERENCE DATUM LEVEL

*M.C. Pathak and K.L. Kotnala*

The reference datum level may be defined as either a (short) horizontal line or a horizontal surface (of limited extent) commonly located near sea level, that is used as a reference level above or below which the altitude of a given surface is measured. Altitude denotes the vertical distance of point or level measured from mean sea level. Thus heights (elevation) in turn coincides as nearly as possible with geoid. The geoid as a global reference surface for heights is the equipotential surface of the earth gravity field that best fits Mean Sea Level (MSL) in the spatial least square sense. The departure of MSL from the geoid is known as the sea surface topography. From this consideration of the geoid it may be sum that certainly in theory the most useful reference datum level that can be chosen in any given limited geographical area is the relevant part of the geoid or its near equivalent local MSL.

As a datum plane for surveying, mean sea level is the best datum to use as it is not so variable as the high or low water marks or the mean level of high and low tides. MSL is the surface level which the oceans and seas of the world would adopt if the tidal forces ceased to operate. In practice MSL as zero reference datum is the average level of the surface of the sea as calculated from a large number of observation taken at equal interval of time over a period of several years (18.6 years) one cycle of moons node. It is worth noting however that mean tide level may be obtained in the field more easily than mean sea level and from fewer observations. It should be understood that mean sea level, being a calculated value based on measurements made at regular intervals in the course of no longer than approximately the last 150 years, is a level of which there is no long term record in sedimentary deposits or laid forms. In contrast mean tide level is a level whose (approximate) former value may be determined from the sedimentary and geomorphological record of former high tide, low tide and tidal range values. For practical purposes like the construction of sea-level curves, values of former mean tide level rather than of former mean sea level are used.

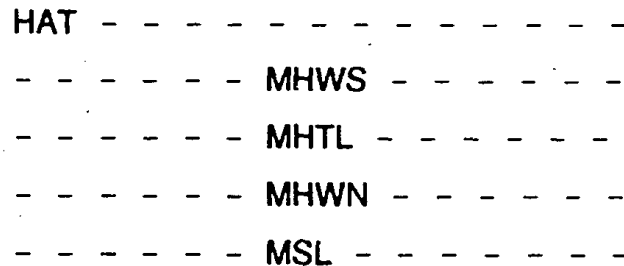
In practice commonly a national reference datum-level is chosen to correspond as closely as possible with MSL at the location that has been selected as the national reference station. For example for the India the reference datum level is based upon Appolo Bunder Bombay.

Examples of subsidiary datum levels are bench marks (whose altitude above the national reference datum level have been determined by spirit levelling) placed by the Survey of India at slected locations throughout the India. An essential feature of such datum levels is that, within any given national territory, the altitude of the each of the individual datum levels is determined in relation to a national reference datum-level at frequent intervals 20 to 30 years. It is interesting to note that this standard bench mark by a precise levelling network are tide to all the tidal stations. A

third type of datum level is the temporary bench marks (TBM) established within a horizontal distance close to the site. A TBM may be used as a temporary datum level for the duration of field season in which it is established but its altitude in relation to a more permanent reference datum level should be determined at or shortly after the time that the TBM established.

## Surface levels of the Sea

Independently of the effects of winds and other superficial agents, the level of the surface of the sea at given location changes continuously throughout the tidal cycle, in broad terms ranging between the level of high water and that of low water, two levels which vary between 'spring' and 'neap' values depending on the position of the moon in relation to earth. Diagrammatic representation of positions of the surface level of the sea at location where the tidal cycle is not perfectly symmetrical shown in Fig. 1. It should be noted that ecologically, mean high tide level (MHTL) is an important 'sea level indicator', in practice being used more frequently than mean high water of spring tides (MHWS) or mean high water of neap tides (MHWN).



Mean sea level may be lower rather than higher, than mean tide level verticle scale varies depending upon the location.

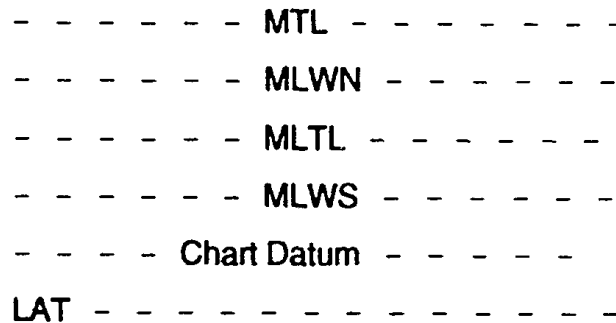


Fig. 1 Abbreviations used: HAT and LAT - Highest and Lowest Astronomical tide levels; MHWS and MLWS - mean high water and low water levels of spring tides; MHTL and MLTL - Mean high and mean low tide levels; MHWN and MLWN - mean high water and mean low water levels of neap tides; MTL - mean tide level ; MSL - mean sea level; Chart Datum is a level to which soundings on a published chart are reduced, and above which Tidal predictions and tidal levels are given in tide tables.

## **Sea Level**

The following methods are useful in detecting the present and past sea level changes:

### **(i) Tide-Gauge records:**

The simplest definition of SL is the height, relative to some datum, of the surface of the sea as measured at a given place and time. This so called instantaneous sea level is in continuous change, the most observable being those caused by surface waves and tides are recorded by tide gauge.

A continuous record of high tide, accurately observed at fixed interval of time and referred to a stable bench mark provides the raw material for determining the average sea levels; mean tidal levels, such as mean high water, mean low water spring etc. MSL an average sea level is defined as an arithmetic mean of all, or of a set of specific measurements at selected hours of wave smoothed instantaneous SL obtained at a given place over a given period of time. Thus there are daily, monthly, yearly, and X-annual records of MSL, MHW etc.

### **(ii) Field-data records:**

The first tide gauge was established in 1682 in Amsterdam. However most of the tide gauge record cover a much shorter time span. Only 112 stations in the world have records before 1900. For the study of the sea level changes in the more distant past and in areas where no tide gauges have been installed, one has to resort to evidence of naturally recorded SL positions, derived from fossils, sea level indicators, and other field data.

## **Depth**

Depth is by far the most elusive and frustrating item related to Navigational Safety; it is the main expression of the constantly changing topography of the sea floor. The measurement of depth has to be related to a datum plane. This datum plane is different from the one to which heights are referred. This datum plane is generally known as chart datum.

## **Datum for hydrographic surveys**

There is a need to establish the altitudinal relationship between the surveying ship which is changing its vertical position continuously throughout the tidal cycle and a stationary reference datum ashore. A careful attention should be given to the fact that the vertical control datum is fundamentally different from the chart datum to which depths in charts are referred. The chart datum of the nautical charts do not necessarily an equipotential surface but generally a level of the sea defined by some phase of tide in situ. A a general discussion on datum used for hydrographic surveys and their definitions are presented below:

Chart datum: "is the datum plane finally adopted for the published chart for determination of water depth below it and coincides with astronomical low water (based on International Hydrographic Bureau)".

Sounding datum is a plane to which soundings are reduced in the course of hydrographic survey. It is the datum used for compiling the fair chart.

### **General consideration in selection of a datum:**

In selecting a datum for determination of water depth the following considerations are borne in mind.

i) The datum should be low enough for the navigator to be confident that under normal weather conditions, the depth shown on chart is reliable.

ii) The datum should not be so low that it gives a unduly pessimistic idea of the least depth of water likely to be encountered in course of navigation.

iii) The datum should be in harmony with the datums of neighbouring surveys.

The selection of sounding datum is therefore a matter of judgement and compromise and, within the limits imposed by the above considerations, is an arbitrary level.

### **(iii) Recovering a former datum**

The tidal constants cannot be obtained satisfactorily from less than one month's observation and, by the time that the analysis has been completed, it is probable that a considerable amount of sounding will have been done. To save the time in the area where surveys were conducted earlier, the earlier established datum should be used. Bench marks are marked points of known elevation, measured from sea level or another datum. In this case re-establishment of datum is simply a matter of levelling between the bench mark and the pole and establishing datum at the known level below bench mark. If the recorded bench mark is destroyed, the original datum can be recovered from any other bench mark included in the levelling system. The relationship between bench mark and tide pole is determined by levelling.

### **Transfer of datum**

On an open coast of which an original survey is being carried out, the hydrographers' objective should be to establish a datum which, at the beginning of the survey is suitable and then to transfer the datum along the coast. The objective of transfer is to ensure that, when the tide falls to datum in one place, it falls to datum at all other points in the survey area. This ensures not only that the survey will give a realistic picture of the seabed but also that, where two areas with datum join, the soundings will match.

In most cases the survey commences in an area close to one previously surveyed and so the original datum already exists. The length of the interval between tidal stations along the coast will vary with tidal conditions. Where tidal conditions alter rapidly it may be necessary to have tidal stations every nautical mile or so; where even on an open coast tidal conditions alter gradually, a maximum distance between tidal stations should be maintained to about ten nautical miles.

### **Establishing datum by reference to the land levelling system:**

The essential problem involved in the determination of altitude is that of measuring the vertical distance between two points. The only method that is sufficiently reliable to be recommended here is the use of surveyors level (preferably of the Automatic type) in combination with the surveying staff. The method involved in using the combination of level and staff in terrain of regular or irregular topography and precautions to be taken to minimise the operational errors are discussed in detail in the standard text books. In field practice the distance between level and the staff should never exceed 150 m. All traverses should be closed with an error of less than 0.1 m. Traverses larger than this should be repeated. This task can be minimised by the creation of frequent temporary bench mark during the original survey so that in the case of resurvey these need be checked.

Transferring datum when tide is "semidiurnal" and "diurnal" are explained in detail in the Admiralty Publications.

### **Suggested Readings**

1. Clark, D. 1958. *Plane and geodetic surveying for Engineers Volume 1*. Plane Surveying, 5th edition (Constable, London).
2. Doodson, A.T. and Warburg, H.D. 1941. *Admiralty Manual of tides*. (Her Majesty's Stationery Office, London).
3. Hatfield, H.R. 1969. *Tides and tidal streams, Chapter 2 in Admiralty Manual of Hydrographic Surveying. Vol. 2*, (The Hydrographic of the Navy, Taunton).
4. Torge, W., 1980. *Geodesy* (Walter de Gruyter, Berlin).