



# Step-by-Step Guide to Dumpy Level Survey



A dumpy level (also known as a Builder's Level) is an optical instrument used to establish or check points in the same horizontal plane. It is used in archaeological surveying to measure horizontal levels, for example to demonstrate the difference in height at the top and base of a slope such as an excavated pit or a surviving earthwork.

## Equipment

The level 'kit' consists of a level head (in box), staff and tripod.

The **level head** comprises an eyepiece, bullseye spirit level, three levelling screws and a focus for the telescope lens; the base also incorporates a 360 degree compass.

The **5m staff** is in sections. Each 'block' represents one centimetre, and each 'E' represents 5 centimetres. The 10 cm sections alternate back and forth and between black and white, and the colour alternates between black and red for each metre.

The **tripod** is composed of aluminum and plastic, with three extendable/lockable legs and a base plate with screw fitting with which to attach the level head. There is a canvas carrying strap and a belt to secure the legs together.



## Benchmarks and Temporary Bench Marks (BM/TBM)

Find the nearest OS Bench Mark (BM), which is part of the national height system for mainland Great Britain and forms the reference frame for heights above mean sea level. Bench Marks are no longer maintained by the Ordnance Survey (although Fundamental (F)BMs are), but they should be marked on most maps. If the height value is not shown on the map, Ordnance Datums can be obtained from Bench Mark databases: <http://www.ordnancesurvey.co.uk/benchmarks/>; or <http://www.bench-marks.org.uk/search>

Bench Marks can usually be found on churches, but also on other notable buildings, houses, bridges etc. The database describes where it is and what type of benchmark symbol is used (usually carved into stone, the centre of the horizontal groove is the height reference). It is worth finding the nearest BM to your survey site as soon as possible so that you can establish the best way to transfer the height from the BM to your site.

In Swavesey we were able to use a BM on the north side of the church. The value of this was found in the database: 8.5222m OD – we used 8.52m, to two decimal points.



If there is no BM nearby to your site you can establish a Temporary Bench Mark (TBM) at an arbitrary height, for example 100m (to ensure all heights are positive). At some point you will also need to find the nearest BM, to tie your TBM into and then make your final level calculations.

**To set up a TBM:** mark an easily identifiable permanent feature nearby – eg. a coloured brick in a wall (as in the photograph right), or a fence post; a wooden stake may also be used but check with the landowner (if it is a scheduled monument this is not an option). Make a careful note with a precise description describing the location and nature of the TBM, preferably with a note annotated on a map and a digital photograph (if you have a handheld GPS use this!)



## Setting up the level

1. Set up the **tripod** where you have a clear sight of the benchmark, at a similar height to but preferably higher, than the benchmark. If possible, set up in the centre of the area that you intend to survey, or somewhere that you can see all of the site as well as the backsight/Bench Mark, with the top plate relatively level. Release the catches on each leg and extend to full length, close the catches. Space the tripod legs well apart, with the level plate about chest height of the person who will be reading the levels. NB: the tripod needs to low enough for the smallest person on site to use the dumpy level!



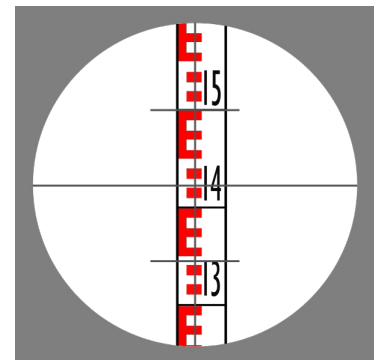
Note: Bear in mind that if at some point you have to move the level (higher or lower, or to a new location) you will need to re-level it and retake the backsight reading (see below).

2. Place the level head on the baseplate and attach it to the central screw beneath the baseplate. With the telescope parallel to two of the foot screws, level off by adjusting the two foot screws simultaneously, turning them in **opposite** directions until the level bubble is central. Then turn 90 degrees so the telescope points towards the third foot screw, and use the third screw to adjust the spirit level until the bubble is central along this axis. Check again in all directions. Now you should be perfectly level. NB: If the legs get kicked or moved by mistake, you will have to repeat the above steps.

## Taking a reading

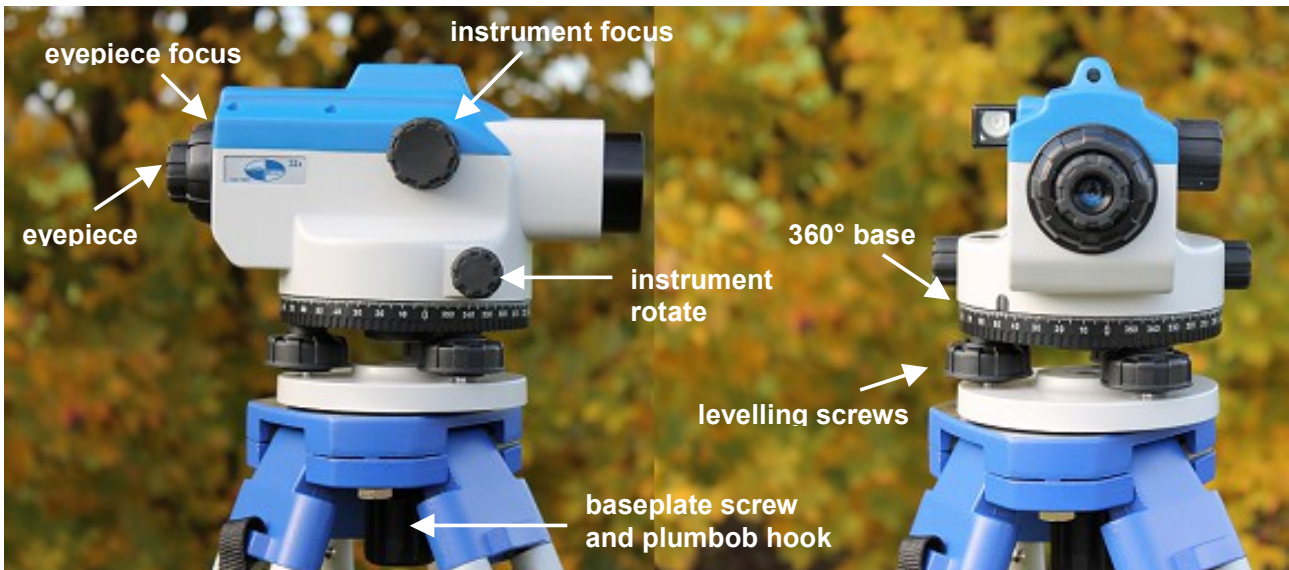
### 1. Taking the backsight (BS)

- The first measurement that you need to take is the backsight. This will enable you to calculate the height of the instrument/level (IH) from which all other levels are calculated.
- The person with the staff should place the bottom of the staff level on the BM or TBM, keeping it as vertical as possible.
- The person at the Level rotates the telescope until the central line/cross hairs are lined up with the staff; you may need to



focus the eyepiece first to see the cross hairs then the telescope focus to see the numbers on the staff; use the fine adjustment to be perfectly lined-up.

- When looking through the telescope, you take the reading where the central or stadia cross hairs meet, to the nearest centimetre. For example in the diagram to the right (above) the reading would be 1.42m.



The levelling bubble should be central

**2. Calculating the instrument height (IH) (or height of the Level)**

In order to calculate the height of the instrument (IH; ie the height of the Level Head telescope) you add the value of the reading you have just taken to the known value of the BM or TBM that you are using.

**3. Taking Foresight (FS) readings and calculating reduced levels**

Begin taking height (level) readings of anything you want to illustrate on your site: top of slope, bottom of slope, break of slope – to illustrate changes in height and create profiles.

Mark the location of your levels on the plan, starting at 1 (see example below) or the next available number if returning to a survey, and read off each height reading and record these in a separate notebook. Make sure you write clearly and record the date, where the survey is, what the BM or TBM is and the initials of the people undertaking the survey.





Each time you will have to rotate the telescope, sight on the staff in its new location, focus and carefully take the reading, always check twice that you have read the number correctly

Once you have taken all the levels you want, you will need to calculate the actual height values, or reduced levels (RL) by subtracting each one from the instrument height (IH). This gives you the 'real' height of the ground at the base of the staff.

### Example from Swavesey

The Bench Mark value was 8.52m, however this was set too high to read through the level, so a TBM was created on the concrete at the base of the wall, which was 0.7m below the height of the BM, giving the height of **TBM 1** of 7.82m.

This was then used to backsight to, which gave a reading of 0.3m, which added to the TBM gave an IH of 8.12m (TBM1 + BS = IH). A foresight was then taken on the new TBM (a black brick in the churchyard wall facing the survey area), this reading was 0.16m, which subtracted from the IH gives a value of 7.96 for **TBM 2** (IH – FS = TBM2).

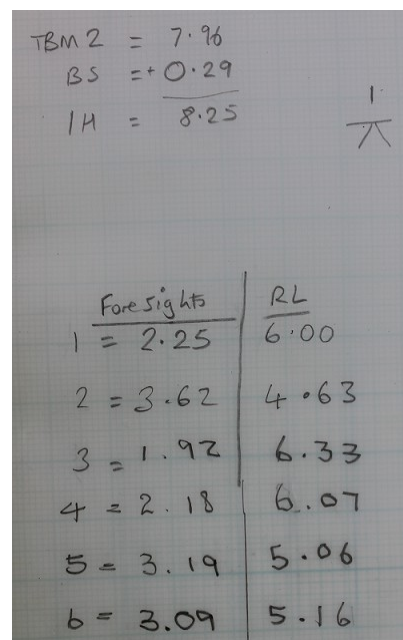
BM = 8.52 -  
BS = -0.7  
**TBM 1 = 7.82m +**  
 BS = 0.30  
 IH = 8.12 -  
FS = 0.16  
**TBM 2 = 7.96m**

The value of **TBM 2** was **7.96m**, the new backsight reading was 0.29m, giving an instrument height of 8.25m (TBM + BS = IH). A number of foresights were then taken within the survey area and these readings were then subtracted from the instrument height to give a real/reduced level.

**TBM 2 = 7.96 +**  
 BS = 0.29  
 IH = 8.25

$$(IH - FS = RL)$$

Fore sights (m)	Reduced Level (m)
1 = 2.25	6.00
2 = 3.62	4.63
3 = 1.92	6.33
4 = 2.18	6.07
5 = 3.19	5.06
6 = 3.09	5.16



## And finally....Some notes on taking care and use of the equipment

- The **staff** can be difficult to steady in high winds; you do need to keep it vertical and still. Do not use fully-extended near overhead power cables.
- Always pull out (and return) the sections one at a time, and put the staff back in its sleeve after use. Keep mud and grit off it as much as possible, as this will scratch the painted markings. After a survey, dampen the microfibre cloth supplied and wipe off each section of the staff as you close it up.
- The **level head** is a precision instrument, and should be handled carefully. When not in use it should always be kept in its box. If it is raining please make sure that you cover it with a bag or rain hood, or preferably unscrew the head and place it in its box. If the level head does become wet, make sure that it dries out somewhere inside/out of the rain before being returned to its box. If you don't dry it out properly, moisture may seep inside which will result in the telescope 'fogging up' and possible damage to the internal parts.
- When your survey is complete, carefully unscrew the level head and place it in its correct position within the box, close the lid and make sure the catch is secure.
- PLEASE TAKE CARE NOT TO DROP THE BOX: If the level head or box containing the level head is kicked or dropped you must report this to the *Jigsaw* team as soon as possible as it may require calibration or repair.
- Undo the catches on the **tripod** legs and carefully move the retract the legs and clamp the catches back and fasten the belt. Please ensure that the tripod does not get dented or damaged, as this may make it unusable.

## Further reading

Bettess, F. 1992. Surveying for Archaeologists. University of Durham Department of Archaeology.