

# Survey of Craig y Garreg-lwyd West Top

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## 1) Introduction

Craig y Garreg-lwyd West Top (Hill Number 14361, Section 30D, OS 1:50000 Map 124, OS 1:25000 Map OL18W, Grid Ref. SH730427) is listed as a TuMP (a hill with greater than or equal to 30m of drop) in the Database of British and Irish Hills (DoBIH). The Geograph 1:10000 scale map has spot heights for the summit and bwlch as 478m and 443m respectively. There are no spot heights on either of the 1:50000 or 1:25000 scale OS maps. The difference between these heights yields a value of 35m for the estimated drop, hence its classification as a TuMP. Recently, however, it was reported that the drop had been measured and was found to be only 29.9m which, if correct, would remove the TuMP classification of the hill. This value for drop is very close to the 30m criterion and, moreover, the measurement uncertainty to 99.8% confidence for the equipment used is +/-0.3m for each of the summit and bwlch measurements. Consequently, our fellow editors of The Database of British and Irish hills requested that we re-survey the hill to confirm the drop measurement since, if correct, this would result in the hill being removed from the list of TuMPs.

## 2) Equipment used and Conditions for Survey

A Leica NA730 Professional Automatic level (X30 telescopic system)/tripod system and a “1m” E-staff extendable to 5m were used to determine the positions of the bwlch and summit.

Absolute heights were measured using a Leica Viva GS15 receiver. This receiver is a dual-frequency, multi-channel instrument, which means it is capable of locking on to a maximum of 12 GPS and 8 GLONASS satellites, as availability dictates, and receiving two signals (at different frequencies) from each of these satellites. The latter feature reduces inaccuracies that result from atmospheric degradation of the satellite signals. As a stand-alone instrument, it is capable of giving position and height to an accuracy of about two metres and five metres respectively. Despite the on-board features of the GS15 receiver, there are still sources that create residual errors. To obtain accurate positions and heights, corrections were made to the GNSS (Global Navigation Satellite System) data via imported RINEX data from Ordnance Survey which were post-processed using Leica GeoOffice 8.3. Repeated measurements with the Leica Viva GS15 instrument made on the same point yield a height precision of +/-0.06m.

Note that small hand-held GPS receivers used for general navigation can only receive up to 12 GPS satellites and each at a single frequency and therefore these instruments have a poorer positional accuracy of +/-5metres and a height accuracy of no better than +/-10 metres. Some recently produced hand held GPS Garmin receivers can also receive signals from GLONASS satellites which greatly improve the speed at which these instruments can achieve a satellite “fix”.

Conditions for the survey, which took place between 12.00hr and 17.00hr BST, were fair. The weather was cool, 10 degrees Celsius, with periods of mist during the survey giving visibility of about 50m. The wind was light, 10 – 15mph.

### 3) The Survey

#### 3.1) Character of Hill

Craig y Garreg-lwyd West Top lies about 3.5km South East of Blaenau Ffestiniog and is most easily approached from a car park on the B4391, a road which traverses a large area of moorland on its route from the A4212 West of Llyn Celyn to the small village of Llan Ffestiniog. The large car park offers fine views over the steep valley to the West and the Afon Cynfal which cascades over the nearby Rhaeadr y Cwm. From the car park a walk of about 200m West leads to a locked gate and vehicle track that winds up the hillside to Llyn Morwynion, a further 500m distant. From here the dam and outflow are crossed and then a NW bearing leads in just over 500m to the bwlch between Craig y Garreg-lwyd West Top and its parent. It is then a short stroll to the summit. All in all, the route is just 2km with a mere 100m of ascent. Generally, the terrain makes for easy, although at times wet, walking. However, after crossing a wall just beneath the summit, the vegetation becomes quite thick whilst the ground at the bwlch is very boggy. On our visit the views were limited by mist, but on a good day the view West would be extensive and outcrops and crags of the nearby parent hill, Craig y Garreg-lwyd with Y Garnedd just behind, would add interest to the view East.

#### 3.2) Summary of Survey Method

Upon arrival at the bwlch it was quickly realised that a significant amount of time might be required to determine its exact position. While fairly well defined in the hill to hill direction, the profile of the bwlch in the valley to valley direction appeared to be very flat for a distance of about 150m and a significant area was bog. In order to find the location of the bwlch it would be necessary to lay out a grid of flags, as described in previous reports. Consequently, it was decided to begin the survey on the summit which posed less of a problem.

#### 3.3) The Summit

The summit area comprises a cairn in area of tussock grass and thick heather. The cairn appeared to be at the highest point, but it was decided to carry out a survey with level and staff to establish this. The level was set up about 3m NE of the cairn and staff readings were taken of all candidate high points. The summit was found to be ground immediately adjacent to the cairn on its NW side. The cairn itself was built from large rocks which gave it a very open structure and it took little work to establish that no higher ground was present under it.

Next the tripod was set-up over the summit position and the Leica Viva GS15 was fixed to it with a clamp and tribrach (the “short tripod” configuration). The height of the receiver above the ground was then measured with the integral tape. The vertical offset from measuring point to the ground was 0.489m (see photograph in Appendix 1) plus 0.255m for the tribrach/hook system. GNSS data were collected for 60min with an epoch time of 15 seconds.

The data for the Leica Viva GS15 were processed in Leica GeoOffice 8.3 using the six nearest base stations. The results are given in the table below:-

System	Easting	error(1SD)	Northing	error(1SD)	Height(m)	error(1SD)
GS15	273043.885	0.002	342743.233	0.002	473.794	0.017

The height of the summit is 473.79m

The ten figure grid references recorded by hand-held Garmin GNSS receivers for the summit were:-

Garmin Oregon 450	SH 73048 42746	Accuracy: averaged	Height = 484m
Garmin Montana 600	SH 73047 42746	Accuracy: averaged	Height = 477m
Garmin Etrex 20	SH 73047 42746	Accuracy: averaged	Height = 480m

### 3.4) The Bwlch

The first task was to determine the line of the valley to valley traverse across the bwlch. Once achieved, the highest point along this line would then identify the approximate bwlch position and laying a grid of flags around this would identify it more accurately. To the unaided eye the ground appeared to rise from the SE to a high point, then descend slightly, before rising to another high point near the NW end of the bwlch and then finally fall away towards the valley. So the first task was to investigate this second rise. It was quickly established to be several metres lower than the ground near the SE end of the bwlch area which is now where the survey was concentrated. Preliminary work with the level and staff identified the area in which the survey would concentrate. This area was very boggy, comprising a thick layer of moss, which just supported the weight of a surveyor, overlying free-standing water. Probes showed the depth to be at least 20cm to 30cm in parts. Four parallel lines of flags were placed in the hill to hill direction with the flags approximately 5m apart and each line also approximately 5m apart. The Leica NA730 was then set up at a convenient position where all flags in the grid could be observed and staff readings were taken of each flag. In order to gather a consistent set of data the staff was placed so that it was just resting on the surface of the soft ground. A diagram of the grid along with the staff readings in metres is given in Appendix 2. Note that the higher the staff reading then the lower the ground at that point. First, it may be seen that the readings in column 2 are, with but one exception, higher than those in any other column showing that the ground here is lower and therefore not on the bwlch. In column 3 there are four readings between 1.94m and 1.95m showing how flat the area is just here. In column four there are two points with readings of 1.92m and 1.94m but a lower point of 2.01m. Finally, in column 5 four points lie between 1.95m and 1.97m. The higher staff readings in each column are highlighted in blue which should show the general direction of the valley to valley line. However, in this case it is seen that the general bwlch area is very flat indeed. There is raised ground in column 2 shown by the 2.01m and 2.06m readings which was made visible to the naked eye by a change in vegetation and the line of the bwlch goes round it. There is a slight hollow in column 4 at 2.01m, but most of the low ground readings in columns 3, 4, and 5 lie between 1.92m and 1.97m and show just how flat the whole area is. The line of the bwlch appears to drift to the North (bottom right hand corner of the diagram) and indeed this can be seen visually when looking down the valley to valley direction. This line lies quite close to the steep side of Craig y Garreg-lwyd.

Next the tripod was set up over a convenient position in the square row 5, column 5 where the ground was fairly stable. There was still liquid mud beneath the set-up position however. The Leica Viva GS15 was fixed to the tripod with a clamp and tribrach (the “short tripod” configuration). The height of the receiver above the surface (with as much vegetation removed as possible) was then measured with the integral tape. The vertical offset from measuring point to the ground was 0.632m (see photograph in Appendix 1) plus 0.255m for the tribrach/hook system. GNSS data were collected for 60min with an epoch time of 15 seconds.

The data for the Leica Viva GS15 were processed in Leica GeoOffice 8.3 using the six nearest base stations. The results are given in the table below:-

System	Easting	error(1SD)	Northing	error(1SD)	Height(m)	error(1SD)
GS15	273220.625	0.002	342799.316	0.003	443.628	0.009

The height of the bwlch = 443.63m

The drop as determined by the summit and bwlch heights is  $473.794 - 443.628 = 30.166\text{m}$

The ten figure grid references recorded by hand-held Garmin GNSS receivers for the bwlch were:-

Garmin Oregon 450	SH 73222 42802	Accuracy: averaged	Height = 450m
Garmin Montana 600	SH 73224 42804	Accuracy: averaged	Height = 447m
Garmin Etrex 20	SH 73226 42802	Accuracy: averaged	Height = 447m

#### 4) Summary of Operating Conditions

GS15	
Data Collection summit (min)	64
Data collection bwlch (min)	65
Number of Base Stations used in Processing for all points	6
Epoch Time (sec)	15
Tropospheric Model	Hopfield
Geoid Model	OSGM15
Cut off Angle (degs)	15

#### 5) Coordinate Recovery Analysis

In order to verify the precision and consistency of a GNSS dataset, Ordnance Survey recommends a procedure called Coordinate Recovery Analysis. Instead of processing the data with reference to all the nearest OS Base Stations under approximately 100km distance, as used in this report, the data is first processed with reference to only the nearest Base Station. The data is then reprocessed with the survey point taken as a Reference Point and all the remaining Base stations taken as survey points. These measured values for the OS Base Stations can then be compared directly with the actual OS values for Position and Height. (This has been carried out via an Excel Spreadsheet supplied to us by OS).

Although the spreadsheet calculates a number of different parameters, two important ones are presented in the tables below. "Height Difference U metres" is the vertical height difference between the height of the Base Station as measured in this survey compared with the actual OS value. "Separation  $D_{ij}$  metres" is the distance in 3-d space between the measured and actual OS values for each Base Station. The results for the survey of the summit are presented below.

Base Station	Code	Distance to Survey Point km.	Height Difference U metres	Separation $D_{ij}$ metres
Machynlleth	MACY	41		
St Asaph	ASAP	43	0.0172	0.0199
Aberdaron	ADAR	60	0.0063	0.0080
Holyhead	HOLY	80	0.0350	0.0393
Shrewsbury	SHRE	84	0.0221	0.0240
Daresbury	DARE	94	0.0383	0.0407
Aberporth	ABEP	102	-0.0262	0.0287
Shobdon	SHOD	105	-0.0096	0.0105
Blackpool	BLAP	107	0.0351	0.0419
Brecon	BREC	117	-0.0181	0.0215

The results for Craig y Garreg-lwyd West Top Summit show a consistent dataset as all measured OS Base stations are within 0.05m distance and height of the OS actual values even for Base Stations up to 120km distance. Note that only those base stations less than 100km distant from the survey points (Machynlleth – Daresbury) were used for determining heights of summit and bwlch.

## 6) Discussion of Results

For the Leica Viva GS15, a one hour data collection time gives results with a measurement uncertainty of  $\pm 0.06\text{m}$ . This measurement uncertainty applies to both the bwlch and summit measurement. The summit position was found to within  $\pm 0.05\text{m}$  of height. In addition the measurement uncertainty in height associated with the location of the bwlch is  $\pm 0.05\text{m}$  as determined by the staff measurements. Therefore the overall measurement uncertainty for the determination of drop from the Leica Viva GS15 is  $\pm 0.11\text{m}$  [square root ( $0.06^2 + 0.06^2 + 0.05^2 + 0.05^2$ )]. The drop is therefore  $473.794 - 443.628 = 30.17 \pm 0.11\text{m}$  as determined by the Leica Viva GS15. However, it should be noted that the extremely waterlogged nature of the ground at the bwlch means that, should it dry out, then the ground level would sink substantially. The minimum probe depth we found was in the vicinity of squares 5 & 6 in column 5 where values of 10cm to 20cm were obtained. Consequently, in the event of a prolonged drought we would expect the bwlch to be in this area and the drop to increase by 10cm to 20cm as the area dried out.

## 7) Summary and Conclusions

The **summit of Craig y Garreg-lwyd West Top** is at grid reference \* SH 73047 42746 and is ground by the cairn on its NW side. Its height is **473.8m  $\pm$  0.08m**.

The **bwlch of Craig y Garreg-lwyd West Top** is at \* SH 73224 42803 and is unfeatured ground in bog. Its height is **443.6  $\pm$  0.08m**.

The **drop for Craig y Garreg-lwyd West Top** is **30.2  $\pm$  0.1m** and consequently **Craig y Garreg-lwyd West Top** remains a **TuMP**.

- NB: Grid references for Garmin receivers are quoted in the summary.

## Appendix 1



**The summit of Craig y Garreg-lwyd West Top looking South-West**



**The summit of Craig y Garreg-lwyd West Top looking North-East**





**Offset for Leica Viva GS15 set-up at summit**



**GS15 on bwlch within array of flags: summit of Craig y Garreg-lwyd West Top is in background**



**Offset for Leica Viva GS15 set-up at bwlch**



## Appendix 2: Survey of the bwlch

