

# Survey of Cefn Perfa

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## **1) Introduction**

Cefn Perfa (Hill Number 15004, Section 31B, OS 1:50000 Map 148, OS 1:25000 Map 200E, Grid Ref. SO173579) is listed as a P30 hill (TuMP) in the Database of British and Irish Hills with just 30m of drop. Myrddyn Phillips had carried out a survey some years ago using his basic levelling technique and measured the drop for Cefn Perfa to be 29.6m. Therefore Cefn Perfa is listed as a Sub-Pedwar in “Y Pedwarau” (Myrddyn Phillips and Aled Williams, *Europeaklist May 2013*); the category for qualification to this list is any Welsh hill at or above 400m and below 500m in height with a minimum drop of 30m. However, on 11 January 2014, Myrddyn Phillips repeated a survey of this hill using his Trimble GeoXH 6000 mapper and measured the drop to be 30.0m. Taking into account the measurement uncertainty of these two surveys, the drop is clearly very close to 30.0m and could be either side of it.

The purpose of this survey is to measure accurately the drop for Cefn Perfa to determine if it exceeds 30m or not and thereby resolve its classification.

## **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, and also to line survey between these two points.

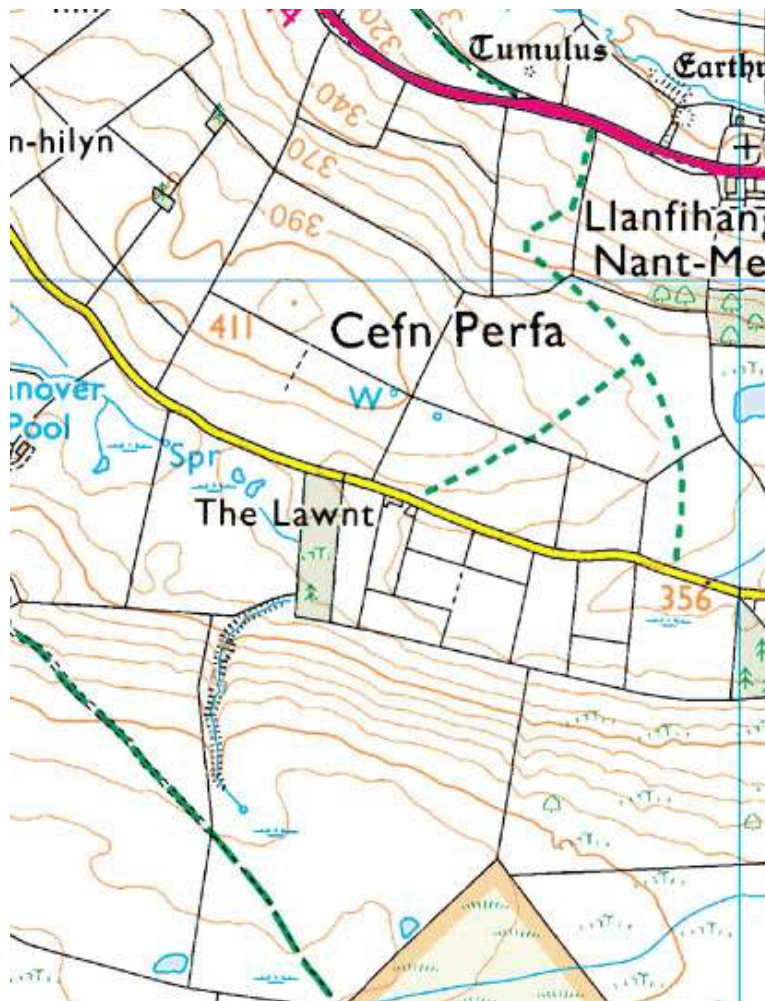
Absolute heights were measured using a Leica Geosystems Viva GS15 Professional receiver and a Trimble GeoXH 6000 receiver. Both instruments are dual-frequency, multi-channel instruments, which means they are capable of locking on to a maximum of 12 GPS and 8 GLONASS satellites as availability dictates, and receive 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 stand-alone instruments they are capable of giving position and height to an accuracy of about two metres and five metres respectively. 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 units can achieve a satellite “fix”. Despite the on-board features of the Viva GS15 and GeoXH 6000 receivers, 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 the Ordnance Survey which were post-processed using Leica Geo Office 8.3 software for the GS15 data and Trimble GPS Pathfinder Office processing software for the GeoXH 6000 data.

Conditions for the survey, which took place between 11.00hr and 15.30hr GMT were good. The weather was warm, sunny, 12 degrees Celsius with a very light wind and visibility was excellent.

### 3) The Survey

#### 3.1) Character of Hill

Cefn Perfa is a small hill situated about 0.75km South East of Fforest Inn which is at the junction of the A481 and A44 roads. It is in the Fforest Glud hills which are on the outskirts of Llanfihangel Nant Melan. An extract of the OS 1:25000 map showing the summit and bwlch is presented below.



The summit is marked with a 411m spot height and the bw lies about 200m to the South West of it and on the opposite side of the minor road. Both the summit and the bw are on private land and permission, which was willingly given, to survey these points was requested from the two landowners.

Both the bw and the summit are covered with short grass as the land is used for grazing farm animals. Access to both points can be gained via field gates just to the West of The Lawnt. Although there are no tracks to the summit, the ascent is very easy and only takes a few minutes.

### 3.2) Summary of Survey Method

The survey commenced at the bwlch whose position was identified with Leica level and staff, and then marked with a survey nail. Another survey nail was placed at a convenient position just South of the road and adjacent to the fence and staff readings were taken from these two nails. These two points represented the first two points for a line survey from bwlch to summit. Before starting the line survey the Leica GS15 was set up directly over the bwlch survey nail. To utilise time economically, the GS15 was set to collect GNSS data while the line survey to the summit continued.

The last step in the line survey was to locate the summit position which was marked with a survey nail before the final staff reading was taken. The level was left in place on the tripod at this final position and the GS15 was retrieved and then placed over the summit nail with the same set up as for the bwlch. Once GNSS data were being collected, the line survey then continued from summit to bwlch.

The absolute heights of both the bwlch and the summit were measured with the Trimble GeoXH 6000 placed directly over these points.

### 3.3) The Bwlch

The bwlch area for Cefn Perfa can be identified easily visually as it is quite well defined and small. It lies just over the fence on the South side of the minor road and is part of a distinct ridge in the hill to hill direction. However, there were two areas to the South and East that may have been contenders. The level was set up at a convenient position and adjusted so that its height was about the same as the lowest point on the small ridge (the bwlch?) and these two areas were observed. It was immediately clear that these positions were several metres lower and could be discounted. The height of the level on the tripod was readjusted so that systematic staff readings of the bwlch area could be taken to pinpoint the bwlch which was then marked with a survey nail. We estimated that the bwlch had been identified to a height accuracy of +/-0.02m.

The ten-figure Grid References measured for the bwlch were:-

Garmin Montana 600	SO 17292 57790	Height = 382m
Garmin Etrex 20	SO 17292 57787	Height = 384m

The Leica GS15 was then set up over the bwlch position and was supported by a “quickset” tripod. The unit was mounted on a 2.000m pole and a photograph of the set up is shown in Appendix 1. GNSS data were collected for 1 hr 45 minutes. The position and height data for the bwlch that were recorded by the Leica Viva GS15 was post-processed with Leica GeoOffice 8.3 using imported OS RINEX data for the nine nearest base stations under 100km distance and the Computed model for tropospheric correction. These results and for the Trimble GeoXH 6000 processed in Trimble GPS Pathfinder Office using the five nearest base stations are given in the table below:-

System	Easting	error(1SD)	Northing	error(1SD)	Height(m)	error(1SD)
GS15	317288.928	0.002	257782.850	0.001	381.102	0.009
GeoXH 6000	317288	Not recorded	257782	<0.05(?)	381.178	Not recorded

The height of the bwlch is 381.10m

### 3.4) The Summit

The exact position of the summit was established by taking systematic level and staff readings and is represented by no specific feature. The position was marked with a survey nail. We estimated that the summit had been identified to a height accuracy of +/-0.01m.

The ten-figure Grid References recorded for the summit are:-

Garmin Montana 600            SO 17393 57977            Height = 413m  
Garmin Etrex 20                SO 17393 57978            Height = 413m

The Leica GS15 was then set up over the summit position and was supported by a “quickset” tripod. The unit was mounted on a 2.000m pole and a photograph of the set up is shown in Appendix 1. GNSS data were collected for 1 hr 48 minutes. The position and height data for the summit that were recorded by the Leica Viva GS15 were post-processed with Leica GeoOffice 8.3 using imported OS RINEX data for the nine nearest base stations under 100km distance and the Computed model for tropospheric correction. These results and for the Trimble GeoXH 6000 processed in Trimble GPS Pathfinder Office using the five nearest base stations are given in the table below:-

System	Easting	error(1SD)	Northing	error(1SD)	Height(m)	error(1SD)
GS15	317389.119	0.003	257973.092	0.001	411.161	0.004
Geo XH 6000	317389	Not recorded	257973	<0.05	411.244	Not recorded

The height of Cefn Perfa is 411.16m.

### 3.5) The Line Survey

This procedure commenced at the bwlch where a staff reading was taken with the staff placed on the marking survey nail with the level set up in a convenient position towards the hill. Once a set of readings had been taken (Backsights BS) the staff was then moved to an uphill position, but the level not moved apart from a rotation through 180 degrees to take another set of readings (Foresights FS). This process of alternately moving the staff and level was repeated uphill until the final reading was taken with the staff on the summit position. Readings were taken from the horizontal and also the lower and upper stadia lines of the level to provide a check on any staff misreadings and to improve accuracy. If in any set of three readings the average was greater than 1mm different from the horizontal reading, then that set was remeasured. This procedure was repeated until the final reading was taken on the survey nail marking the summit.

The line survey was then repeated in the summit to bwlch using exactly the same procedure. The results for the two line surveys are shown in Appendix 2 and gave drops for Cefn Perfa of 30.070m and 30.065m respectively.

#### 4) Summary of Operating and Process Conditions

	GS15	GeoXH 6000
Data Collection bwlch (min)	105	25
Data collection summit (min)	108	18
Number of Base Stations used in Processing for all points	8	5
Epoch Time (sec)	15	1
Tropospheric Model	Hopfield	Unknown
Cut off Angle (degs)	15	5

#### 5) Discussion of Results

We estimate the uncertainty error associated with a 2 hour data set for the Leica GS15 to be +/- 0.05m. We also estimated that the uncertainty in height for the location of the bwlch and summit were +/-0.02m and +/-0.01m respectively. Therefore, we estimate the total uncertainty in each of these measurements to be approximately +/-0.06m. As yet we do not have a similarly derived uncertainty measurement for the Geo XH 6000.

The height of Cefn Perfa was measured to be 411.16+/-0.06m with the GS15. The survey carried out with the GeoXH 6000 measured the height to be 411.24m. The two measurements differ by 0.08m and are within expected agreement. A previous survey carried out with the GeoXH 6000 measured the height of Cefn Perfa to be 411.18m which is also in excellent agreement.

The height of the bwlch was measured to be 381.10+/-0.06m, 381.18m and 381.15m for the GS15 and two GeoXH 6000 surveys respectively. Again the datasets are consistent and in good agreement.

The calculated drops from the GNSS data for the GS15 and two Geo XH 6000 surveys are 30.06+/-0.08m, 30.07m and 30.04m respectively. All three data sets are in good agreement and show the drop for Cefn Perfa just exceeds 30m.

The most accurate method to measure the drop is the line survey where the closing error for the two surveys was 0.005m. The average drop for the two line surveys was 30.068m and the result confirms the validity of the GNSS measurements.

Therefore we are confident that the drop for Cefn Perfa exceeds 30.00m

#### 6) Summary and Conclusions

The **summit of Cefn Perfa** is at grid reference \* SO 17393 57978 and is unfeatured grass. Its height is **411.16+/-0.06m**.

The **bwlch of Cefn Perfa** is at \*SO 17292 57789 and is unfeatured grass. Its height is **381.10+/-0.06m**.

The **drop for Cefn Perfa is 30.07+/-0.02m** and therefore this hill **retains its TuMP status but becomes a new Pedwar**.

The previous discrepancies in survey results indicating drops either side of 30.00m have been resolved.

\* NB average hand-held Garmin GPS grids are quoted in the summary.  
John Barnard and Myrddyn Phillips, 09 May 2014

## Appendix 1



**Leica GS15 set up at Bwlch – mole hills are not natural ground!!**



**Leica GS15 setup on summit**

## Appendix 2

**Title:-** Survey of Cefn Perfa

**Instrument:-** Leica NA370 Automatic level

**Date:-**

13/03/2014

Point Number	Horizontal Line			Lower Stadia Line			Upper Stadia Line			Mean BS metres	Mean FS metres	Height Difference metres
	Backsight BS metres	Foresight FS metres	Backsight BS metres	Foresight FS metres	Backsight BS metres	Foresight FS metres	Backsight BS metres	Foresight FS metres				
<b>Bwlich to Summit (JB Level and Data recording, MP Staff)</b>												
1	3.814	3.328	3.626	3.162	4.002	3.494	3.814	3.328				
2	3.272	0.495	3.097	0.420	3.446	0.570	3.272	0.495				
3	4.701	0.346	4.565	0.284	4.836	0.408	4.701	0.346				
4	4.811	0.225	4.694	0.137	4.928	0.312	4.811	0.225				
5	4.688	0.473	4.582	0.384	4.795	0.561	4.688	0.473				
6	4.406	0.899	4.327	0.816	4.487	0.981	4.407	0.899				
7	4.407	0.314	4.261	0.200	4.554	0.426	4.407	0.313				
8	4.111	0.281	3.939	0.182	4.283	0.380	4.111	0.281				
9	2.881	0.663	2.751	0.630	3.013	0.695	2.882	0.663				
						SUM =	37.092	7.022				30.070
<b>Summit to Bwlich (JB Level and Data recording, MP Staff)</b>												
1	0.663	4.373	0.630	4.134	0.695	4.612	0.663	4.373				
2	0.259	4.416	0.215	4.281	0.304	4.555	0.259	4.417				
3	0.870	4.503	0.757	4.394	0.981	4.614	0.869	4.504				
4	1.438	4.757	1.330	4.631	1.546	4.885	1.438	4.758				
5	0.400	4.805	0.306	4.645	0.495	4.965	0.400	4.805				
6	0.195	4.638	0.091	4.455	0.299	4.820	0.195	4.638				
7	0.517	4.716	0.463	4.530	0.574	4.903	0.518	4.716				
8	1.616	3.814	1.584	3.626	1.650	4.002	1.617	3.814				
						SUM =	5.959	36.025				-30.065