Survey of Foel Wen and Foel Wen South Top

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The Team:

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1) Introduction

Foel Wen (Hill Number 2095, Section 30E, 1:50000 OS Map 125, 1:25000 OS Map 255, GR SJ099334) and Foel Wen South Top (Hill Number 2097, Section 30E, 1:50000 OS Map 125, 1:25000 OS Map 255, GR SJ102330) are in the Berwyns about 5km West of the small village of Llanarmon Dyffryn Ceiriog. Both of these hills are classified as "Nuttalls" since they are above 2000 feet in height with greater than 15m drop to their critical cols. The Database of British and Irish Hills has received a number of different 10 figure Grid References for the summit position of Foel Wen.

Both of these hills had been surveyed by Myrddyn Phillips on 21 June 2014 when heights and Grid References were obtained using his Trimble GeoXH 6000. However, for Foel Wen these Grid References were not in agreement with others who had visited this hill. None of the people who supplied these Grid References used surveying equipment to accurately identify the summit position.

The purpose of this survey was to locate the position of the summit of Foel Wen in order to eliminate this confusion. At the same time the opportunity was taken to remeasure the summit heights with the Leica GS15 and Trimble GeoXH 6000 for both Foel Wen and its South Top.

2) Equipment used and Conditions for Survey

The ground survey to locate the positions of the summits were carried out using a Leica NA730 Professional Automatic level (X30 telescopic system)/tripod system and a "1m" **E**-staff extendable to 5m.

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 11.30hr and 15.00hr BST were satisfactory. Visibility was good, but while the day was forecast to be the hottest for the year and with no rain, the temperature was well below expectation. The chill effect was worsened considerably by quite strong

winds which although not affecting the survey, made shelter very desirable while waiting for the GS15 to collect data!

3) Character of Hills

Foel Wen and its South Top are rounded grassy summits on the northern side of Cwm Maen Gwynedd and are part of the Berwyn Mountains. The Berwyns in general have a reputation of being featureless heather-clad hills. However these hills are quite different and are part of a delightful horseshoe walk that continues in a broadly westerly direction until the main Berwyn ridge is reached to ascend Cadair Berwyn and Moel Sych. The descent from there is easterly over Moel yr Ewig and Godor before dropping into the valley to the starting point. This whole valley is very green and all the flanks of the hills are usually dotted with grazing sheep. Access to these hills is best obtained via the farm track, Right of Way, which starts by the telephone box and leads up through the farmyard of Maes. Beyond Maes the Right of Way, which is way-marked, turns through a gate and leads up the open hillside to a conifer plantation. Here there is a choice of routes. Either one can continue on the track to the bwlch between Mynydd Tarw and Foel Wen South Top, or one can ascend Mynydd Tarw by following the edge of the wood to the hill's summit and then continue along the grassy ridge. The only real problem with access to these hills is that parking is very limited, but there is room for 2-3 cars about 200metres South of the phone box where the minor road crosses the stream.

4) Survey of Foel Wen Summit

An enlarged extract of the summit area of Foel Wen taken from the 1:25000 OS Map is shown below.

This map shows a spot height of 691m just to the North of the centre of the 690 contour ring. The spot height is also to the North of the boundary fence that runs WNW to ESE which approximately bisects the 690m contour ring. Visually it is very difficult to identify the highest point, but the consensus of opinion of the survey team was that it was on the North side of the fence. The summit area is quite flat but the problem of locating the summit is made worse by the higher grass/vegetation on the North side of the fence which means that one's eye is naturally drawn to that area. (The vegetation at the summit can be seen in the photograph displayed in Appendix 1).

The Leica NA730 level was set up on a tripod on ground just North of the fence and at the Eastern end of the 690m contour. To the South of the fence and a few metres further to the East there is a distinct rock which appears to be the highest point in this area South of the fence. Measurements with the staff confirmed this but the area to the West and to the North of the fence was measured to be about 0.5m higher. However, unexpectedly from visual appearance, ground even further to the West and on the same side of the fence, was measured to be clearly higher. In order to investigate the height of this area more thoroughly, the level was set up on its tripod further to the West but still on the North side of the fence. Staff measurements clearly showed the area to the West, the highest point marked with a wooden stake about 35cm high, to be 0.43m higher than the area around the marked spot height and 0.9m higher than the highest point on the South side of the fence.

The Leica GS15 was set up on its short tripod configuration directly over the highest point (see photo in Appendix and note wooden stake beneath the tripod) and GNSS data were collected for 50 minutes. The vertical offset used as measured by the tape (see photograph in Appendix 1) was 0.578m. The data were processed using Leica GeoOffice V8.3, the computed Tropospheric Model and imported RINEX data from the eight nearest OS Base stations under 100km distance. The results are shown below together with the processed data from the Trimble GeoXH 6000 which was also subsequently placed on the highest point next to the wooden stake.

System	Easting	error(1SD)	Northing	error(1SD)	Height(m)	error(1SD)
GS15	309934.187	0.001	333407.798	0.002	690.625	0.005
GeoXH 6000	309934.296		333407.946		690.692	

Measurements were taken from both the 1:25000 OS Map and Geograph to obtain Grid References for the marked 691m spot height and these are in accord with the Grid References measured by both the Leica GS15 and Trimble GeoXH 6000. Therefore it seems the spot heights on the maps correspond to the position of the small wooden stake and this indeed does mark the hill's summit.

5) Survey of Foel Wen South Top Summit

An enlarged extract of the summit area of Foel Wen South Top taken from the 1:25000 OS Map is shown below.

The structure of this summit is very similar to Foel Wen described earlier in this report. The 680m contour ring is bisected by a fence running in a SE to NW direction and a 687m spot height is marked on the South side of this fence. Visually one would expect the summit to be in the area of the spot height so this is where the survey with level and staff commenced. The Leica NA730 level was set up on the tripod a few metres South of the fence and staff readings were systematically taken in this area. The highest ground was identified as being on the South side of the fence and a few metres away from it with no feature identifying it. There is an embedded rock further from the fence on its South side but that was measured to be 0.03m lower than the highest point. The highest identified ground on the North side of the fence was 0.05m lower.

The Leica GS15 was set up on its short tripod configuration directly over the highest point (see photograph in Appendix 2) and GNSS data were collected for 50 minutes. The vertical offset used as measured by the tape (see photograph in Appendix 2) was 0.550m. The data were processed using Leica GeoOffice V8.3, the computed Tropospheric Model and imported RINEX data from the eight nearest OS Base stations under 100km distance. The results are shown below together with the processed data from the Trimble GeoXH 6000 which was also subsequently placed on the highest point.

System	Easting	error(1SD)	Northing	error(1SD)	Height(m)	error(1SD)
GS15	310232.595	0.003	333044.845	0.001	687.891	0.003
GeoXH 6000	310232.634		333044.965		687.906	

A measurement taken from the 1:25000 OS Map to obtain the Grid References for the marked 687m spot height showed this position to be about 30m West of the Summit as located in this survey.

5) Summary of Operating and Process Conditions

	GS15
Data Collection summits (min)	50
Number of Base Stations used in Processing for all points	8
Epoch Time (sec)	15
Tropospheric Model	Computed
Cut off Angle (degs)	15

6) Discussion of Results

The main uncertainty in the measured heights for both Foel Wen and its South Top results from the unevenness of the vegetated ground. We would estimate that this would result in a height uncertainty of +/-0.1m.

The survey for Foel Wen raises the point that sometimes it is very difficult to visually identify the highest point of a hill. Clearly a "flat" summit area makes this more difficult, but occasionally one meets other features that somehow confuse ones interpretation of height and the summit of Foel Wen is a good example of this and of course the reason for leading to this survey.

The table below shows a summary of data from four individuals who have been to the summit of Foel Wen on different occasions and have tried to visually identify this position. They reported their "Garmin" based grid reference and the summit feature. Apart from author MR, who correctly identified the summit position, all the other authors were 40m or more away from it. There is no criticism implied here, and indeed the authors at the time of this survey would also have incorrectly located the summit position, but it does show the importance of using level and staff to identify summit and col positions accurately.

Author	Date	Grid Reference	Summit Feature
DF	04/06/2010	SJ 09999 33378	No feature - grass
PDC	02/02/2005	SJ 09986 33403	Cairn
MP	21/06/2014	SJ 09972 33404	No feature – grass
MR	24/04/2014	SJ 09933 33412	Small wooden stake

7) Summary and Conclusions

The height of the **summit** of **Foel Wen** is 690.6+/-0.1m and the summit position is marked with a small wooden stake. Its Grid Reference is ***SJ 09936 33411**.

The height of the **summit** of **Foel Wen South Top** is 687.9+/-0.1m and the summit position is on grass and has no feature identifying it. Its Grid Reference is ***SJ 10234 33048**.

* Grid References adjusted to Garmin

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Appendix 1

Leica Viva GS15 after collecting data on the Summit Position of Foel Wen

Vertical Offset for the GS15 Setup on Foel Wen Summit

Appendix 2

Leica Viva GS15 after collecting data on the summit of Foel Wen South Top

Vertical Offset for Leica Viva GS15 Setup on Foel Wen South Top Summit