

Survey of Waun Garnedd-y-Filiast

28 August 2018

The Team:

Surveyors – John Barnard and Graham Jackson

1) Introduction

Waun Garnedd-y-Filiast (Hill number 2070, Section 30D, OS 1:50000 Map 116 and OS1:25000 Map OL18E, Grid Ref SH874452) is listed as a Nuttall in the Database of British and Irish Hills. The hill has a spot height of 644m on the 1:50k map, while the 1:25k and 1:10k maps give a spot height of 650m, but in a different position. There is no spot height for the bwlch on any map, the best estimate for its height being 635m which gives the hill a drop of just 15m.

In Anne and John Nuttalls' book "The Mountains of England and Wales Volume 1:Wales", Third Edition, they report under the Route description for Waun Garnedd-y-Filiast, "In July 1999 Myrddyn, Dewi, two friends and a surveying level spent three hours measuring this top. They concluded it rose by 15.1m..."

Consequently, Waun Garnedd-y-Filiast is only classed as a mountain by the narrowest of margins. The purpose of this survey was to obtain an accurate measurement of drop by line survey and also an accurate determination of the height of the summit and bwlch using a survey grade Leica Viva GS 15 Professional GNSS (Global Navigation Satellite System) receiver to determine its eligibility.

2) Equipment used and Conditions for Survey

The summit positions were identified and drop was measured using a Leica NA730 Professional Automatic level (X30 telescopic system)/tripod system and a "1m" E-staff extendable to 5m as required by Ordnance Survey.

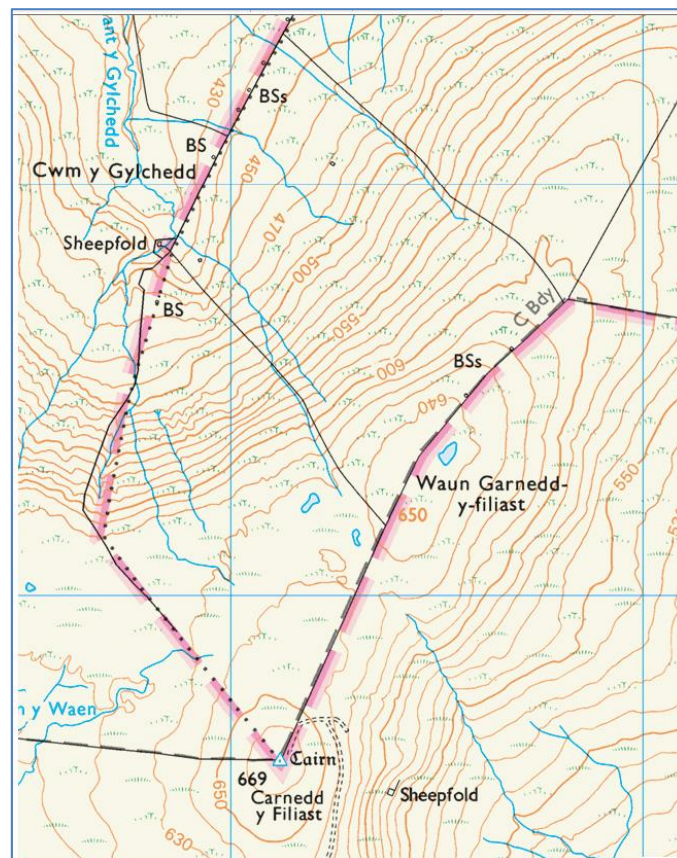
Absolute heights were measured using a Leica Geosystems Viva GS15 Professional receiver. This instrument is dual-frequency and multi-channel, which means it is capable of locking on to a maximum of 12 GPS and 8 GLONASS satellites as availability dictates, and receives two signals (at different frequencies) 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 Viva GS15 receiver, there are still sources that create residual errors. To obtain accurate positions ($\pm 0.01\text{m}$) and heights ($\pm 0.05\text{m}$), corrections were made to the GNSS (Global Navigation Satellite System) data via imported RINEX data from Ordnance Survey and this dataset was post-processed using Leica Geo Office 8.3 software.

Conditions for the survey, which took place between 10.00hrs and 16.00hrs BST on 28 August 2018, were fair. The temperature was about 15 degrees Celsius. The wind on the summit was light, at about 10mph. The sky was overcast, but the cloud base was above 2000ft for most of the survey. However, later in the day, while collecting data with the Leica Viva GS15 on the summit, rain spread from the south and the cloud base lowered to just below 2000ft.

3) Character of the Hill

Waun Garnedd-y-Filiast is one of a group of heather-clad mountains that lies near the town of Bala and just north of the reservoir of Llyn Celyn. An approach along good tracks may be made from the reservoir where there is ample parking, but this necessitates a walk of 6km and 450m of ascent. A shorter route starts from the north at the end of the minor road that leaves the A5 at Cerrigydrudion and proceeds west for nearly 8km terminating at the farm of Blaen-y-cwm, where there is limited parking for a couple of cars. From here it is a walk of just 2.5km with 300m of ascent to the summit of Waun Carnedd-y-Filiast following a good farm track south-west to the bwlch at 430m and from there a faint ATV track nearly to the summit ridge. It is wise to follow the ATV track if possible, as the terrain comprises thick heather on the upper flanks of the hill. Once on the ridge an indistinct walkers' track on the far side of a fence leads after about 700m to the summit cairn.

The whole summit area is clothed in thick heather except by the fence where the indistinct walkers' track continues to Carnedd-y-Filiast which lies 700m SSW of its lower neighbour.



An extract from the OS 1:25000 map (Ordnance Survey Crown Copyright) is shown above.

4) Survey of the Summit and Bwlch of Waun Garnedd-y-Filiast

The first task for the team was to determine the position of the summit which previous visitors have determined to be a cairn that lies just a few metres west of the fence. The Leica NA730 was set up on a tripod at a convenient position near the cairn and staff readings were taken at several positions on both sides of the fence. The thick heather in the summit area gives the impression that the cairn does not lie on the summit. However, it was soon determined that the whole area was quite flat and that the highest point was indeed at the cairn itself.

Next our attention turned to the area of the bwlch separating Waun Garnedd-y-Filiast from Carnedd y Filiast, which was just a short journey of about 200m distance south-west from the summit. This comprises a large and apparently flat area approximately 100m by 50m in extent, much of which is very wet, and the centre of which is filled with sphagnum moss. Closer inspection showed the large area of sphagnum moss to have two channels running from each end of it in a north-west to south-east direction each of which was also filled with thick sphagnum moss. We suspected these channels to be the start of streams issuing from each end of the central area. Our first task was to check more closely just where the area of the bwlch lay. The Leica NA730 was set up at a convenient position on firm ground and staff readings were taken at regular intervals of approximately 15m from a point to the south-east by the fence to a point about 120m to the north-west. On this traverse the ground was found to rise by about 0.3m to the area of sphagnum moss and there after the ground began to fall by about 0.2m at the far north-west end of the traverse. This reconnoitre confirmed that the bwlch lay in the area of the sphagnum moss. Next a grid of flags was set out over this area, with each flag being 10m from its neighbours, and staff readings taken on each in order to determine the bwlch position more precisely. Some of the flags lay within the area of sphagnum moss with one being placed at the start of each exit channel. Prior to taking staff readings on these, care was taken to ensure removal of the vegetation to reveal the underlying soil prior to placing the staff. The photographs in Appendix 1 show the general area of the bwlch and a portion of the grid of flags. The results are illustrated in the diagram below where the higher the staff reading the lower the ground. It may be seen that the area of lowest ground illustrated by the green squares runs approximately in an ESE to WNW direction and that this area is all very much of the same height. The square 2.08m was chosen as the bwlch position for the purpose of the line survey, although all the ground shaded green in the grid is very much of the same height.

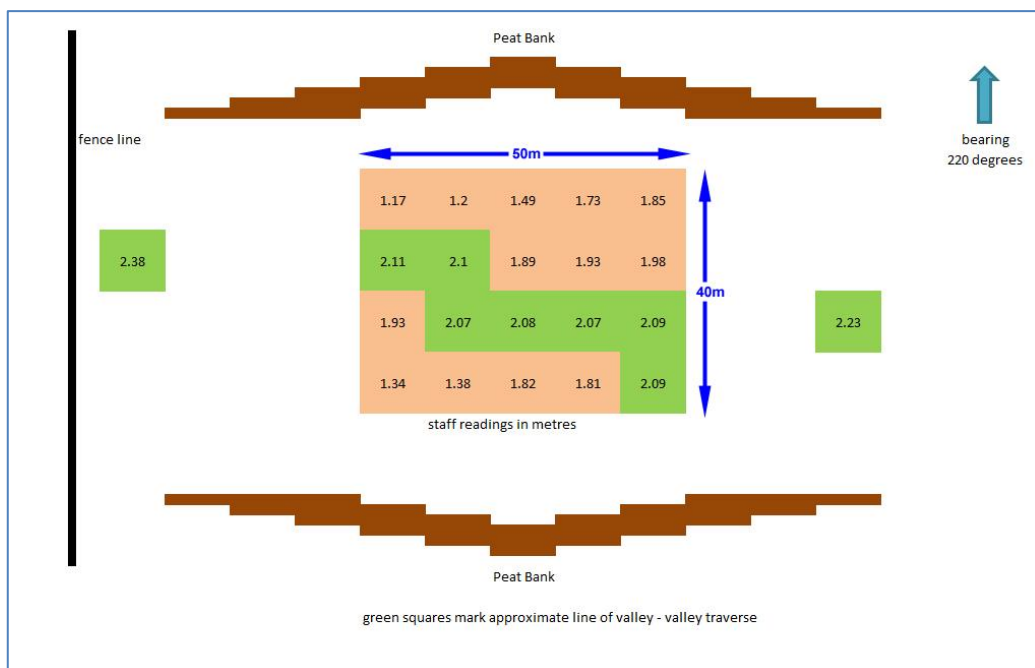
The ten-figure grid references for this position are:

Garmin Oregon 450	SH 87314 45129	Accuracy: averaged	Height: 642m
Garmin Montana	SH 87316 45129	Accuracy: averaged	Height: 641m
Garmin Etrex 20	SH 87316 45129	Accuracy: averaged	Height: 642m

These are values taken directly from the Garmin receivers and so are not OSTN15 (see Summary)

The diagram below illustrates the bwlch topography.

Schematic Diagram of Bwlch showing Staff Readings



4.1) The Line Survey

Next a line survey from the bwlch to the summit was carried out. The Leica NA730 level was set up on the tripod at a convenient position near to the bwlch and staff readings were taken with the staff on the bwlch position. Once this 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). The line survey route then continued towards the summit. This process of alternately moving the staff and level was repeated 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 mis-readings 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 re-measured. Once completed the line survey was then repeated, this time going from the summit to the bwlch and using exactly the same method as just described. The line survey readings are given in Appendix 2.

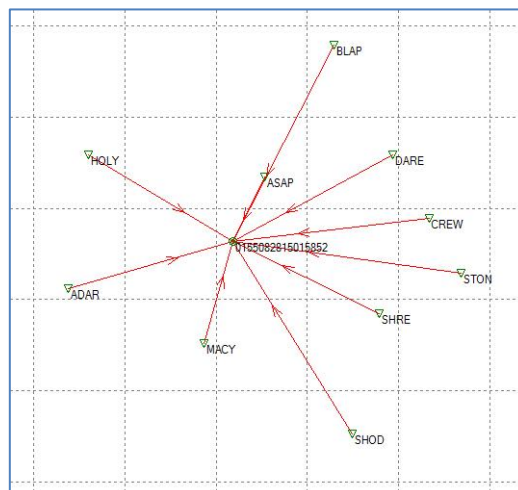
The drop measured by the line survey is 15.06m with a closing error of 4mm.

It should be noted that in a drought the bwlch would become much drier and this would probably result in the ground shrinking there. Consequently, this value for drop should be considered a minimum value.

5) Determination of Summit Height of Waun Garnedd-v-Filiast

On returning to the summit the Leica Viva GS15 receiver was mounted on the short tripod assembly directly over the summit position (see photograph in Appendix 1). GNSS data were collected for 1 hour with an epoch time of 15 seconds. A photograph is shown in Appendix 1 of the tape reading, 0.492m, for the short tripod set up.

The data for the Leica Viva GS15 were processed in Leica GeoOffice 8.3 using the ten nearest base stations: (St Asaph – ASAP 32km, Machynlleth – MACY 46km, Shrewsbury – SHRE 72km, Holyhead – HOLY 74km, Aberdaron - ADAR 74km, Daresbury – DARE 80km, Crewe – CREW 87km, Blackpool – BLAP 98km, Shobdon – SHOD 99km, Stone – STON 101km). We used Broadcast Ephemeris data received by the GPS during the survey rather than Precise Ephemeris data, since we have found this makes little difference to the height results. The Hopfield Tropospheric model was chosen for the calculations to suit the data collection times and the wide difference in height between the base stations and the summit of the mountain. The vertical offset from measuring point to the summit was 0.492m plus 0.255m for the tribrach/hook system and this was used in the calculations. The spatial distribution of the base stations around the survey point used in the calculations is shown below.



As far as is possible, the base stations are evenly distributed around the survey points and heights measured from each base station were within +/-0.06m of the mean result for the summit.

The results for Waun Garnedd-y-Filiast are tabulated below:

System	Easting	error(1SD)	Northing	error(1SD)	Height(m)	error(1SD)
GS15	287401.914	0.001	345244.291	0.002	650.885	0.008

The height of Waun Garnedd-y-Filiast is 650.89m.

Consequently, the height of the bwlch is: $650.89 - 15.06 = 635.83\text{m}$.

6) Summary of Operating Conditions

Variable	Waun Garnedd-y-Filiast
Data collection summit (min)	62
Number of Base Stations used in Processing for all points	10
Epoch Time (sec)	15
Tropospheric Model	Hopfield
Geoid Model	OSGM15
Cut off Angle (deg)	15

7) Coordinate Recovery

In order to verify the precision and consistency of a GNSS dataset, Ordnance Survey (OS) 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 are first processed with reference to only the nearest Base Station, in this case St. Asaph (ASAP). The data are 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 the “Height Difference U metres” and “Separation D_{ij} metres” which are the vertical height difference and distance in 3-d space respectively between the measured and actual OS values for each Base Station.

The results for the summit measurement for Waun Garnedd-y-Filiast calculated using the Hopfield tropospheric model are presented below.

Base Station	Code	Distance to Survey Point km.	Height Difference U metres	Separation D_{ij} metres
St Asaph	ASAP	32	Reference	Reference
Machynlleth	MACY	46	0.0038	0.0103
Shrewsbury	SHRE	72	0.0239	0.0251
Holyhead	HOLY	74	0.0267	0.0311
Aberdaron	ADAR	74	0.0048	0.0182
Daresbury	DARE	80	0.0271	0.0272
Crewe	CREW	87	-0.0306	0.0307
Blackpool	BLAP	98	0.0743	0.0746
Shobdon	SHOD	99	0.0055	0.0121
Stone	STON	101	-0.0304	0.0309

The results show a consistent dataset, as all measured OS Base Stations are within 0.07m distance and height of the OS actual values for Base Station distances up to about 101km. The requirement of OS is that all values should be below 0.1m.

8) Discussion of Results

The value for the drop was measured as 15.06m and the line survey had a closing error of only 0.004m. However, the largest error for the determination of drop lies not with the line survey. The height of the bwlch may well change by a few centimetres depending on the level of rainfall in the weeks prior to the measurement. Since on our visit the bwlch was water-logged, we conclude that our measurement is a minimum value for drop. The area of the bwlch is also very flat so we are only able to give the grid reference for its position to eight figures.

The summit of Waun Garnedd-y-Filiast was at the position of the cairn, although ground in the immediate vicinity was also very close in height. We would estimate the height uncertainty associated with its correct location to be $\pm 0.03\text{m}$. The height uncertainty associated with a 1hr dataset has been measured by us and is $\pm 0.06\text{m}$ for data processed in propriety software. The measurement uncertainty for the height of Waun Garnedd-y-Filiast is therefore $(0.03^2 + 0.06^2)^{0.5} = \pm 0.07\text{m}$.

10) Summary of Results

The **drop** for Waun Garnedd-y-Filiast was measured to be **15.06m** thereby confirming its status as a **Nuttall**.

The height of **Waun Garnedd-y-Filiast** is **650.9m \pm 0.07m** and the summit is the cairn at Grid Reference *SH 87401 45244.

The bwlch is at *SH 8731 4512 and its height is **635.8m** determined from the difference between the summit height measurement and the drop measurement.

*grid reference is OSTN15

Appendix 1



View of the bwlch from fence showing grid of flags



Survey of the bwlch showing part of the array of flags



Photograph showing the terrain at the bwlch



Tape reading for the Leica Viva GS15 on the summit

Appendix 2

Title:- Waun Garnedd-y-Filiast

Instrument:- Leica NA730

Date:- 28-Aug-18

Point Number	Horizontal Line			Lower Stadia Line			Upper Stadia Line			Mean BS	Mean FS	Height Difference	BS Distance	FS Distance
	Backsight R	Foresight F	Height H	Backsight R	Foresight F	Height H	Backsight R	Foresight F	Height H					
	metres	metres	metres	metres	metres	metres	metres	metres	metres	metres	metres	metres	metres	metres
Bwlch to Summit (JB Level and GVJ Staff)														
1	4.281	0.361		4.049	0.312		4.511	0.410		4.280	0.361		46.200	9.800
2	3.654	0.223		3.454	0.171		3.853	0.274		3.654	0.223		39.900	10.300
3	4.055	0.194		3.912	0.156		4.199	0.231		4.055	0.194		28.700	7.500
4	4.463	0.613		4.231	0.535		4.695	0.691		4.463	0.613		46.400	15.600
									Sum =	16.452	1.390	15.062	161.200	43.200
Summit to Bwlch (GVJ Level and JB Staff)														
1	0.613	3.621		0.535	3.425		0.691	3.819		0.613	3.622		15.600	39.400
2	0.183	4.700		0.155	4.528		0.215	4.876		0.184	4.701		6.000	34.800
3	0.242	3.489		0.200	3.289		0.283	3.690		0.242	3.489		8.300	40.100
4	0.393	4.677		0.369	4.452		0.417	4.904		0.393	4.678		4.800	45.200
									Sum =	1.432	16.490	-15.058	34.700	159.500