Survey of Drysgol

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1) Introduction

Drysgol (Hill Number 14869, Section 31B, OS 1:50000 Map 136, 147 OS 1:25000 Map 214W, Grid Ref. SN946744) 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 1:10000 & 1:25000 scale maps have a spot height of 484m for the summit and no spot height at the bwlch, although there is a spot height of 457m for a position that is clearly a few hundred metres east of the bwlch area. The 1:50000 map also has a height of 484m for the summit, but no spot height for the bwlch. A LIDAR study of the summit area yielded a summit height of 483.9m, but as the DTM and DSM values were the same it was concluded that the algorithm for removing vegetation had probably failed to do so. It was therefore suspected that the summit height was slightly less than 483.9m. It is clear from the map that the bwlch area is extensive and it is also reported to be very wet and covered in tussock grass and thick heather. Best estimates from the 1:10000 and 1:25000 maps suggest a bwlch height of 453m which give a value for drop of about 31m, hence its classification as a Tump by the Database of British and Irish Hills. A previous survey by Myrddyn Phillips reported a bwlch height of 454.3m and a summit height of 483.6m, yielding a value of 29.2m for the drop, and therefore indicating that the hill should be removed from the list of Tumps. The purpose of this survey was to remeasure the drop for Drysgol, paying particular attention to the determination of bwlch position and height.

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.

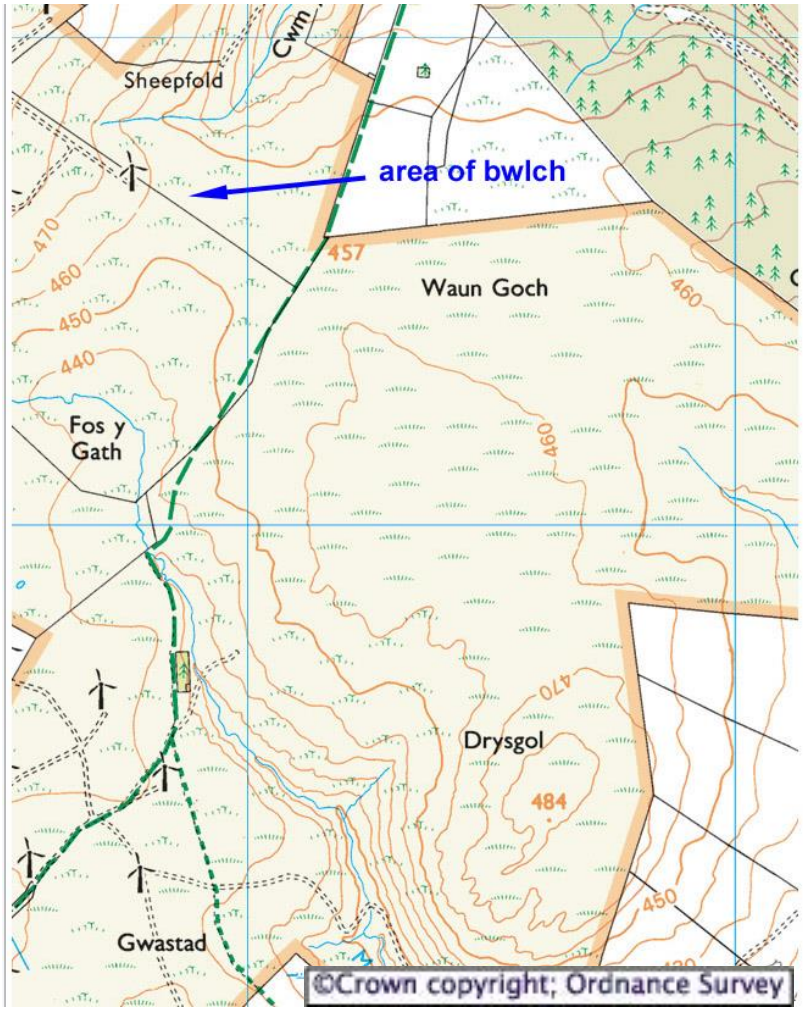
Note that small hand-held GPS receivers used for general navigation can only receive up to 12 GPS satellites and each at a single frequency and therefore these instruments have a poorer positional accuracy of +/-5metres and a height accuracy of no better than +/-10 metres. Some recently produced hand 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 11.00hr and 15.30hr GMT, were fair. The weather was cool, 5 degrees Celsius, with a wind speed of 15mph gusting to 35mph. There were occasional heavy showers although these were of relatively short duration and did not interfere with the survey.

3) The Survey

3.1) Character of Hill

Drysgol is situated just to the east of the A470 between Llangurig and Rhayader. To its north and west lies the Bryn Titli windfarm which is serviced by an access road from the A470. The hill is covered in thick heather up to 1m high in places, including the summit, while the bwlch is additionally adorned with tussock grass, as described above. Access to the hill may be achieved either from the road to the windfarm or from the minor road to the east, and the map shows a bridleway that joins these two possible starting points. Regrettably, the bridleway shown on the map is barely visible on the ground and therefore does not offer the easy access to the bwlch which the map promises.



Thick heather and tussock grass are also features of the ground between the bwlch and the summit, although a path not marked on the map does exist for part of the way. We started from the A470 where, by the entrance to the windfarm road, there is limited parking on the grass verge for a couple of cars. A sign advises that parking is not permitted at the entrance itself although it is extensive and of tarmac. A climb of about 200m over 1km of distance brings the walker to a plateau and the

first of the wind turbines. From a cross-roads the route continues on a wide track in a north-east direction to a copse of trees and a building by a stream. Once across the bridge over the stream, a faint path then leads north towards the bwlch, but soon disappears in the heather and tussock grass. From this point it is a further 500m to the area of the bwlch. A map of the hill is shown above, courtesy of Ordnance Survey.

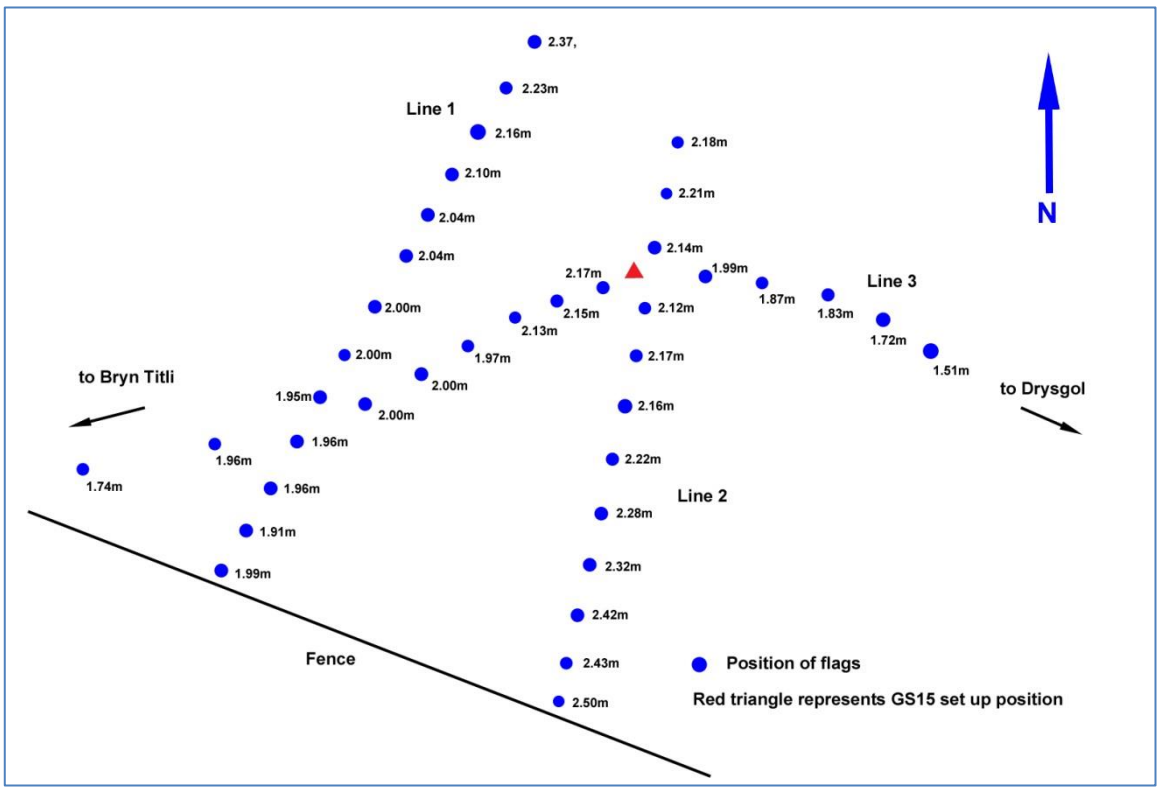
3.2) Summary of Survey Method

It was recognised prior to starting the survey that the critical measurement was likely to be that of the bwlch. Consequently, it was decided to visit the bwlch first and devote effort to locating its position accurately and then only once a height measurement had been taken there would we turn our attention to the summit.

3.3) The Bwlch

Upon arrival at the bwlch it was quickly realised that a significant amount of time might be required to determine its exact position. As suggested from a study of the map, it is extensive and not well defined in either the hill to hill or valley to valley direction. In addition the lush covering of vegetation also hides the profile of the bwlch. It was soon recognised that laying out a grid of flags over such a large area would be inappropriate and therefore another strategy was adopted. A reconnoitre located the approximate line of the valley to valley direction and consequently we were able to lay a line of flags 5m apart along this line (Line 1 in the diagram below). The Leica NA730 level was then set up at a convenient position and staff readings were then taken on each flag. From these readings it was quickly established how flat much of the area was, although this work did show where the land was beginning to fall to the north east. For about 50m the staff readings varied

Layout of Flags at Bwlch



by only 10cm and this was due mainly to the unevenness of the terrain. To the south west, just beyond a fence, the land clearly fell quite quickly to the stream that was crossed on our outward journey. Having established the flatness of the col we next lay a second line of flags (Line 2). This line was not parallel to the first but ran from an obviously lower position about 30m away from it

and by the fence to a higher point about 15m from the far end of the first line (as shown in the diagram). From the two sets of readings the line of the hill to hill direction of the bwlch could be determined. From the second line of flags it was clear that this began to turn towards the summit of Drysgol and from the first line it was clear that the line began to turn towards Bryn Titli. A third line of flags was then laid out to confirm the visual observation and enable a more precise position for the bwlch to be located. We estimate that the position of the bwlch was located to within 10m and, taking the unevenness of the terrain into consideration to within 10cm of height. This estimate excludes the measurement uncertainty associated with the GNSS measurement.

Next the tripod was set-up over the bwlch 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 0.671m (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 ten nearest base stations and the Hopfield Tropospheric Model. The results are given in the table below:-

System	Easting	error(1SD)	Northing	error(1SD)	Height(m)	error(1SD)
GS15	293909.326	0.002	275668.051	0.002	454.154	0.006

The height of the bwlch is 454.15m

The ten figure grid reference recorded for the bwlch is SN 93909 75668 (OSTN15).

3.4) <u>The Summit</u>

Following the conclusion of the survey at the bwlch we next moved to the summit. The Leica NA730 was set up on its tripod at a convenient position and readings were taken of other possible summit candidates. It was quickly established that the summit position described by previous visitors was correct (SN 94631 74413 Garmin readings). There were also three knolls in the summit area and these were shown to be lower as was ground to the NE which fell gently away.

Staff readings and grid references of these features are given below:

Staff reading for summit (no feature) = 0.95m

Staff reading for knoll 1 = 1.95m (SN 94566 74440 Garmin reading)

Staff reading for knoll 2 = 2.85m (SN 94554 74390 Garmin reading)

Staff reading for knoll 3 (with post) = 3.05m (SN 94565 74319 Garmin Reading)

Knoll 1 is 1.00m lower than summit

Knoll 2 is 1.9m lower than summit

Knoll 3 is 2.1m lower than summit

Next 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 0.624m (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 ten nearest base stations. The results are given in the table below:-

System	Easting	error(1SD)	Northing	error(1SD)	Height(m)	error(1SD)
GS15	294626.860	0.003	274408.464	0.001	483.714	0.008

The height of the summit = 483.71m

The drop as determined by the summit and bwlch heights is 483.714 – 454.154 = 29.560m

4) Summary of Operating Conditions

	GS15
Data Collection summit (min)	61
Data collection bwlch (min)	61
Number of Base Stations used in Processing for all points	10
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 approximately100km 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 $\mathbf{D_{ij}}$ 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 and bwlch are presented below.

			Summit	Summit	Bwlch	Bwlch
Base Station	Code	Distance to Survey Point km.	Height Difference **U** metres	Separation $\mathbf{D_{ij}}$ metres	Height Difference **U** metres	Separation $\mathbf{D_{ij}}$ metres
Machynlleth	MACY	31				
Brecon	BREC	48	-0.0346	0.0362	-0.0117	0.0154
Shobdon	SHOD	49	0.0052	0.0067	0.0049	0.0085
Shrewsbury	SHRE	70	0.0197	0.0269	0.0111	0.0187
Aberporth	ABEP	73	-0.0225	0.0247	-0.0229	0.0234
Aberdaron	ADAR	92	-0.0048	0.0066	0.0009	0.0092
Swansea	SWAS	93	0.0401	0.0425	-0.0349	0.0355
Droitwich	DROW	95	0.0171	0.0189	0.0108	0.0138
Cardiff	CARI	98	-0.0463	0.0483	-0.0185	0.0203
St Asaph	ASAP	99	0.0294	0.0304	-0.0080	0.0178

The results for Drysgol summit and bwlch show a consistent dataset as all measured OS Base stations are within 0.05m distance and height of the OS actual values for Base Stations up to 100km distance.

6) Discussion of Results

For the Leica Viva GS15, a one hour data collection time gives results with a measurement uncertainty of ±0.06m. This measurement uncertainty applies to both the bwlch and summit measurement. The summit position was found to within ±0.05m of height. In addition the measurement uncertainty in height associated with the location of the bwlch is ±0.1m as determined by the staff measurements. Therefore the overall measurement uncertainty for the determination of drop from the Leica Viva GS15 is ±0.14m [square root (0.06^2 +0.05^2 + 0.06^2 +0.1^2)]. The drop is therefore 483.716 – 454.159 = 29.56±0.14m as determined by the Leica Viva GS15.

7) Summary and Conclusions

The **summit** of **Drysgol** is at grid reference * SN 94626 74408 and is unfeatured ground. Its height is **483.7m±0.08m**.

The **bwlch** of **Drysgol** is at * SN 93909 75668 and is unfeatured ground. Its height is **454.2±0.12m.**

The **drop** for **Drysgol** is **29.6±0.14m** and consequently **Drysgol** does not qualify for the list of Tumps.

* NB: Grid references are OSTN15.

John Barnard & Graham Jackson, 3 December 2018

Appendix 1

The Leica Viva GS15 set up on the bwlch of Drysgol

Tape reading for Leica Viva GS15 set up on bwlch

Leica Viva GS15 set up on summit of Drysgol

Tape reading for Leica Viva GS15 set up on summit