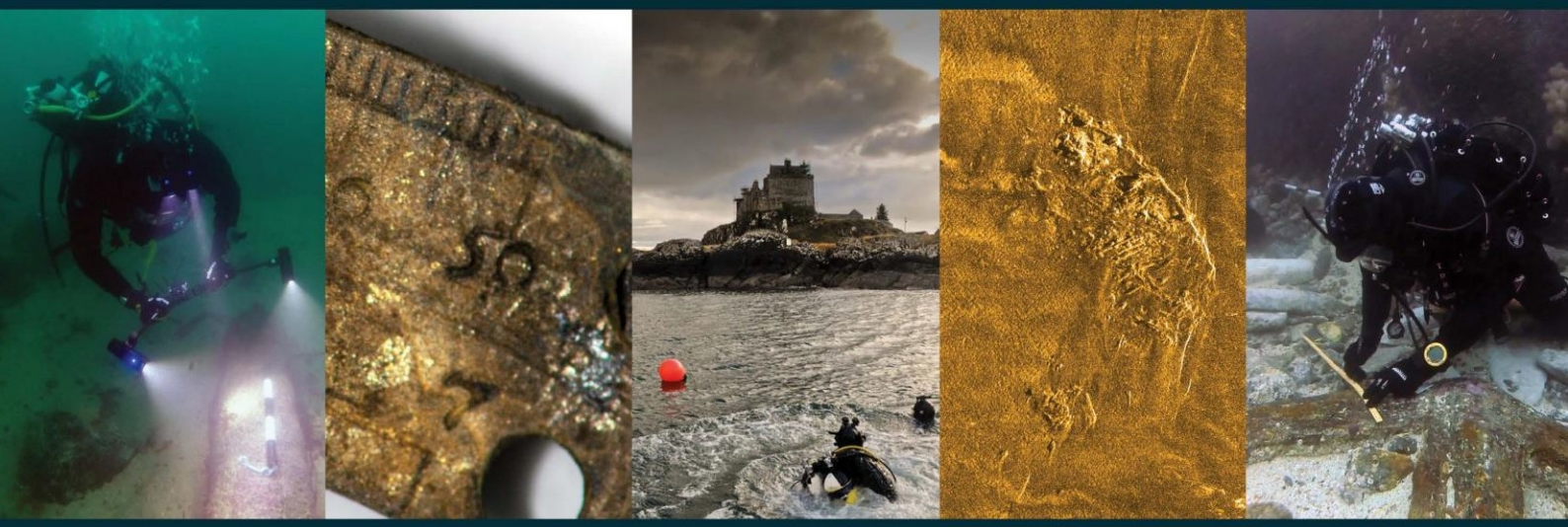
Cotswold Archaeology marine

Visual Impact Provision (VIP), Snowdonia Project

Archaeological review of marine geophysical survey data



for

Intertek

on behalf of
National Grid

CA Project: 770405

CA Report: 16542

Andover Cirencester Exeter Milton Keynes

Visual Impact Provision (VIP), Snowdonia Project

Archaeological review of marine geophysical survey data

CA project: 770405
CA report: 16542

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SUMMARY

Project name: Visual Impact Provision (VIP), Snowdonia Project
Location: Gwynedd
National Grid reference: 261019 337855

Cotswold Archaeology (CA) was commissioned in by Intertek on behalf of National Grid to undertake archaeological assessments of:

- marine geophysical survey data collected by Bibby Hydromap between 22 and 28 June 2017, and
- adjacent terrestrial geophysical survey data collected by RSK between 3 and 12 July 2017.

These assessments were undertaken in collaboration with Coastal and Offshore Archaeological Research Services (COARS), University of Southampton.

The surveys were conducted in a 200m wide survey area centred on the preferred tunnel alignment for cable undergrounding works associated with the Visual Impact Provision (VIP), Snowdonia Project. The surveys were undertaken in advance of boreholes and cone penetration tests (CPT) within the estuary in order to inform the marine licence to undertake these ground investigations.

The archaeological review of the geophysical survey data included the examination of sub-bottom and magnetometer data to identify, locate and characterise features with possible archaeological potential that could be impacted by borehole activities, and to establish the archaeological and palaeo-environmental potential of the sub-surface sediments that may be encountered.

Despite considerable efforts by the survey companies, the project-specific geophysical surveys conducted in the Dwyryd estuary achieved limited coverage of the ground investigation locations owing to the extremely challenging environment, including shallow water depths and shoaling conditions. Two borehole and three CPT locations have no survey data available to help identify

whether any potential archaeological (or UXO) material is present on or below the seabed at the proposed locations.

No archaeological exclusion zones (AEZs) are recommended in relation to the ground investigation locations, although it has not been possible to undertake an archaeological assessment of locations BH116, BH118 and CPT101, CPT102 or CPT103.

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1. INTRODUCTION

Outline

1.1. The Visual Impact Provision (VIP) Project represents a major opportunity to conserve and enhance the natural beauty, wildlife and environmental heritage within protected landscapes. The project will make use of a £500m allocation by Ofgem to carry out work to help reduce the impact of existing transmission lines in English and Welsh Areas of Outstanding Natural Beauty (AONBs) and National Parks.

1.2. The VIP, Snowdonia Project in the Snowdonia National Park aims to reduce the visual impact of National Grid's 4ZC overhead line (OHL) across the Dwyryd estuary near Penrhyndeudraeth, Gwynedd by relocating a section of the OHL below ground.

1.3. Marine geophysical investigations have been undertaken to inform the marine licensing authorities in advance of ground investigations. These investigations, including boreholes and cone penetration tests (CPT) within the estuary, will inform the engineering design for a tunnel to carry the underground cables. The survey area for the VIP Project is 0.2km wide and 1.3km in length.

1.4. Cotswold Archaeology was appointed to undertake the marine archaeological desk-based assessment of the VIP survey area, and commissioned Coastal and Offshore Archaeological Research Services (COARS), University of Southampton to assess the marine geophysical data collected by Bibby HydroMap Limited (June 2017) below mean high water springs (MHWS), and by RSK (July 2017) above MHWS along the western and eastern margins, as part of the tunnel alignment survey and UXO risk assessment. The purpose of this desk-based review of the geophysical data are two-fold:

- the examination of sub-bottom and magnetometer data, within the areas proposed for geotechnical investigation, to identify, locate and characterise features with possible archaeological potential that could be impacted by borehole activities; and

- the assessment of sub-bottom profiler data in order to establish the archaeological and palaeo-environmental potential of the sub-surface sediments that may be encountered.

1.5. There are four borehole and ten CPT locations planned for geotechnical investigation within the intertidal and sub-tidal areas of the Dwyryd estuary. Locations are provided in Table 1 and shown in Figure 1.

Ground investigation location	Easting	Northing
BH115	260921.89	338150.35
BH116	261210.25	338090.93
BH117	261354.44	337944.58
BH118	261642.03	337924.26
CPT101	260716.12	338194.31
CPT102	260803.12	338186.6
CPT103	260876.23	338178.34
CPT104	261067.81	338054.22
CPT105	261192.61	338048.81
CPT106	261276.31	338008.33
CPT107	261325.31	337934.95
CPT108	261413.62	337903.11
CPT109	261527.11	337845.31
CPT110	261621.76	337819.66

Table 1: Proposed ground investigation locations within Dwyryd estuary

2. SURVEY AREA BACKGROUND

Geology

2.1. The solid geology underlying the survey area is the Ffestiniog Flags formation, which consists of mudstones, siltstones and sandstones, although the northern edge of the survey area just edges into the Dolgellau formation of mudstones and siltstones. These are overlain by the modern estuarine tidal flat sediments. In the absence of deep coring through the estuary, however, the actual superficial sedimentary sequence is poorly understood.

2.2. While there have been no investigations of the stratigraphy of the Dwyryd estuary sedimentary sequence, its geomorphology has been subject to in-depth study. Studying the estuary's sedimentary processes, Mahamod (1989) demonstrated that sedimentation is predominantly controlled by fast tidal currents and, in the bay, by weak tidal currents. The spatial distribution of textural parameters of the estuarine sediments related to the strength of tidal currents as well as the morphology and bathymetry of the inlet. The estuarine sediments, predominantly sand, are very similar in texture and mineralogy to the adjacent beach sediments, but markedly different to the river sediments It is suggested, therefore, that large amounts of sand have been transported from coastal areas into the estuary.

3. GEOPHYSICAL SURVEY SPECIFICATION AND DATA ACQUISITION

3.1. Following consultation with the Royal Commission on the Ancient and Historical Monuments of Wales (RCAHMW) and the Gwynedd Archaeological Planning Service (GAPS), it was agreed that only sub-bottom seismic and magnetometer surveys were required for an archaeological assessment of marine geophysical survey data prior to ground investigations across the estuary.

Marine geophysical survey

3.2. The marine geophysical survey, up to MHWS, was undertaken by Bibby Hydromap between 22 and 28 June 2017 using a shallow draft vessel (MV Blue Rib). The objectives of this survey were to acquire:

- magnetometer data to be used in the detection of possible unexploded ordnance (UXO) targets;
- sub-bottom profile (SBP) boomer data to be used to define shallow soil profiles; and
- single-beam echo sounder (SBES) bathymetric data to align the sub-bottom profiler data to lowest astronomical tide (LAT).

3.3. The survey area is a section of the Dwyryd estuary below the Pont Briwet road bridge. The survey area was defined as approximately 1.3km x 0.2km. Water depths in the survey area were all above LAT so only high-water work was

possible. Survey operations were undertaken on the spring tides, when the tidal range was between 0m and 5.37m.

3.4. Bathymetry was acquired using a Midas Surveyor SBES. The magnetometer survey was undertaken using a Geometrics G882 caesium vapour magnetometer towed *c.* 10m behind the vessel. SBP was undertaken through a C-Boom low voltage boomer system, comprising a C-Boom towed boomer plate, a low weight catamaran, a C-Boom portable seismic energy source and an Applied Acoustics AH360 8-element. Positioning was acquired using a C-Nav 3050 GNSS system using the C-Nav2 correction service. USBL positioning was not possible on the towed survey equipment, so the course of the sensor over the ground was calculated using vessel heading, mechanical angle and cable length.

3.5. Data coverage for the SBES and the magnetometer was limited by shoal conditions on both sides of the survey area resulting in coverage of an area of approximately 0.6 x 0.2km. Consequently the survey achieved good data coverage for the channel area but the combination of sand bars and shallow water (even at high spring tide) prevented the achievement of full coverage up to the MHWS. Necessary avoidance of shallow sandbars resulted in gaps of up to 45m between survey lines. SBP data were acquired over four lines across the survey area with one additional line run to test the equipment from the slipway in Minfford to the survey area.

Terrestrial geophysical survey

3.6. The terrestrial geophysical survey, above MHWS, was undertaken by RSK between 3 and 12 July 2017 on both the eastern and western margins of the survey area. These surveys included some marsh and terrestrial areas, either side of the survey area, to investigate the possible presence of UXO.

3.7. The terrestrial surveys consisted of a gradiometry and total field magnetic survey. Two sets of Geometrics G858 caesium vapour magnetometers were used to collect the data, arranged in a vertical gradiometry configuration, with position determined by a differential geographical positioning system (dGPS) mounted on a backpack worn by the surveyor. An additional stationary G880 caesium vapour magnetometer was used as a base station to record daily variations in the Earth's magnetic field. Some areas could not be accessed owing to deep water channels. Processed magnetic data (gradient and total fields) and survey coverage were provided along with locations of interpreted UXO anomalies.

Geodetic and projection parameters and vertical datum

3.8. Survey positions were recorded in the geodetic datum OSGB36. Vertical data were processed to LAT, reduced using the UK Hydrographic Office (UKHO) vertical offshore reference frame (VORF) model.

4. METHODOLOGY

4.1. Geophysical assessment was undertaken using the Coda Octopus Survey Engine 4.3 and ArcGIS 10.4.1 programs. SBP data were analysed using the former with the positions of sub-surface anomalies exported as shapefiles. These were uploaded into ArcGIS 10.4.1 alongside processed magnetometer data provided by the survey companies, following professional guidelines (Plets *et al*. 2013). The Natural Resources Wales composite digital elevation dataset, derived from multiple LiDAR surveys resampled at 1m resolution, was used as an elevation model for the survey area. As this is a composite dataset, however, it is not used to infer the presence / absence of any possible archaeological material visible on the surface unless corroborated by the newly acquired geophysical datasets.

4.2. Due to the difficult site-surveying conditions, notably the shallow water depths, the main geophysical survey technique used both above and below MHWS was magnetometry. The identification of features with archaeological potential are therefore predominantly based upon this dataset (supplemented wherever possible with LiDAR and sub-bottom seismic survey). Consequently, in the absence of other supporting information, archaeological potential is closely aligned with the anomalies identified in the UXO survey results.

4.3. Although the whole survey area has been assessed, there has been a focus on a circular buffer zone of 25m radius centred on each proposed ground investigation location to assess archaeology and archaeological potential. The 25m radius buffer is intended to accommodate the positioning and anchoring of the vessel / platform that will be used for the on-site ground investigations.

5. RESULTS

Sub-bottom stratigraphy

5.1. The boomer survey was conducted along four survey lines (2017-021_006 to 009), between 115m and 528m in length, in the centre of the survey area. A fifth line (2017-021_010), extending 1.5km southwest towards Minfford, run to test the

equipment, was predominantly outside the survey area. The data from within the survey area shows evidence of acoustic blanking in several areas, which the surveyors attributed to the sea state during surveying.

5.2. A discontinuous reflector is visible just below the seabed in some locations, thought to represent the base of the near-surface estuarine sediments (i.e. modern sediments). This could represent cut and fill features associated with the extensive movement of the sand banks in this area. At greater depth there is a second discontinuous horizon, at c. 18-22m below the seabed, which may represent a bedrock surface. This horizon shows some shallow dipping structures which helps to distinguish it from a strong seabed multiple reflection that is also found in some lines around c. 15-20m. In several instances this multiple reflection inhibits the identification of any sub-surface horizons which may be present. In some lines the multiple reflection is likely to have obscured the visibility of any deeper seismo-stratigraphic features. The structure of the sediments overlying the deeper horizon is poorly resolved within the available data. In the near-surface deposits there were no visible geophysical features, such as refraction hyperboles, which might indicate the presence of buried archaeological material along the survey lines.

5.3. The presence of acoustic blanking within the seismic profiles, coupled with discontinuous reflectors and a lack of clearly defined structures between the seabed and potential bedrock surface at c. 18-22m, has prevented the identification of palaeo-landscape features (e.g. palaeo-channels) in the available seismic datasets. The geotechnical ground investigations will provide the necessary data to establish whether a bedrock surface is present at the suggested depth and the nature of the sediments that overly it, including any with archaeological potential (e.g. peats or submerged channels).

5.4. Four proposed geotechnical survey locations (BH117, CPT105, CPT106 and CPT107) are within 12m of a SBP survey line, while four (BH115, BH118, CPT101-103 and CPT110) are located more than 100m from the nearest survey line. In the latter locations, there can be no estimation of the thickness of deposits overlying solid geology.

Magnetometer survey

5.5. The marine magnetometer survey resulted in the identification of twelve anomalies, while the terrestrial survey identified 22 anomalies (see Appendix 1). In addition to the 25 terrestrial anomalies, the terrestrial survey also identified two linear magnetic features that could indicate possible buried linear obstructions. Anomaly L2_01 is located on the northern edge of the channel. Although there are no visible anomalies within the available LiDAR data, it is possible that this might represent some debris washed up onto the marsh bank from the channel. The dimensions, 5 x 15m, could suggest a possible buried feature such as a wooden hulk. None of these potential buried magnetic anomalies are situated close to the proposed ground investigation locations.

5.6. A summary of the four borehole and ten CPT locations alongside the available data are provided in Table 2. For each location the magnetic data coverage, including survey lines, was assessed against the proposed ground investigation locations to assess:

- whether any data were available;
- if available, what data coverage there was; and
- if any magnetic anomalies were present (Fig. 3).

5.7. An area of 25m radius around each ground investigation location was assessed for the presence of possible archaeological material (Figs 1 & 3). As limited information, regarding the proposed method for acquiring the CPTs and boreholes including the navigational and positional accuracy of any platform used, was available, this is a conservative value.

5.8. Locations CPT101 and CPT102 have no survey coverage and are more than 20m from the nearest magnetic survey lines. It is therefore not possible to make any assessment of the archaeological potential associated with these proposed locations. Please note that anomaly S2_13 rests right on the perimeter of the 25m buffer zone of CPT101; it is at a depth of 0.9m with a magnitude of 47 nano-Tesla (nT) and is identified as potential UXO. In the absence of any other corroborative data we must interpret any potential UXO location also as a potential archaeological target. This location should therefore be avoided.

GI location	Easting	Northing	Survey coverage of location	Magnetic anomalies within 25m of location
BH115	260921.89	338150.35	*c.* 80% within terrestrial survey area	No magnetic anomalies within adjacent survey area
BH116	261210.25	338090.93	Located >20m from nearest marine survey line. No coverage at actual location	Magnetic survey line 25m north has area of enhanced magnetics including anomaly S1_9 (-7.08nT).
BH117	261354.44	337944.58	Located at intersection between three survey lines. 95% buffer zone coverage	No magnetic anomalies within buffer zone and adjacent survey area
BH118	261642.03	337924.26	10m west of terrestrial survey area c. 30% coverage	No magnetic anomalies within adjacent surveyed area
CPT101	260716.12	338194.31	25m beyond survey coverage	Anomaly S2_13 on buffer boundary.
CPT102	260803.12	338186.6	26m beyond survey coverage	N/A (no data available)
CPT103	260876.23	338178.34	< 7m west, south and north of terrestrial survey area	No magnetic anomalies within adjacent surveyed area
CPT104	261067.81	338054.22	Located upon marine survey line. Buffer zone does not have full coverage	No magnetic anomalies within buffer zone or adjacent survey area
CPT105	261192.61	338048.81	Adjacent to marine survey line and full coverage.	No magnetic anomalies within buffer zone
CPT106	261276.31	338008.33	Located 10m north of nearest survey line. 90% buffer zone coverage	Pair of magnetic anomalies on line 21m NNE (S1_6; -2.63nT) and 29m NE (S1_7; 4.65nT) of location
CPT107	261325.31	337934.95	10m south of nearest survey line. 70% buffer zone coverage.	No magnetic anomalies within imaged buffer zone and adjacent survey area
CPT108	261413.62	337903.11	Located upon marine survey line. 70% buffer zone coverage	No magnetic anomalies within imaged buffer zone and adjacent survey area
CPT109	261527.11	337845.31	Located 12m from nearest survey line. 100% buffer zone coverage.	No magnetic anomalies within buffer zone and adjacent survey area
CPT110	261621.76	337819.66	65% of buffer zone within terrestrial survey area.	No magnetic anomalies in imaged buffer zone and within adjacent terrestrial survey area.

Table 2 Assessment of geophysical survey data within Dwyryd estuary

5.9. CPT103 and BH116 lie within 4.5m of the nearest magnetic data. For CPT103 there are data for all quadrants bar the north-west. No anomalies have been identified in the other three quadrants; the nearest identified anomaly is 67m from the proposed CPT location. Data exists for BH116 to both the north (c. 4.5m) and south (12.8m) of the anomaly and within the buffer zone. The expression of anomaly S1_9 (-7.08 nT) lies within the buffer zone but with the target centred 3m outside of this zone. This is identified as a potential UXO and therefore a potential archaeological target and should be avoided. No assessment could be made of the actual location, however, owing to the absence of any magnetic data in a strip 18m wide oriented WNW-ESE over BH116.

5.10. As the proposed location of BH118 is 10m west of the limits of the terrestrial survey area and 40m east of the limits of the marine survey we are unable to make an assessment of the archaeological potential of the location. It is worth noting, however, that the nearest magnetic anomaly is 103m due east of the borehole location (potential UXO target S2_2); the whole inter-tidal zone surveyed in this area has no identifiable UXO anomalies or potential buried objects within it.

5.11. CPT106, CPT107 and CPT109 are located c.10-12m from the nearest survey line, but are within the area of interpolated magnetic residuals. While CPT107 and CPT109 have no magnetic anomalies within the buffer zone where data coverage exists (note CPT107 has no data in the southern half of the buffer zone), CPT106 is located 21m SSW and 29m southwest of two small magnetic anomalies (S1_7 and S1_6 respectively).

5.12. BH115, BH117, CPT104, CPT105, CPT108 and CPT110 are all close (<2-3m) to marine survey lines or are within the terrestrial geophysical survey area and do not show any magnetic anomalies at the proposed ground investigation locations. Only CPT105, however, has full coverage for the 25m radius buffer zone, so it is not possible to confirm the absence of potential targets in the other buffer zones.

6. OVERVIEW

6.1. The project-specific geophysical surveys conducted in the Dwyryd estuary have achieved limited coverage of the current proposed ground investigation locations

(CPT105 and CPT109). BH116, BH118 CPT101, CPT102 and CPT103 have no survey data over their proposed locations to help identify whether any potential archaeological (or UXO) material is present on or below the seabed at the proposed locations. It is therefore not possible to make definitive statements about these locations.

6.2. BH118 and CPT103 both lie outside but immediately adjacent to areas where geophysical surveys have been conducted. While it is not possible to make an assessment of the actual proposed ground investigation locations, the geophysical survey to the east of each location did not contain any magnetic anomalies. Although BH116 was not directly covered an anomaly, S1_9 (-7.08 nT), lies 28m to the NNE. In the absence of actual data covering these locations, the absence of adjacent anomalies cannot be taken as being representative of the proposed ground investigation locations. All other proposed borehole/CPT locations have some magnetometer data coverage and, with the exception of CPT106 where two small anomalies were detected 20-29m north of the proposed location, there are no magnetic anomalies within 25m of the proposed ground investigation locations that might indicate that ferrous material with archaeological potential is present.

6.3. No AEZs are recommended in relation to the current proposed ground investigation locations, although as stated it has not been possible to undertake an archaeological assessment of locations BH116, BH118 and CPT101, CPT102 or CPT103.

7. REFERENCES

Mahamod, Y., 1989. *Sedimentary Processes of the Dwyryd estuary*. Unpublished PhD Thesis, University College of Wales.

Plets, R., Dix, J. and Bates, R., 2013. *Marine Geophysics Data Acquisition, Processing and Interpretation: Guidance Notes*. Swindon, Historic England

260713

261301

338518

338143

337769

CPT101

CPT102

CPT103

BH115

BH116

CPT104

CPT105

CPT106

BH117

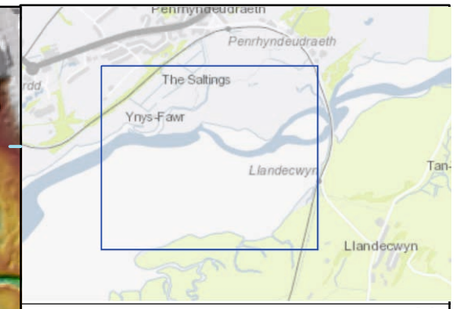
CPT107

CPT108

BH118

CPT109

CPT110



N

Legend

- Borehole
- CPT
- 25m Buffer
- Route Corridor

LiDAR (m ODN)

6

0

0 150 m

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PROJECT TITLE

National Grid Visual Impact Provision
Snowdonia National Park, 4ZC Line

FIGURE TITLE

Proposed borehole and CPT locations with 25m buffer zone. Locations superimposed on Lidar datasets

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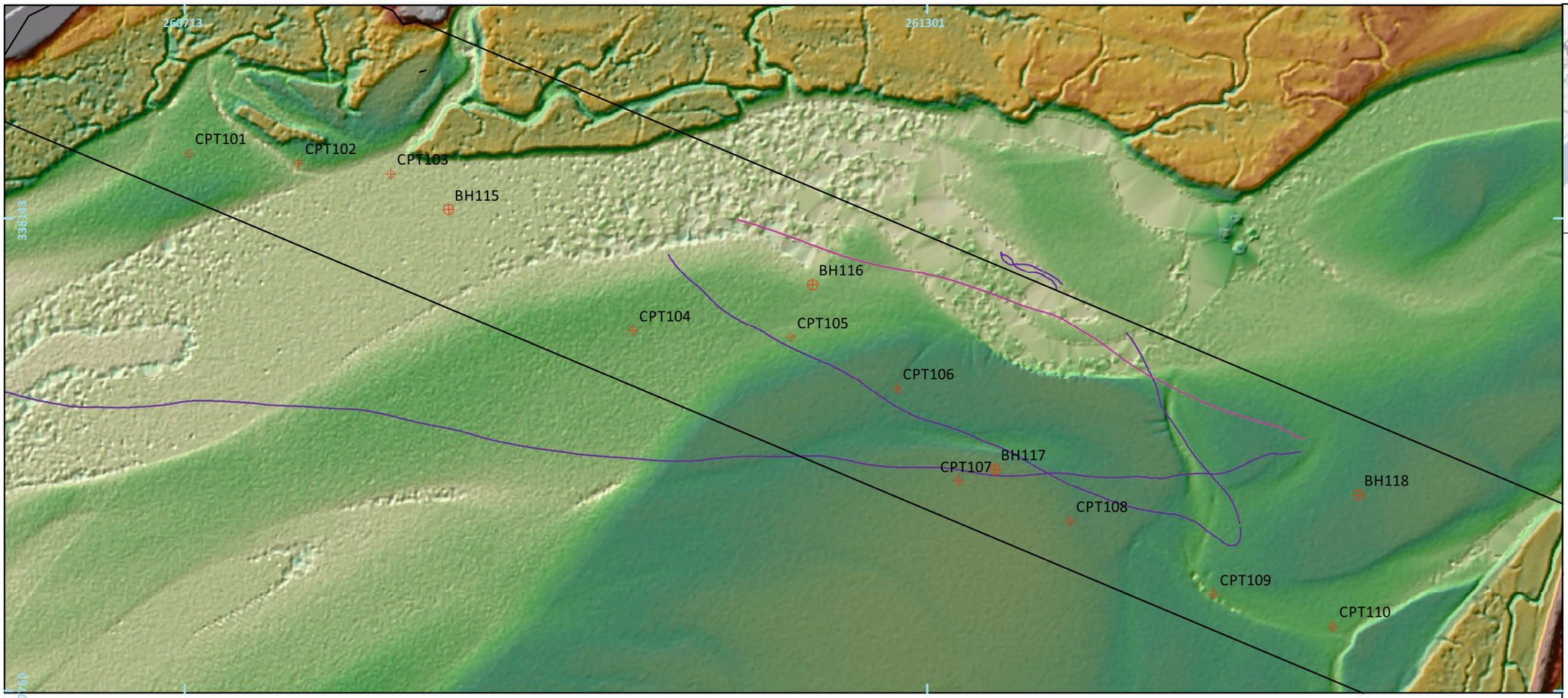
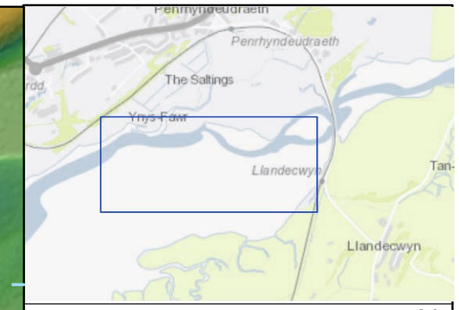




N

Legend

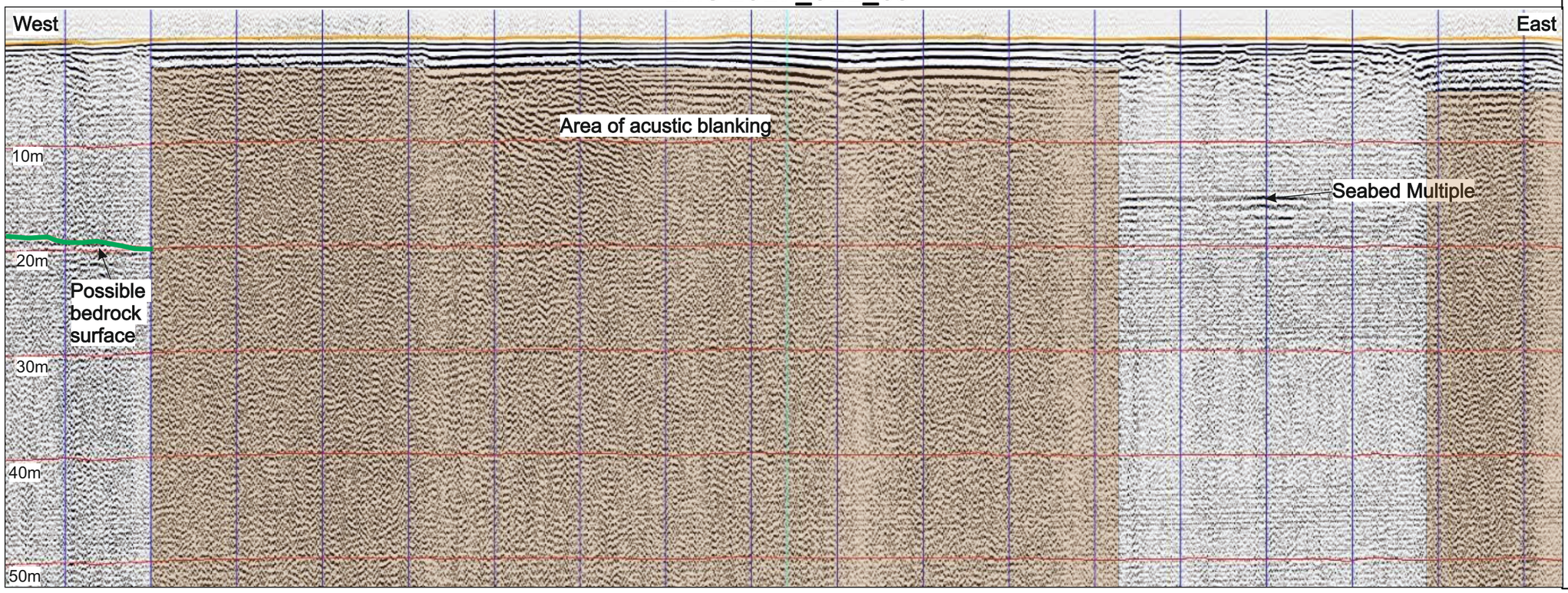
- Borehole
- CPT
- Route Corridor
- Seismic Survey Lines
- Line 2017_021_09

LiDAR (m ODN)

6

0

Line 2017_021_09



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PROJECT TITLE

National Grid Visual Impact Provision
Snowdonia National Park, 4ZC Line

FIGURE TITLE

Marine Seismic Suvey Lines with example of data from line 2017_021_09

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260713
261301
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337769

S2_17
S2_23
S2_16
S2_14
S2_21
S2_22
S2_12
S2_5
S2_7
S2_4
S2_3
S2_19
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CPT106
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CPT107
S1_5
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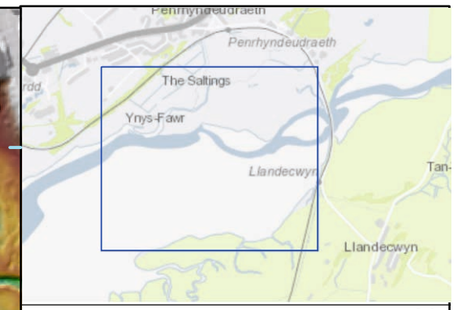
CPT109
CPT110
S2_1



N

Legend

- Borehole
- CPT
- Route Corridor
- Marine Survey Lines
- Terrestrial Survey Lines

Magnetic Anomalies

- 1 to 5nT
- 5 to 10nT
- 10 to 30nT
- >30nT
- Linear Magnetic Anomalies

LiDAR (m ODN)

6

0

0 150 m

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PROJECT TITLE

National Grid Visual Impact Provision
Snowdonia National Park, 4ZC Line

FIGURE TITLE

Survey coverage of terrestrial and marine magnetic survey tracks, with identified magnetic anomalies

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APPENDIX 1: IDENTIFIED MAGNETIC ANOMALIES

Marine geophysical survey				
Target ID	**Easting**	**Northing**	**Wavelength (m)**	**Amplitude (nT)**
S1_1	261588	337833	15.59	-8.81
S1_2	261559	337863	6.48	8.62
S1_3	261524	337933	17.65	-9.19
S1_4	261510	337905	13.48	1.96
S1_5	261419	337931	11.34	-5.27
S1_6	261304	338019	13.99	-2.63
S1_7	261289	338026	8.68	4.65
S1_8	261261	338105	36.19	4.01
S1_9	261226	338114	37.68	-7.08
S1_10	261179	338139	41.36	6.25
S1_11	261105	338117	25.46	3.67
S1_12	261140	338165	43.87	12.63

Terrestrial geophysical survey				
Target ID	**Easting**	**Northing**	**Wavelength (m)**	**Amplitude (nT)**
S2_1	261774	337809	4.5	116
S2_2	261743	337903	3.1	62
S2_3	260940	338265	1.6	50
S2_4	260928	338269	2	23
S2_5	260934	338281	2.3	32
S2_6	260929	338242	2.1	11
S2_7	260901	338260	1.4	125
S2_8	260821	338216	3.1	80
S2_9	260803	338222	2.2	22
S2_10	260778	338240	1.5	16
S2_11	260770	338248	1	21
S2_12	260737	338251	2.5	25
S2_13	260717	338219	1.5	47
S2_14	260687	338261	1.5	9
S2_15	260666	338231	1	11
S2_16	260655	338274	1.7	5
S2_17	260772	338312	1.3	12
S2_18	260908	338249	5	65
S2_19	260814	338258	0.7	>300
S2_20	260784	338263	1	>300
S2_21	260781	338267	0.6	>300
S2_22	260795	338265	1.4	>300
S2_23	260772	338297	1.7	49
S2_24	260889	338223	3.9	>300
S2_25	261715	337870	1.7	6

Target ID	Start Easting / Northing	End Easting / Northing
L2_01	360997 338178	260998 338192
L2_02	261014 338213	261021 339239

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