CHERISH UAV Survey Report No.
CH/BIRKBECK-RCAHMW-AU 41

DINAS DINLLE PREHISTORIC COASTAL HILLFORT, GWYNEDD

CHERISH GEOPHYSICAL SUVREY - GPR TRIAL EVENT REPORT: 23/09/2020

CHERISH
Newid Hinsawdd a Threftadaeth yr Arfordir
Climate Change and Coastal Heritage
Aithrú Aeráide agus Oidhreacht Chaitrína
Birkbeck UNIVERSITY OF LONDON
1872 PRIFYSGOL ABERYSTWYTH UNIVERSITY
CBHC RCAHMW
Comisiwn Brenhinol Henebion Cymru
Royal Commission on the Ancient and Historical Monuments of Wales

CHERISH
Newid Hinsawdd a Threftadaeth yr Arfordir
Climate Change and Coastal Heritage
Athrú Aeráide agus Oidhreacht Chultúrtha

Dinas Dinlle – Geophysical Survey Event Report

County:	Gwynedd
Community:	Llandwrog
NGR:	SH43705635
NPRN:	95309
SM No:	CN048
Surveyed by:	Charlie Bristow (Birkbeck University), Lucy Buck (Birkbeck University), Patrick Robson (Aberystwyth University), Daniel Hunt (RCAHMW)
Date of Survey:	23/09/2020
Report Number:	CH/BIRKBECK-RCAHMW-AU 41
Report Authors:	Charlie Bristow and Louise Barker
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Date of Report:	11/08/2023

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World Wide Web: http://www.rcahmw.gov.uk/ http://www.cherishproject.eu/

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1. SUMMARY

A geophysical ground penetrating radar (GPR) trial survey was carried out at Dinas Dinlle coastal hillfort (NPRN 95309) on 23 September 2020 by CHERISH (Aberystwyth University and RCAHMW) and Birkbeck University, as part of CHERISH investigations of the hillfort and surrounding environment. Three areas were selected for survey, the mound in the northern interior of the hillfort (NPRN 703006), the hillfort's eastern defences and the hillfort's southern defences.

This survey was carried out to test the use of GPR profiles (using Pulse EKKO 200 MHz antennas) across some of the steeper terrain of the hillfort. This system had previously been used by CHERISH (Aberystwyth University: Department of Geography and Earth Sciences) and Birkbeck University (Department of Earth and Planetary Science) to study the geomorphology of the landscape surrounding Dinas Dinlle, particularly towards Morfa Dinlle (Bristow, 2011; Duller, 2011; Bristow et al., in prep).

The GPR survey complements a series of CHERISH funded geophysical surveys at the hillfort (Hopewell, 2018; Barker, 2019; Udyrysz-Kraweć and Wajzer, 2020).

The results show potential for the use of this GPR system across the steeper terrain at the hillfort and consideration should be given in the future to expanding its coverage across other parts of the monument.

2. CHERISH PROJECT BACKGROUND

CHERISH (Climate, Heritage and Environments of Reefs, Islands and Headlands) is a European-funded project led by the Royal Commission on the Ancient and Historical Monuments of Wales, in partnership with the Discovery Programme: Centre for Archaeology and Innovation Ireland, Aberystwyth University: Department of Geography and Earth Sciences and Geological Survey, Ireland.

The project commenced on 1st January 2017 and ran for six and a half years to the end of June 2023; it benefitted from €4.9 million of European Union (EU) funds through the Ireland – Wales Co-operation Programme 2014-2020, Priority Axis 2 – Adaptation of the Irish Sea and Coastal Communities to Climate Change.

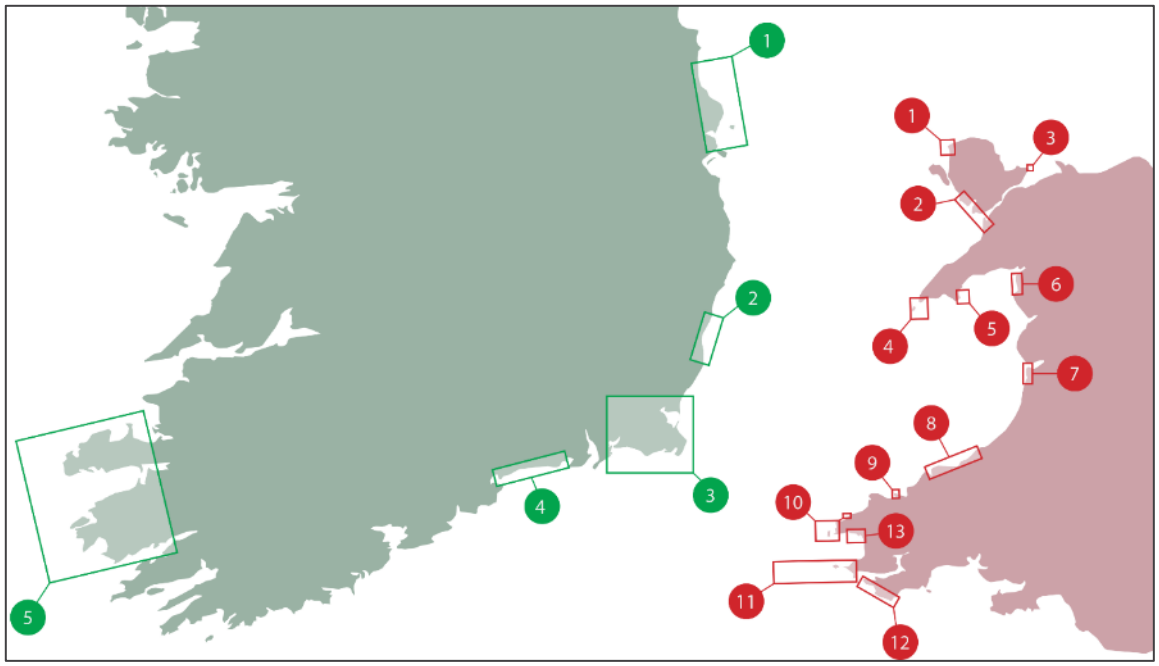

Figure 1: Map of Ireland and Wales showing the 17 principal CHERISH project areas. Dinas Dinlle is in Wales, Area 2 (© Crown: CHERISH Project).

CHERISH was a cross-disciplinary project aimed at raising awareness and understanding of the past, present and near-future impacts of climate change, storminess and extreme weather events on the cultural heritage of reefs, islands and headlands of Wales and Ireland. The project sought to fill gaps in data and knowledge, and develop a greater understanding of climate change impacts on fragile coastal heritage sites.

3. LOCATION AND INTRODUCTION

Dinas Dinlle coastal hillfort (SH 4370 5635) is located immediately south of the small, low-lying coastal hamlet of Dinas Dinlle in the parish of Llandwrog, some 7 kilometres southwest of Caernarfon in Gwynedd. It is positioned overlooking Caernarfon Bay, close to the southern end of the Menai Strait, and is situated at the at the western edge of the reclaimed wetlands of the Caernarfonshire coastal plain with Foryd Bay to the northeast (Figure 2).

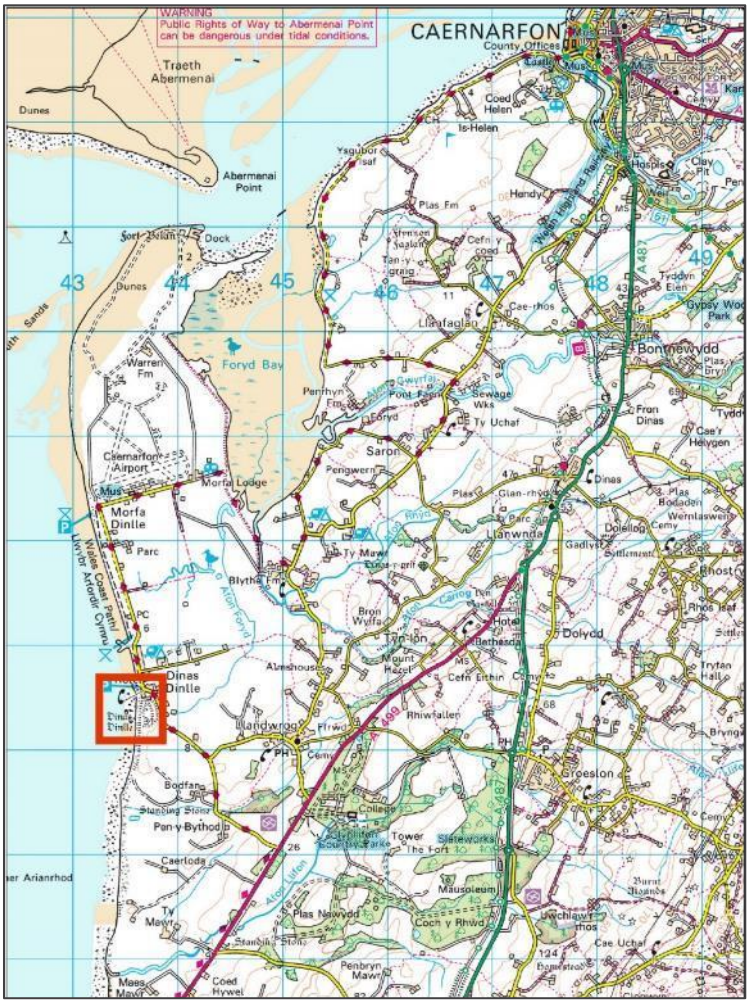

Figure 2: Map showing the location of Dinas Dinlle hillfort within the red box (This map is based upon Ordnance Survey material with the permission of Ordnance Survey on behalf of the Controller of His Majesty's Stationery Office © Crown copyright, 2023. Licence number: 100022206. Map created using ArcPro).

The hillfort is a substantial earthwork monument (SM: CN048; SSI ID: 616; NPRN: 95309; PRN: 1570) enclosing the summit of a glacial deposit and encompassing an area some 32,000m² (3.2 hectares) in extent. It would originally have enclosed some 4 hectares, but severe erosion has removed the western defences and a small section of the interior (Figure 3).

Figure 3: Dinas Dinlle Hillfort, clearly showing the erosion to the western side of the monument. Crown Copyright: RCAHMW AP_2014_0877.

Based on the morphology and excavation evidence, the hillfort dates from the Iron Age (800 BC – AD 43) and continued in use during the Roman period (AD 43- 410). It also features prominently in early medieval Welsh literature and folklore - it is mentioned in the fourth branch of the Mabinogi - and thus a longer history of use/reuse may be likely. This history stretches to the modern day with the hillfort incorporated into a golf course during the early decades of the twentieth century, and later during the Second World War, defences for the protection of the nearby RAF Llandwrog were constructed into the foot of the fort's northern slopes (SM: CN 396). Excavated features and finds of neolithic, medieval and post medieval date in the field directly to the south of the hillfort also provide a wider chronological and archaeological context (Lynes et al, 2021; Hopewell and McGuinness 2022).

4. GEOPHYSICAL SURVEY

The GPR trial survey was carried out on 23 September 2020 by the CHERISH (Aberystwyth University and RCAHMW) and Birkbeck University as part of CHERISH investigations at Dinas Dinlle hillfort and surrounding environment.

The survey was carried out to test the use of GPR across some of the steeper terrain of the hillfort. It complements a series of CHERISH funded geophysical surveys at the hillfort:

Date	November 2017 and May 2018
Survey type	Magnetometry
Surveyed by	Gwynedd Archaeological Trust
Areas surveyed	9.2 ha across: - The hillfort - The adjoining southern field
Equipment used	Bartington Grad601–2 dual Fluxgate Gradiometer
Resolution	Within the hillfort: 0.5m × 0.125m resolution Outside hillfort: 1.0m × 0.25m resolution
Report	Hopewell, D., 2018, *Geophysical Survey at Dinas Dinlle Hillfort, Llandwrog, Gwynedd*, (GAT Report 1434. CHERISH Archive No. CHG001).

Date	August 2019
Survey type	Resistivity
Surveyed by	Eden Mapping
Areas surveyed	1,567m² Mound (NE corner of hillfort interior)
Equipment used	Geoscan Research RM15 twin array
Resolution	1.0m GAT 0.5m resolution
Report	Barker, N, 2019, *Dinas Dinlle, Llandwrog: Geophysical Survey*. (Eden Mapping Report No. GAT-19-DIN. CHERISH Archive no. CHG002).

Date	October 2019
Survey type	Ground penetrating radar
Surveyed by	SUMO Geophysics
Areas surveyed	11,380m² Hillfort interior
Equipment used	Mala MIRA High Density Array Radar in conjunction with 8 × 400MHz antennae towed by an all-terrain vehicle (ATV)
Resolution	0.08m × 0.05m
Report	Udyrysz-Krawеć, M. & Wajzer, M. 2020. *Geophysical Survey Report. CHERISH Ireland-Wales Project – Dinas Dinlle Hillfort, Llandwrog.* (SUMO Survey Report 16438. CHERISH Archive No. CHG003).

The GPR Trail

Three areas were selected for survey (Figure 4), a profile across the mound in the northern in the northern interior of the hillfort (NPRN 703006) and 2 profiles across the hillfort's defences, covering the east and south ramparts.

Figure 4: Location of GPR lines at Dinas Dinlle (This map is based upon Ordnance Survey material with the permission of Ordnance Survey on behalf of the Controller of His Majesty's Stationery Office © Crown copyright, 2023. Licence number: 100022206. Map created using ArcPro).

The Mound:

LOCATION OF SURVEY	
CHERISH AREA: Area 2 – Dinas Dinlle	
SITE NAME: Dinas Dinlle coastal hillfort	**SCHEDULED MONUMENT:** CN048
LOCATION: Mound SH 43710 56390	**RECORD NUMBER (NPRN):** 703006
DETAIL: One 29m line, oriented west to east across the mound - SH 43702 56389 to SH 43727 56404.	

EQUIPMENT USED	
GPR	Sensors and Software Pulse EKKO Pro with 200 MHz antennas. Sensors and Software Pulse EKKO Ultra with 200 MHz antennas.
GNSS	Leica GS16 & CS20 operating as RTK receiving corrections from Leica SmartNet.

SURVEY PARAMETERS	
PROFILES	Three profiles were collected along the line with slightly different survey parameters. • Line 23, Pulse Ekko Pro with antenna spacing of 1 m and step size of 0.2 m. • Line 24, Pulse Ekko Pro with antenna spacing of 1 m and step size of 0.1 m. • Line 2, Pulse Ekko Ultra with antenna spacing 1m and step size of 0.1 m.
POSITIONING	Positioning in the field was determined using a fibreglass tape measure laid along the ground.
LOCATION & ELEVATION	GNSS point recorded every 0.5 m (see Appendix 1)

PROCESSING	
AGC	An automatic gain (AGC) max 100, was applied to all profiles.
TOPOGRAPHIC CORRECTION	Applied to all profiles using a velocity of 0.07 m/ns which is a typical value for silty soil. The velocity was determined using hyperbola matching in EKKO view software (see Appendix 2)

Results:

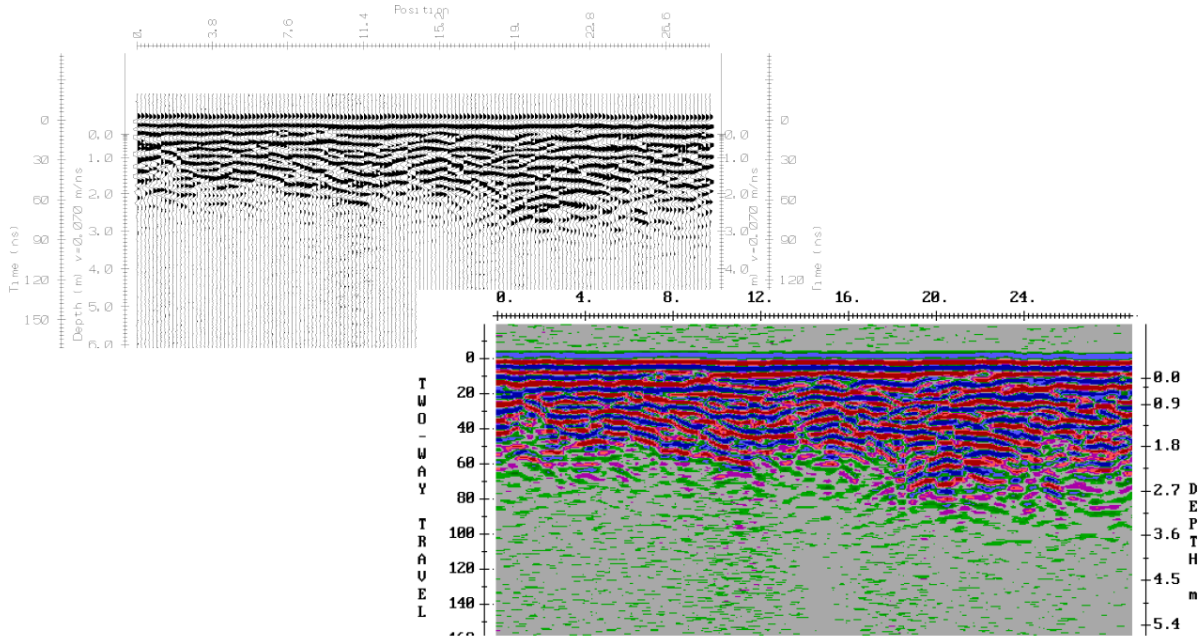

Figure 5: Line 23, 200 MHz antennas, with Pro spaced 1 m apart and 0.2 m step size, AGC gain max 100, black and white wiggle trace (above) and colour (below).

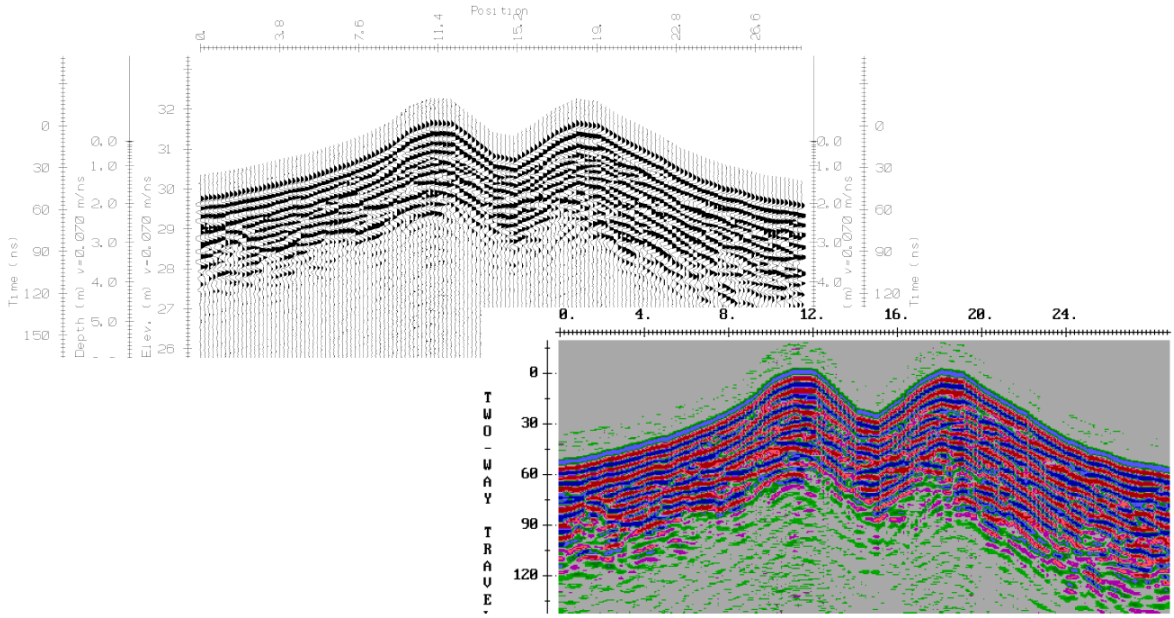

Figure 6: Line 23, 200 MHz antennas, with Pro spaced 1 m apart and 0.2 m step size, AGC max 100 and topographic correction, black and white wiggle trace (above) and colour (below).

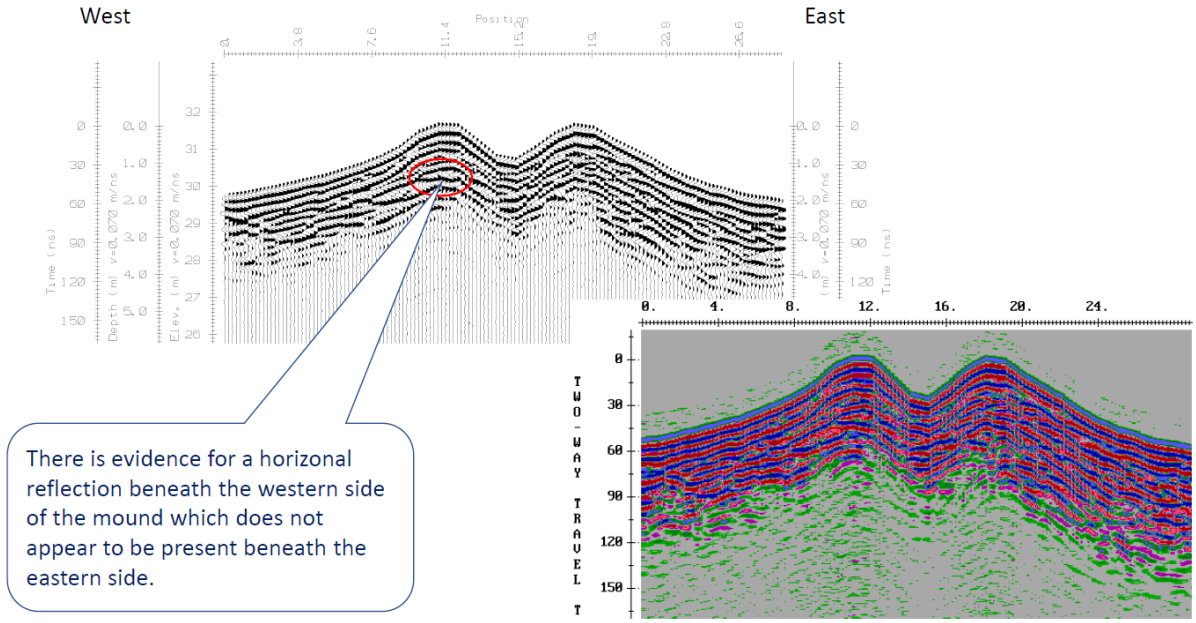

Figure 7: Initial Interpretation Line 23, 200 MHz antennas, with Pro spaced 1 m apart and 0.2 m step size, AGC max 100, migration and topographic correction, black and white wiggle trace and colour.

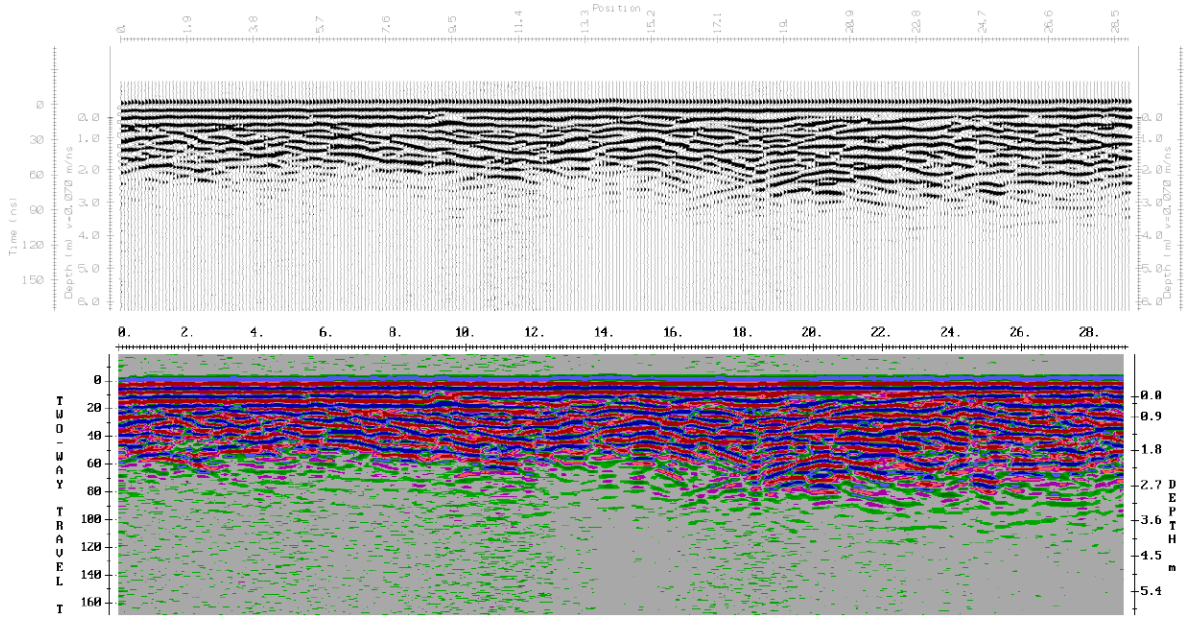

Figure 8: Line 24, 200 MHz antennas, with Pro spaced 1 m apart and 0.1 m step size. With a smaller step size there are twice as many measurements along the profile and improved spatial resolution. AGC max 100, black and white wiggle trace (above) and colour (below).

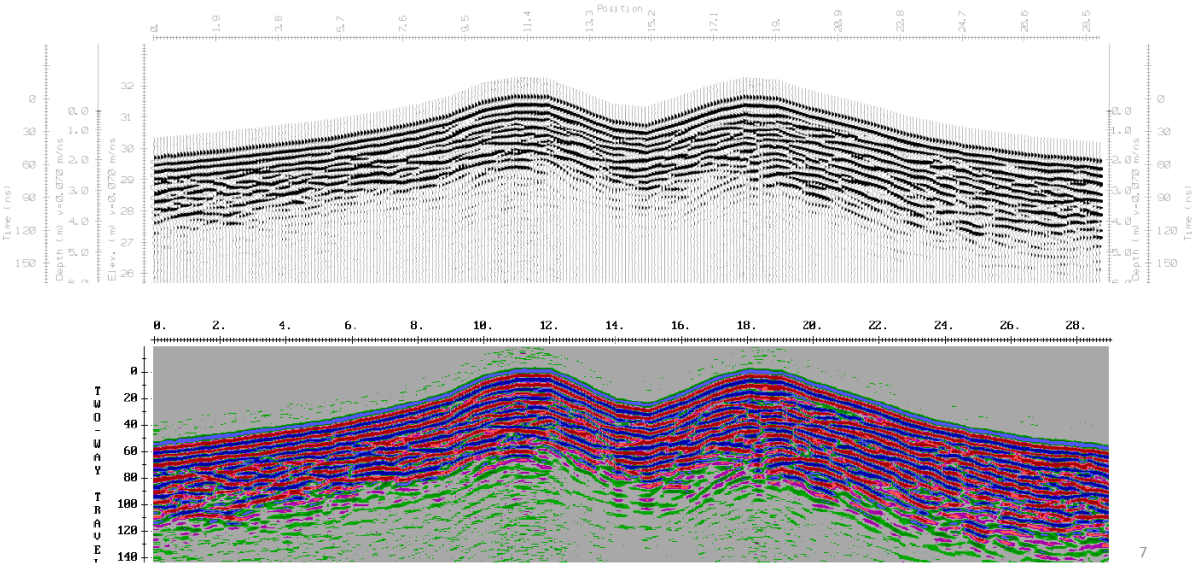

Figure 9: Line 24, 200 MHz antennas, with Pro spaced 1 m apart and 0.1 m step size, AGC max 100 and topographic correction, black and white wiggle trace (above) and colour (below).

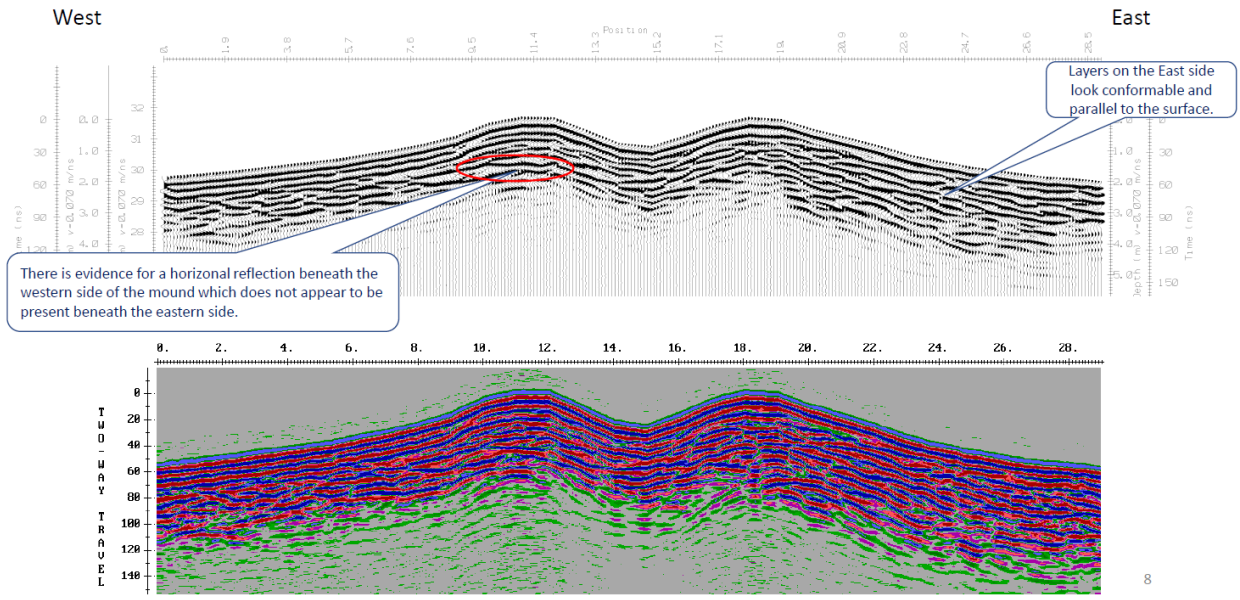

Figure 10: Initial Interpretation Line 24, 200 MHz antennas, with Pro spaced 1 m apart and 0.1 m step size, AGC max 100, migration and topographic correction, black and white wiggle trace (above) and colour (below). A possible explanation for the reflection pattern is that the eastern half of the mound with conformable reflections parallel to the surface is in-situ, whilst the unconformity at the base on the western side might be spoil excavated from the central depression.

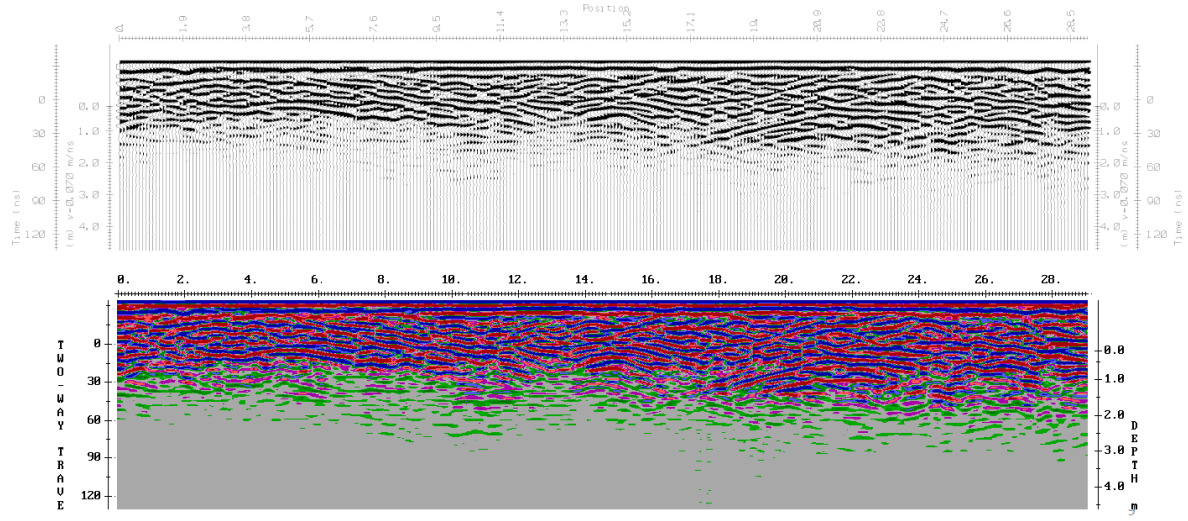

Figure 11: Line 2, 200 MHz antennas, with Ultra spaced 1 m apart and 0.1 m step size, AGCmax 100, black and white wiggle trace (above) and colour (below).

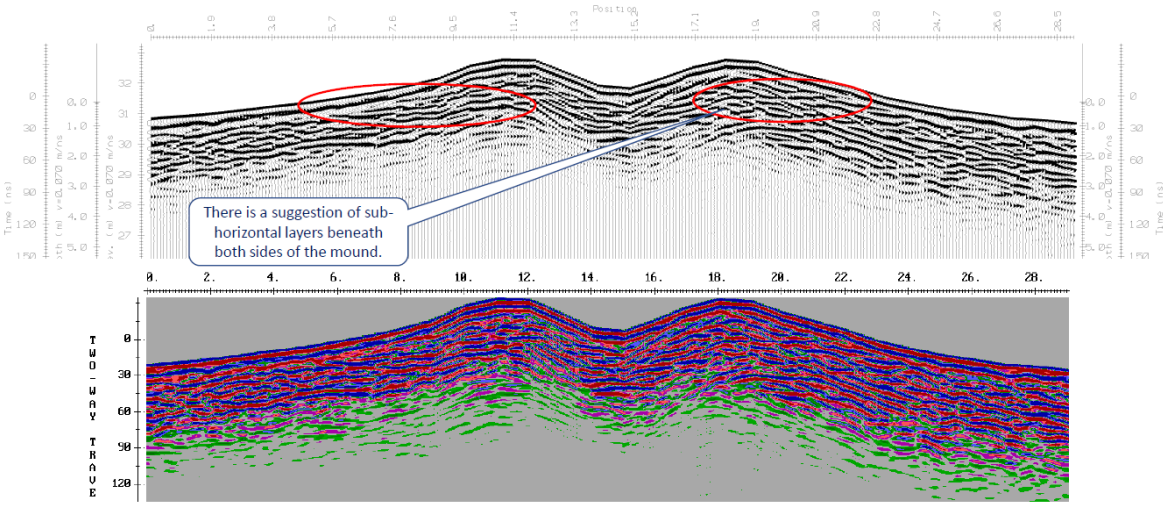

Figure 12: Line 2, 200 MHz antennas, with Ultra spaced 1 m apart and 0.1 m step size, AGC max 100, black and white wiggle trace (above) and colour (below). The ultra system gives higher resolution images and it looks like there could be sub horizontal reflections beneath both sides of the mound, suggesting that the structure is man-made.

The Defences:

LOCATION OF SURVEY	
CHERISH AREA: Area 2 – Dinas Dinlle	
SITE NAME: Dinas Dinlle coastal hillfort	**SCHEDULED MONUMENT:** CN048
LOCATION: East Rampart	**RECORD NUMBER (NPRN):** 95309
DETAIL: One 60m line SH 43790 56371 to SH 43734 56369.	

LOCATION OF SURVEY	
CHERISH AREA: Area 2 – Dinas Dinlle	
SITE NAME: Dinas Dinlle coastal hillfort	**SCHEDULED MONUMENT:** CN048
LOCATION: South Rampart	**RECORD NUMBER (NPRN):** 95309
DETAIL: One 50m line SH 43700 56247 to SH 43682 56291.	

EQUIPMENT USED	
GPR	Sensors and Software Pulse EKKO Ultra with 200 MHz antennas
GNSS	Leica GS16 & CS20 operating as RTK receiving corrections from Leica SmartNet.

SURVEY PARAMETERS	
PROFILES	One profiles was collected along each line with an antenna spacing of 1 m and step size of 0.1 m.
POSITIONING	Positioning in the field was determined using a fibreglass tape measure laid along the ground.

LOCATION & ELEVATION	GNSS point recorded every 0.5 m (see Appendix 1)

PROCESSING	
AGC	An automatic gain (AGC) max 100, was applied to all profiles.
TOPOGRAPHIC CORRECTION	applied to all profiles using a velocity of 0.07 m/ns which is a typical value for silty soil. The velocity was determined using hyperbola matching in EKKO view software. (see Appendix 2)

Results:

In Figures 13 and 14 below, red lines are drawn where stratigraphic boundaries can be seen in the data - a change in reflection character and termination of reflections. Interpretation has not been taken further at this stage as the data reveals complex stratigraphy. Further profiles across other section of the defences are recommended to aid further interpretation and comparison.

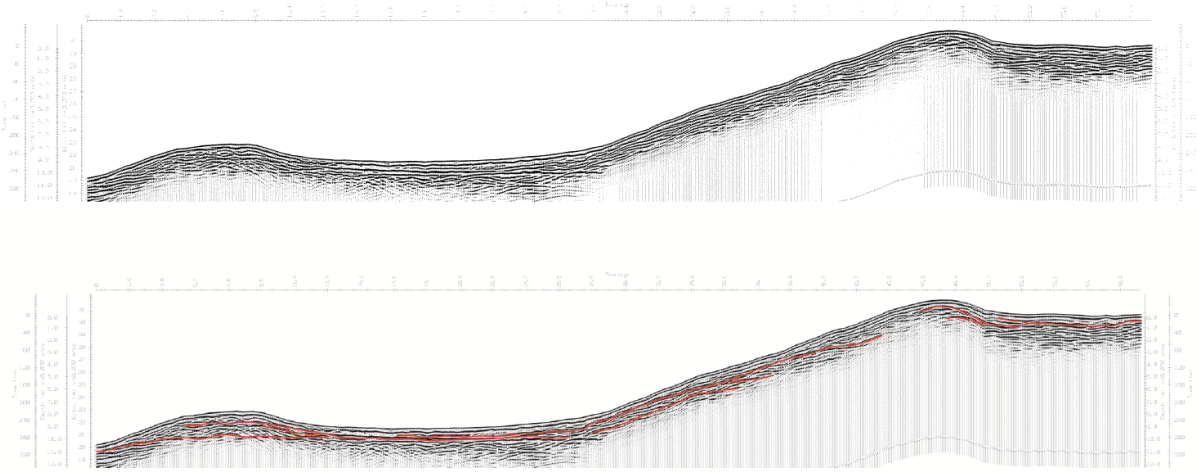

Figure 13: East Rampart. 200 MHz antennas, with Ultra spaced 1 m apart and 0.1 m step size, AGC max 100, black and white wiggle trace (above) and stratigraphic boundaries highlighted in red (below).

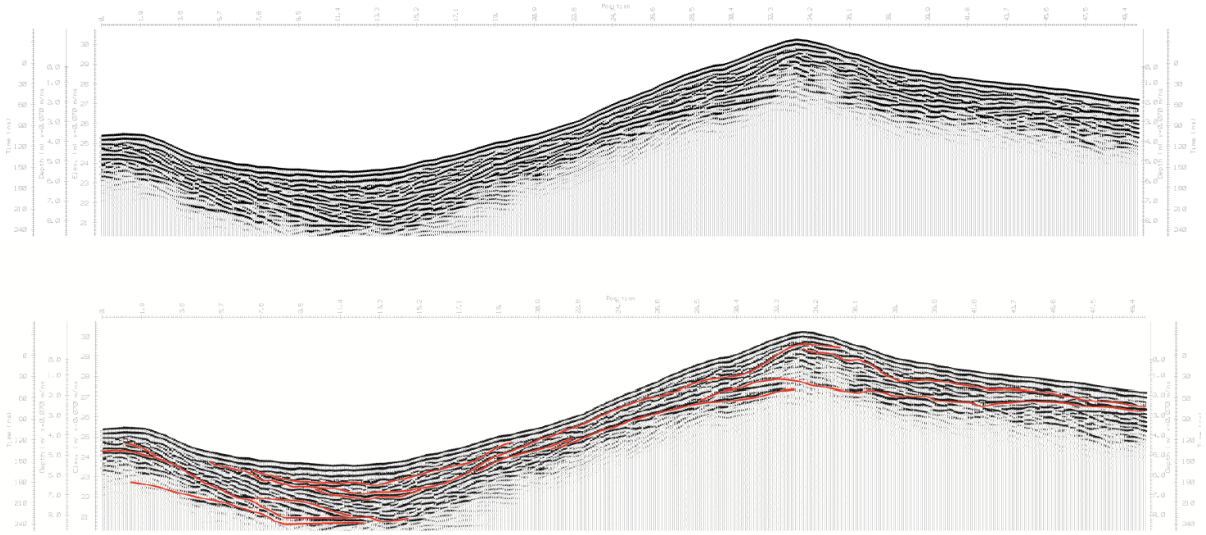

Figure 14: South rampart. 200 MHz antennas, with Ultra spaced 1 m apart and 0.1 m step size, AGC max 100, black and white wiggle trace (above) and stratigraphic boundaries highlighted in red (below).

5. CONCLUSION

The results show there is considerable potential for use of this GPR system (the Ultra producing higher resolution images) across the steeper terrain at the hillfort. Consideration should be given to expanding the coverage of this survey across other parts of the monument, in particular the number and length of the profiles across the defences of the hillfort.

6. REFERENCES

Barker, N, 2019, *Dinas Dinlle, Llandwrog: Geophysical Survey*. (Eden Mapping Report No. GAT-19-DIN). http://www.walesher1974.org/her/groups/GAT/media/GAT_Reports/GATreport_1582_compressed.pdf

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Lynes, M., Ferreira, C., Oattes, A., Jones, B., Evans, R., McGuinness, N., Young, C., 2021. *Dinas Dinlle Gwynedd. Cloddio Gwerthuso Archeolegol: Adroddiad Terfynol / Archaeological Evaluation Excavation: Final Report.* (GAT Report No. 1582. CHERISH Archive No. CHG004).

http://www.walesher1974.org/her/groups/GAT/media/GAT_Reports/GATreport_1582_compressed.pdf

Udyrysz-Krawec, M. & Wajzer, M. 2020. *Geophysical Survey Report. CHERISH Ireland-Wales Project – Dinas Dinlle Hillfort, Llandwrog.* (SUMO Survey Report 16438. CHERISH Archive No. CHG003

APPENDIX 1: GNSS LOCATION AND ELEVATION READINGS.

Leica GS16 & CS20 operating as RTK receiving corrections from Leica SmartNet.

Mound

Tape Position (metres)	Point ID	Easting	Northing	Height
0	GPR0001	243702.9337	356389.4015	29.6648
1	GPR0002	243703.8371	356389.8038	29.7392
2	GPR0003	243704.7456	356390.2575	29.8369
3	GPR0004	243705.6038	356390.7133	29.9525
4	GPR0005	243706.4777	356391.197	30.0797
5	GPR0006	243707.3546	356391.681	30.1874
6	GPR0007	243708.2202	356392.1528	30.3462
7	GPR0008	243709.0763	356392.6242	30.5118
8	GPR0009	243709.9335	356393.0829	30.7154
9	GPR0010	243710.7681	356393.5816	30.9752
10	GPR0011	243711.5769	356394.0391	31.3946
11	GPR0012	243712.4018	356394.5185	31.5894
12	GPR0013	243713.2884	356395.0172	31.5654
13	GPR0014	243714.1127	356395.4753	31.1564
14	GPR0015	243714.8982	356395.9109	30.7361
15	GPR0016	243715.7675	356396.3789	30.6425
16	GPR0017	243716.6282	356396.7849	30.9682
17	GPR0018	243717.437	356397.2653	31.3399
18	GPR0019	243718.2846	356397.6767	31.5789
19	GPR0020	243719.1523	356398.1889	31.5086
20	GPR0021	243719.9427	356398.6905	31.185
21	GPR0022	243720.7585	356399.2465	30.9299
22	GPR0023	243721.5673	356399.7982	30.6668
23	GPR0024	243722.3144	356400.3015	30.3482
24	GPR0025	243723.1116	356400.8831	30.1357
25	GPR0026	243723.9213	356401.4691	29.9505
26	GPR0027	243724.7333	356402.0308	29.8148
27	GPR0028	243725.4751	356402.6366	29.6641
28	GPR0029	243726.3033	356403.2474	29.6003
29	GPR0030	243727.0763	356403.856	29.4947
30	GPR0031	243727.8818	356404.3776	29.5219

East Rampart

Tape Position (metres)	Point ID	Easting	Northing	Height
0	GPR0400	243790.5547	356371.8972	19.0085
0.5	GPR0401	243790.1197	356371.8819	19.135
1	GPR0402	243789.6552	356371.8541	19.3155
1.5	GPR0403	243789.2397	356371.85	19.5657
2	GPR0404	243788.8123	356371.8091	19.8614
2.5	GPR0405	243788.3857	356371.7834	20.0752
3	GPR0406	243787.9655	356371.7639	20.3525
3.5	GPR0407	243787.5015	356371.7439	20.6367
4	GPR0408	243787.0628	356371.7033	20.8556
4.5	GPR0409	243786.6053	356371.6724	21.0718
5	GPR0410	243786.1345	356371.6594	21.2757
5.5	GPR0411	243785.6511	356371.6331	21.318
6	GPR0412	243785.1555	356371.5888	21.4424
6.5	GPR0413	243784.699	356371.5575	21.5358
7	GPR0414	243784.1826	356371.5129	21.592
7.5	GPR0415	243783.682	356371.4884	21.629
8	GPR0416	243783.1829	356371.4724	21.6688
8.5	GPR0417	243782.6877	356371.4387	21.6236
9	GPR0418	243782.1943	356371.4012	21.656
9.5	GPR0419	243781.706	356371.3554	21.558
10	GPR0420	243781.2417	356371.2965	21.3571
10.5	GPR0421	243780.7919	356371.2242	21.1418
11	GPR0422	243780.3133	356371.1638	20.9276
11.5	GPR0423	243779.8698	356371.1292	20.7774
12	GPR0424	243779.3707	356371.072	20.6831
12.5	GPR0425	243778.8778	356371.0473	20.5546
13	GPR0426	243778.3773	356370.979	20.4979
13.5	GPR0427	243777.9005	356370.9438	20.4542
14	GPR0428	243777.4357	356370.8869	20.3948
14.5	GPR0429	243776.974	356370.8645	20.4181
15	GPR0430	243776.4472	356370.871	20.3619
15.5	GPR0431	243775.9592	356370.8383	20.3356
16	GPR0432	243775.444	356370.8092	20.3347
16.5	GPR0433	243774.9749	356370.76	20.2786
17	GPR0434	243774.4726	356370.7361	20.2565
17.5	GPR0435	243773.9868	356370.7157	20.2734
18	GPR0436	243773.4617	356370.7027	20.2983
18.5	GPR0437	243772.9816	356370.6644	20.2975
19	GPR0438	243772.4769	356370.6501	20.256
19.5	GPR0439	243771.9518	356370.6455	20.3089
20	GPR0440	243771.4768	356370.6182	20.3099
20.5	GPR0441	243770.9682	356370.5781	20.3382

21	GPR0442	243770.5143	356370.5501	20.3334
21.5	GPR0443	243770.0348	356370.4817	20.3565
22	GPR0444	243769.5379	356370.5061	20.3801
22.5	GPR0445	243769.0466	356370.4933	20.4233
23	GPR0446	243768.5544	356370.4814	20.4383
23.5	GPR0447	243768.033	356370.487	20.4996
24	GPR0448	243767.5238	356370.4953	20.5428
24.5	GPR0449	243767.0584	356370.4726	20.6296
25	GPR0450	243766.5316	356370.47	20.6818
25.5	GPR0451	243766.0788	356370.4531	20.7353
26	GPR0452	243765.5554	356370.4525	20.8082
26.5	GPR0453	243765.0639	356370.4432	20.9083
27	GPR0454	243764.5522	356370.4221	21.0192
27.5	GPR0455	243764.0854	356370.4392	21.0894
28	GPR0456	243763.5721	356370.4201	21.1964
28.5	GPR0457	243763.097	356370.413	21.3782
29	GPR0458	243762.6527	356370.417	21.503
29.5	GPR0459	243762.2945	356370.4519	21.7159
30	GPR0460	243761.8582	356370.5053	22.0131
30.5	GPR0461	243761.4946	356370.4429	22.2981
31	GPR0462	243761.0384	356370.419	22.5575
31.5	GPR0463	243760.611	356370.3751	22.7708
32	GPR0464	243760.1678	356370.4049	23.1063
32.5	GPR0465	243759.7483	356370.3487	23.4144
33	GPR0466	243759.3413	356370.3488	23.6256
33.5	GPR0467	243758.9518	356370.3419	23.8932
34	GPR0468	243758.5175	356370.3112	24.2005
34.5	GPR0469	243758.1224	356370.2901	24.4793
35	GPR0470	243757.6309	356370.2453	24.6928
35.5	GPR0471	243757.1994	356370.1968	24.8448
36	GPR0472	243756.7459	356370.1796	25.0543
36.5	GPR0473	243756.2856	356370.1109	25.2905
37	GPR0474	243755.8212	356370.1106	25.4514
37.5	GPR0475	243755.3604	356370.0789	25.6612
38	GPR0476	243754.9182	356370.0297	25.925
38.5	GPR0477	243754.4583	356370.0112	26.1293
39	GPR0478	243753.9996	356369.9947	26.2983
39.5	GPR0479	243753.5909	356369.983	26.5272
40	GPR0480	243753.1963	356369.9698	26.8793
40.5	GPR0481	243752.7442	356369.9192	27.1395
41	GPR0482	243752.3648	356369.8912	27.4037
41.5	GPR0483	243751.8985	356369.9234	27.6566
42	GPR0484	243751.4987	356369.8802	27.993
42.5	GPR0485	243751.029	356369.8945	28.2072
43	GPR0486	243750.5797	356369.879	28.3554
43.5	GPR0487	243750.124	356369.8495	28.5739

44	GPR0488	243749.7192	356369.8483	28.8525
44.5	GPR0489	243749.3033	356369.8531	29.1067
45	GPR0490	243748.8555	356369.8447	29.4022
45.5	GPR0491	243748.4353	356369.8402	29.7117
46	GPR0492	243747.9842	356369.8228	29.9108
46.5	GPR0493	243747.5162	356369.7926	30.0911
47	GPR0494	243747.0541	356369.7643	30.2562
47.5	GPR0495	243746.5929	356369.7132	30.4358
48	GPR0496	243746.0889	356369.708	30.5335
48.5	GPR0497	243745.6003	356369.7363	30.5791
49	GPR0498	243745.0864	356369.7785	30.567
49.5	GPR0499	243744.6181	356369.7606	30.4758
50	GPR0500	243744.1411	356369.7536	30.3154
50.5	GPR0501	243743.6642	356369.7425	30.0735
51	GPR0502	243743.1886	356369.6769	29.7754
51.5	GPR0503	243742.7084	356369.6786	29.6766
52	GPR0504	243742.2264	356369.5954	29.5536
52.5	GPR0505	243741.7181	356369.5994	29.4894
53	GPR0506	243741.2297	356369.5583	29.4674
53.5	GPR0507	243740.7331	356369.5083	29.4201
54	GPR0508	243740.2596	356369.4783	29.4497
54.5	GPR0509	243739.7424	356369.4321	29.4755
55	GPR0510	243739.2561	356369.3573	29.476
55.5	GPR0511	243738.7508	356369.339	29.4433
56	GPR0512	243738.2467	356369.3193	29.401
56.5	GPR0513	243737.7617	356369.2987	29.3607
57	GPR0514	243737.2624	356369.2756	29.3042
57.5	GPR0515	243736.7596	356369.2541	29.2763
58	GPR0516	243736.2977	356369.1953	29.3605
58.5	GPR0517	243735.8306	356369.1574	29.2839
59	GPR0518	243735.3268	356369.1335	29.366
59.5	GPR0519	243734.8373	356369.1085	29.3899
60	GPR0520	243734.3091	356369.1386	29.4292

South Rampart

Tape Position (metres)	Point ID	Easting	Northing	Height
0	GPR0200	243700.2577	356247.7189	24.2408
0.5	GPR0201	243700.199	356248.1429	24.2769
1	GPR0202	243700.0824	356248.6401	24.3312
1.5	GPR0203	243699.9735	356249.1367	24.3046
2	GPR0204	243699.8719	356249.6299	24.2728
2.5	GPR0205	243699.7655	356250.0576	24.0936

3	GPR0206	243699.6646	356250.5215	23.915
3.5	GPR0207	243699.6529	356250.9608	23.6437
4	GPR0208	243699.5629	356251.4032	23.4169
4.5	GPR0209	243699.4826	356251.8909	23.2356
5	GPR0210	243699.4669	356252.3648	23.1187
5.5	GPR0211	243699.4248	356252.842	23.0175
6	GPR0212	243699.3406	356253.3069	22.9158
6.5	GPR0213	243699.2481	356253.8086	22.8046
7	GPR0214	243699.1334	356254.2812	22.7799
7.5	GPR0215	243699.0434	356254.747	22.6692
8	GPR0216	243698.9422	356255.2379	22.6499
8.5	GPR0217	243698.871	356255.7424	22.5842
9	GPR0218	243698.7636	356256.2495	22.5344
9.5	GPR0219	243698.6675	356256.7333	22.5312
10	GPR0220	243698.5465	356257.1924	22.4857
10.5	GPR0221	243698.476	356257.6916	22.4472
11	GPR0222	243698.3405	356258.1624	22.4171
11.5	GPR0223	243698.2274	356258.6632	22.4403
12	GPR0224	243698.1332	356259.0924	22.4084
12.5	GPR0225	243698.0613	356259.5669	22.4359
13	GPR0226	243697.9366	356260.0756	22.4975
13.5	GPR0227	243697.8139	356260.5563	22.5104
14	GPR0228	243697.7383	356261.0454	22.5896
14.5	GPR0229	243697.623	356261.5303	22.6567
15	GPR0230	243697.4898	356261.9957	22.7933
15.5	GPR0231	243697.3715	356262.4369	22.944
16	GPR0232	243697.2696	356262.8797	23.011
16.5	GPR0233	243697.1256	356263.3546	23.1549
17	GPR0234	243696.9962	356263.8058	23.2533
17.5	GPR0235	243696.8283	356264.2782	23.394
18	GPR0236	243696.6961	356264.7202	23.5699
18.5	GPR0237	243696.5451	356265.1336	23.7191
19	GPR0238	243696.3586	356265.6072	23.8824
19.5	GPR0239	243696.1085	356266.0352	23.9402
20	GPR0240	243695.898	356266.4564	24.0929
20.5	GPR0241	243695.6971	356266.8627	24.1961
21	GPR0242	243695.4568	356267.2914	24.3089
21.5	GPR0243	243695.2277	356267.7233	24.471
22	GPR0244	243694.9781	356268.1297	24.6529
22.5	GPR0245	243694.7584	356268.5289	24.8145
23	GPR0246	243694.4999	356268.9439	24.97
23.5	GPR0247	243694.3037	356269.3007	25.2293
24	GPR0248	243694.0575	356269.6803	25.5013
24.5	GPR0249	243693.8521	356270.0339	25.7344
25	GPR0250	243693.5968	356270.4241	25.9745
25.5	GPR0251	243693.3671	356270.7848	26.1388

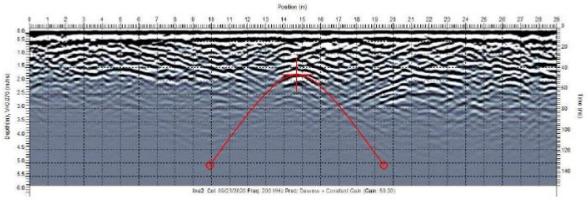
26	GPR0252	243693.1365	356271.1948	26.3625
26.5	GPR0253	243692.901	356271.6025	26.5452
27	GPR0254	243692.6871	356271.9833	26.8139
27.5	GPR0255	243692.4551	356272.3411	27.0203
28	GPR0256	243692.1914	356272.7362	27.2403
28.5	GPR0257	243691.9412	356273.1495	27.4269
29	GPR0258	243691.7124	356273.5413	27.6035
29.5	GPR0259	243691.4803	356273.9437	27.7595
30	GPR0260	243691.2162	356274.3453	27.8139
30.5	GPR0261	243690.9528	356274.7519	27.9924
31	GPR0262	243690.7131	356275.1635	28.204
31.5	GPR0263	243690.4625	356275.558	28.4295
32	GPR0264	243690.1728	356275.969	28.6426
32.5	GPR0265	243689.9952	356276.3401	28.8153
33	GPR0266	243689.7571	356276.7463	28.9902
33.5	GPR0267	243689.5641	356277.1939	29.0802
34	GPR0268	243689.2939	356277.6115	29.023
34.5	GPR0269	243689.0497	356278.0404	28.8996
35	GPR0270	243688.7663	356278.4433	28.7717
35.5	GPR0271	243688.5647	356278.851	28.5723
36	GPR0272	243688.3199	356279.2932	28.4127
36.5	GPR0273	243688.1092	356279.7207	28.3032
37	GPR0274	243687.8866	356280.0941	28.1025
37.5	GPR0275	243687.6503	356280.5068	27.8953
38	GPR0276	243687.4316	356280.9278	27.749
38.5	GPR0277	243687.1867	356281.3701	27.6473
39	GPR0278	243686.9616	356281.7839	27.5394
39.5	GPR0279	243686.725	356282.2418	27.4958
40	GPR0280	243686.5281	356282.6813	27.3588
40.5	GPR0281	243686.3341	356283.1268	27.2973
41	GPR0282	243686.1227	356283.6017	27.1665
41.5	GPR0283	243685.923	356284.0372	27.1238
42	GPR0284	243685.7169	356284.4794	27.0525
42.5	GPR0285	243685.5173	356284.9585	26.9742
43	GPR0286	243685.3476	356285.3915	26.9303
43.5	GPR0287	243685.1169	356285.853	26.8804
44	GPR0288	243684.943	356286.3284	26.8171
44.5	GPR0289	243684.7464	356286.7505	26.7925
45	GPR0290	243684.5708	356287.2415	26.7079
45.5	GPR0291	243684.377	356287.6927	26.6495
46	GPR0292	243684.197	356288.1598	26.5906
46.5	GPR0293	243684.0006	356288.6119	26.5591
47	GPR0294	243683.7835	356289.0848	26.477
47.5	GPR0295	243683.5935	356289.4981	26.3898
48	GPR0296	243683.3844	356289.9519	26.3221
48.5	GPR0297	243683.1655	356290.3931	26.2353

49	GPR0298	243682.9677	356290.8478	26.164
49.5	GPR0299	243682.8004	356291.3126	26.1155
50	GPR0300	243682.6636	356291.781	26.0472

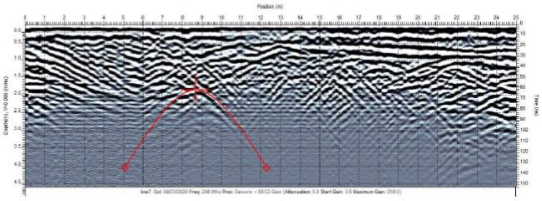
APPENDIX 2: HYPERBOLAS

Hyperbolas used to estimate velocity and depth correction. An average velocity of 0.07 m/ns has been applied.

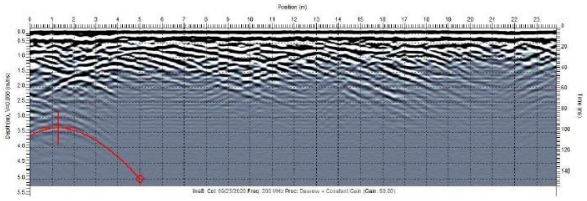
Line 2, 0.076 m/ns



Line 7, 0.06 m/ns



Line 8, 0.068 m/ns



Line 8, 0.085 m/ns