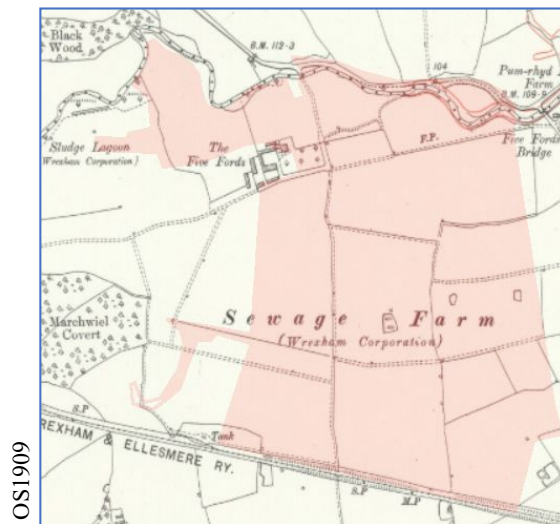




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Five Fords Marchwiell Wrexham

Proposed Glasshouse Development



Heritage Statement July 2020

HER reference number E6559

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Appendix A Description of the Proposed Development

Appendix B Geophysical Survey Report

1. Introduction

1.1 SCOPE OF THIS ASSESSMENT

1.1.1 Description of the proposed development

This report, commissioned by Low Carbon Farming 2 Ltd, presents the findings of a cultural heritage assessment for a proposed glasshouse development on land to the east of Five Fords Sewage Facility, Marchwiell, near Wrexham, LL13 0TF (**Figure 1**). The centre of the Proposed Development Area (PDA) is at approximately NGR SJ 36939 47975.

The PDA comprises 44ha of land, of which the majority is under arable agriculture, **Figure 2**.

The proposed development is set out in detail elsewhere in the Planning Statement. A description of the key components is included at **Appendix A**. The proposed layout is shown on **Figure 3**.

1.1.2 Geology, Soils and Land Use

Soilscapes Classification	Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils (18)
Superficial 1:50000 BGS	Till, Devensian – Diamicton (TILLD) River Terrace Deposits (undifferentiated) - Sand And Gravel (RTD) Alluvium - Clay, Silt, Sand and Gravel (ALV)
Bedrock 1:50000 BGS	Salop Formation - Mudstone, Sandstone and Conglomerate (SAL)
Topography	Impeded drainage
Hydrology	Impeded drainage
Current Land Use	Arable
Historic Land Use	Mixed agricultural then a sewage farm from late 1800s

1.1.3 Scope of cultural heritage

Cultural heritage is represented by a wide range of assets and features that result from past human use of the landscape. These include historic structures, many still in use, above ground and buried archaeological monuments and remains of all periods, artefacts of anthropological origin and evidence that can help reconstruct past human environments. In its broadest form cultural heritage is represented by the landscape and townscape itself.

The assessment considers both direct and indirect effects upon cultural heritage. Indirect effects can occur as a result of changes to the setting of a landscape or asset, whether permanent or temporary. This is particularly relevant to designated cultural heritage assets, such as Scheduled Monuments, Listed Buildings, Conservation Areas, Registered Parks and Gardens and Registered Historic Landscapes.

1.1.4 Authorship

This Assessment and Heritage Statement has been written by Andrew Josephs and Ian Meadows of Andrew Josephs Associates, a consultancy specialising in archaeology and cultural heritage founded in 2002.

Andrew Josephs (BA Hons Archaeology and Environmental Studies) is Managing Director of Andrew Josephs Associates, a consultancy specialising in cultural heritage founded in 2002. Andrew has extensive experience of all periods and facets of cultural heritage. He is involved primarily in planning applications, EIA and the design of mitigation strategies on developments with heritage constraints. Andrew is heritage consultant to over 150 clients across Europe.

He has undertaken in excess of 1000 cultural heritage assessments since becoming one of the UK's first archaeological consultants in 1992. He was previously Principal Consultant (Director of Archaeology) at Entec (now Wood) and Wardell Armstrong. Prior to 1992, he worked as a field-based archaeologist and researcher for universities and units in the UK, Europe and the USA.

He has lectured widely and was visiting lecturer in Environmental Impact Assessment at the University of Nottingham.

Ian Meadows (BA Archaeology and Geology, Dip.Mus) is an archaeologist with over 30 years' experience in a variety of professional areas. He was Senior Project Officer with Northamptonshire Archaeology (now MOLA) from 1992 until 2014 when he joined AJA. Ian is highly experienced project manager of large landscape projects such as long running quarries. Ian has a particular interest in the Roman period and is currently Director of the excavations at Irchester Roman town.

In addition to his fieldwork he is engaged in regular outreach sessions to both professional and amateur groups as part of his role dealing with both adults and children. He has been teaching archaeology and landscape history to adults and children since the late 1980's, previously being engaged as a tutor by Cambridge University, Anglia Ruskin University, Bath University and the WEA and feels it is important to disseminate the information derived from projects to a wider audience.

1.2 DESK-BASED RESEARCH

In order to assess the effects of the potential scheme, cultural heritage information within and up to 1km from the PDA was examined. The study area was determined after consideration of topography and the location of nearby development. This radius was agreed in consultations at the scoping stage.

A variety of sources were consulted including the Clwyd-Powys Historic Environment Record, Cadw's database for the locations of designated sites, Coflein (the online catalogue of archaeology, buildings, industrial and maritime heritage in Wales), reports of previous archaeological investigations, maps and readily available local history materials.

All work has been undertaken in accordance with *Standard and Guidance for Archaeological Desk-Based Assessment* (Chartered Institute for Archaeologists 2008, revised 2012).

1.3 FIELD-BASED RESEARCH

A field evaluation in the form of a geophysical survey was undertaken by Tigergeo in June 2020.

Due to the restrictions imposed by COVID19, a site visit to the PDA and its environs was not carried out. However, a photographic record of the current state and use of the land was taken by Tigergeo, who also examined the PDA for earthworks or other archaeological assets. The locations of designated assets were examined using Google Earth and Google Streetview, and further informed by the LVIA.

1.4 RELEVANT LEGISLATION, POLICY AND GUIDANCE

1.4.1 National legislation

The importance of cultural heritage is clearly recognised at a national level. Certain assets that are deemed to be of particular importance are given legal protection through the *Ancient Monuments and Archaeological Areas Act 1979* and (Scheduled Monuments), the *Planning (Listed Building and Conservation Areas) Act 1990* and *The Historic Environment (Wales) Act 2016* (Scheduled Monuments, historic parks and gardens, Listed Buildings, historic place names, historic environment records and the Advisory Panel for the Welsh Historic Environment).

Planning Policy Wales sets out the Welsh Governments' land-use planning policies (2018, edition 10). It is supplemented by a series of Technical Advice Notes, Welsh Government Circulars, policy clarification letters and regulations.

Sustainable development has been at the heart of planning policy since the introduction of *Planning Policy Wales* in 2002 and this is secured through a plan-led approach (including the Wales Spatial Plan 2004-2024, the draft National Development Framework 2020-2040, Strategic Development Plans and Local Development Plans). Legislation secures a presumption in favour of sustainable development in accordance with development plans unless material considerations indicate otherwise.

Chapter 6 of *Planning Policy Wales* covers distinctive and natural places, the environmental and cultural components of placemaking. It states the Welsh Governments objectives for the historic environment (page 124) which are to seek to:

- *protect the Outstanding Universal Value of the World Heritage Sites;*
- *conserve archaeological remains, both for their own sake and for their role in education, leisure and the economy;*
- *safeguard the character of historic buildings and manage change so that their special architectural and historic interest is preserved;*
- *preserve or enhance the character or appearance of conservation areas, whilst the same time helping them remain vibrant and prosperous;*
- *preserve the special interest of sites on the register of historic parks and gardens; and*
- *protect areas on the register of historic landscapes in Wales.*

It covers planning and the historic environment in detail. Many of its statements are directly relevant to the proposed development including:

- *Section 6.1.7: It is important that the planning system looks to protect, conserve and enhance the significance of historic assets. This will include consideration of the setting of an historic asset which might extend beyond its curtilage. Any change that impacts on an historic asset or its setting should be managed in a sensitive and sustainable way (page 124).*
- *Section 6.1.10: There should be a general presumption in favour of the preservation or enhancement of a listed building and its setting, which might extend beyond its curtilage. For any development proposal affecting a listed building or its setting, the primary material consideration is the statutory requirement to have special regard to the desirability of preserving the building, its setting or any features of special architectural or historic interest which it possesses (page 124).*
- *Section 6.1.21: Planning authorities should protect those assets included on the register of historic landscapes in Wales. As above, the sharing and use of evidence and assessments undertaken for wider reasons, such as Green Infrastructure Assessments, should be used to identify and better understand historic landscapes and ensure their qualities are protected and enhanced. The register should be taken into account in decision making when considering the implications of developments which meet the criteria for Environmental Impact Assessment or, if on call in, in the opinion of the Welsh Ministers, the development is of a sufficient scale to have more than a local impact on the historic landscape. An assessment of development on a historic landscape may be required if it is proposed within a registered historic landscape or its setting and there is potential for conflict with development plan policy (page 126).*
- *Where archaeological remains are known to exist or there is a potential for them to survive, an application should be accompanied by sufficient information, through desk-based assessment and/or field evaluation, to allow a full understanding of the impact of the proposal on the significance of the remains. The needs of archaeology and development may be reconciled, and potential conflict very much reduced, through early discussion and assessment (page 127).*
- *If the planning authority is minded to approve an application and where archaeological remains are affected by proposals that alter or destroy them, the planning authority must be satisfied that the developer has secured appropriate and satisfactory provision for their recording and investigation, followed by the analysis and publication of the results and the deposition of the resulting archive in an approved repository. On occasions, unforeseen archaeological remains may still be discovered during the course of a development. A written scheme of investigation should consider how to react to such circumstances or it can be covered through an appropriate condition for a watching brief. Where remains discovered are deemed to be of national importance, the Welsh Ministers have the power to schedule the site and in such circumstances scheduled monument consent must be required before works can continue (page 127).*

1.4.2 Policy and guidance

Published best practice and guidance on assessing the impact of development on heritage assets include:

- Cadw 2011 *Conservation Principles for the Sustainable Management of Historic Environment in Wales*;
- Welsh Government 2017 *Planning Policy Wales Technical Advice Note 24; The Historic Environment* Cadw/Welsh Government 2017 *Setting of Historic Assets in Wales*;

- Countryside Council for Wales, Cadw & Welsh Assembly Government 2007 *Guide to Good Practice on using the Register of Landscapes of Historic Interest in Wales in the Planning and Development Process*.

Conservation Principles outlines six key principles on which to assess the potential impact of development proposals on the significance of heritage assets:

1. Historic assets will be managed to sustain their values.
2. Understanding the significance of historic assets is vital.
3. The historic environment is a shared resource.
4. Everyone will be able to participate in sustaining the historic environment.
5. Decisions about change must be reasonable, transparent and consistent.
6. Documenting and learning from decisions is essential.

Four heritage values need to be understood before the significance of a heritage asset can be assessed:

1. Evidential value.
2. Historical value.
3. Aesthetic value.
4. Communal value.

Section 7.8 of **Technical Advice Note 24** provides detailed advice on archaeological remains, listed buildings, conservation areas, historic parks and gardens and historic landscapes. In relation to registered historic landscapes its states:

Best practice guidance has been developed to assist local planning authorities and the Planning Inspectorate in their consideration of planning proposals affecting areas on the Register of Historic Landscapes. Proposed developments within a registered historic landscape that require an Environmental Impact Assessment may require an appropriate assessment of the impacts as part of the Environmental Statement.¹²⁶ The Welsh Ministers must be consulted, through Cadw, on such developments.¹²⁷⁽¹⁾

The best practice guide **Setting of Historic Assets in Wales** explains setting, how it contributes to the significance of a heritage asset and why it is important. It also outlines the principles and stages used to assess the potential impact of development proposals on designated heritage assets, how impacts can be mitigated and offset and how setting can be enhanced.

^{1 126} As described in Cadw and CCW A Guide to Good Practice on Using the Register of Landscapes of Historic Interest in Wales in the Planning and Development Process revised (2nd) edition (2007), para 2.8.

¹²⁷ The Town and Country Planning (Development Management Procedure) (Wales) Order 2012, paragraph (1)(iv) of Schedule 4.

1.4.3 Scoping and consultations

Consultations were held with Mark Walters, Development Control Archaeologist, Clwyd-Powys Archaeological Trust to agree the scope of the assessment, including field-based archaeological evaluation, and potential mitigation.

1.5 ASSESSMENT METHODOLOGY AND SIGNIFICANCE CRITERIA

In accordance with the best practice the significance of an impact or effect should be identified.

Four criteria have been considered in evaluating the significance of the residual effects of the proposed development, taking into account any proposed mitigation measures.

1.5.1 Type of Impact

Impacts may be positive, beneficial, negative, adverse, neutral (i.e. no discernible effect) or none. They may be permanent or temporary, of long, medium or short duration, direct or indirect. They may also be cumulative or combined with other impacts occurring in the vicinity.

Direct impacts have a physical effect upon an archaeological site, structure or cultural heritage asset. This may lead to the partial or total destruction of that asset.

Indirect impacts of development upon scheduled monuments, listed buildings, parks and gardens and other designated assets of the cultural heritage landscape are more difficult to assess. Consideration should include the context (or setting) of a cultural heritage asset (or place) and how we should assess its significance. Contextual relationships may be visual, but can also be, for example, historical, functional or intellectual.

1.5.2 Likelihood of the impact occurring

An assessment is made as to the likelihood of the identified impact occurring. Probability is considered as certain, likely, unlikely or not known.

1.5.3 Sensitivity

Three categories of sensitivity are identified: high, medium and low. These are expanded upon in **Table 1**, below.

Table 1 **Definitions of sensitivity**

Sensitivity	Definition
High	Sites and settings of <i>national importance</i> . Scheduled Monuments. Registered Battlefields. Grade I and Grade II* Listed Buildings and Registered Historic Parks and Gardens. Registered Historic Landscapes. Sites may also be discovered as a result of new research that are also of national importance and are candidates for scheduling.
Medium	Sites and settings of <i>regional importance</i> . Archaeological sites and features that are not considered sufficiently important or well-preserved to be protected as Scheduled Monuments. Grade II Listed Buildings and Grade II Registered Historic Parks and Gardens. Conservation Areas.
Low	Archaeological sites and structures, and other components of the historic environment that contribute to the local landscape. Locally designated assets.

1.5.4 Magnitude

The magnitude of change to a cultural heritage asset or landscape is considered in terms of its vulnerability, its current condition and the nature of the impact upon it. With respect to sub-surface archaeology, there may be a degree of uncertainty of the magnitude of change, and where this is the case it is noted. Magnitude is assessed as high, medium, small or none and the criteria used in this assessment are set out in **Table 2**, below.

Table 2 **Criteria for Assessing Magnitude of Change**

Magnitude of Change	Description of Change
High	Complete destruction of a well-preserved archaeological site, historic structure or element of the cultural heritage landscape Change to the setting of a cultural heritage asset such that our ability to understand the resource and its historical context is permanently changed
Medium	Destruction of an archaeological site or other cultural heritage asset already in degraded condition Change to the setting of a cultural heritage asset such that our ability to understand the resource and its historical context is partly or temporarily changed
Small	Destruction of an archaeological site or other cultural heritage asset already in highly degraded condition Change to the setting of a cultural heritage asset such that our ability to understand the resource and its historical context is slightly or temporarily changed
None	No physical effect upon an archaeological site or other asset of the cultural heritage landscape No discernible effect upon the setting of a cultural heritage asset, or our ability to understand the resource and its historical context

1.5.5 Assessing significance

The four criteria are considered together to reach a conclusion upon the significance of residual effects taking into account any mitigation measures. In accordance with the best practice these are quantified as significant, not significant or neutral (i.e. no change to the existing situation). They may be beneficial or adverse. In some cases it may not be possible to quantify the significance of an effect, for example due to a gap in information, and this is noted.

Table 3 presents a matrix of the inter-relationship of sensitivity with magnitude.

Table 3 **Inter-relationship of sensitivity with magnitude**

Magnitude →	High	Medium	Small	None
Sensitivity ↓				
High	Significant	Moderately Significant	Not significant	Neutral
Medium	Moderately Significant	Not significant	Not significant	Neutral
Low	Not significant	Not significant	Not significant	Neutral

2. Baseline Conditions

2.1 DESIGNATED HERITAGE ASSETS

2.1.1 Scope

A search area of 1km from the PDA was assessed to identify the potential effects upon setting. Designated Assets are shown on **Figure 4**.

No designated assets of cultural heritage importance lie within the boundary of the PDA.

2.1.2 Designated Assets within 1km of the PDA

There are no assets other than listed buildings within 1km. The nearest scheduled monument is a section of Wat's Dyke extending from Erddig Park to Middle Sontley, over 3km to the west of the PDA.

The following listed buildings sit within 1km of the PDA (**Table 4**).

Table 4 Designated Heritage Assets within 1km of the PDA

Name	Grade	CADW Ref	Description	Distance from PDA
Church of SS Marcella and Deiniol	II*	1614	A church is recorded on the site from 1254. The present building was erected by public subscription in 1774. Georgian style. Ashlar with slate roof, hipped to chancel. Aisleless with W tower, N transept and polygonal chancel. Nave windows are tall with round heads, those to chancel have square heads. Elegant tower is balustraded with urns surmounted by weather vanes in the shape of cockerels at the corners, tall arched louvred bell openings on each face and beneath these a clock face on S and W face. There is a stone string course and on the W face a tall arched former door opening stone architrave with console brackets. Nave S door in pedimented surround with C20 joinery. The gabled ends of nave and transept are treated as pediments.	685m WSW
Churchyard walls, gatepiers, railings and gates to S of Church of SS Marcella and Deiniol	II	17849	Probably erected late C18 contemporary with the church and modified perhaps earlier C20 with replacement of railings and gates and introduction of lamps and lamp brackets.	700m WSW
Bedwell Hall	II	18057	Two storey, plus attic, brick Hall on a H-plan of probable late C17/early C18 date	600m SE

			with later single storey stable block attached to the rear. Of three bays, with segmental headed casement windows, gabled cross-wings with brick kneelers. Grey slate roof and brick chimneys. Victorian porch with slate roof added to front elevation with margin paned windows. Brick floor bands and aprons to gable ends at attic storey height.	
Pum-Rhyd	II	18058	A building of one storey and attic, largely replacing an earlier building damaged by fire in the 18th century. Red brick construction with earlier timber framing and brick nogging. Grey slate roof with brick axial stack. Three-bay front with off-centre front door set in exposed door frame. Timber frame to dormers is left exposed behind barge boards. To the rear is a projection from the single pile plan-form with exposed timber framing and small casement windows to the rear wall. The interior is largely unaltered, with the former buttery and pantry to the north with original shutters to the front elevation. A dog-leg staircase is supported by large, possibly sub-medieval, chimney stack.	320m E
Parkey Farm	II	10862	Parkey Farm is assumed to have been built in the late C18/early C19 as the home farm for Parkey Hall (demolished 1972). Three storeys, of brick construction, with stone quoins, under a grey slate roof, chimney stacks to east and west gable ends. Symmetrical front elevation with central doorway and remains of doorcase. Six-pane sash windows on stone sills. Some later additions and alterations to two-storey rear and side elevations.	900m E
Milestone	II	87687	Milestone, rounded stone with attached cast iron plaque, with a rounded and shouldered head and painted white with raised lettering 'TO, M, WREXHAM 2, ELLESMERE 10'. Largely hidden by raised ground levels but revealed at the time of inspection.	960m W
Ivydale	II	17845	The building has a complex history and probably originated as 2 or 3 bay house, perhaps C16 or early C17, which was substantially modified probably later C17 with insertion or alteration of a floor. A timber-framed wing was added C17 or early C18. Dormers, a porch and roof envelope introduced late C19/early C20, attached outbuilding converted to kitchen, French windows and fireplaces added later C20.	725m SW

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2.2 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

2.2.1 *Clwyd-Powys Historic Environment Record*

HER information was provided by Gary Duckers, Historic Environment Record Officer, Clwyd-Powys Archaeological Trust. We are grateful for his efficient and helpful service.

The Clwyd-Powys Historic Environment Record (CPHER) was consulted (HER reference number E6559) for sites within a 1km radius of PDA. The data comprised a mixture of find spots, sites and documentary references.

The search produced 110 records none of which predate the medieval period although the absence of earlier evidence may be a reflection of the landscape and a lack of fieldwork since the area was largely part of the Sewage Farm as shown on the Ordnance Survey mapping for 1909 (**Figure 5**).

The results are shown on **Figures 6 and 7**.

2.2.2 *Archaeological Records within the PDA*

The following entries lie within the PDA:

- an orchard (55237²)
- four ponds (55240, 55241, 55242, 55245)
- two sluices (86012, 86013)
- Five Fords farmstead (55236) and farmhouse (102868) – both demolished
- Remnant ridge and furrow (82639)

These are discussed below within the context of the wider landscape.

2.2.3 *Medieval*

The evidence for the medieval period is limited to 15 records. A single hammered silver penny of one of the Edwards was possibly found to the north of the PDA (118967) but its precise provenance is slightly in doubt.

The remaining entries are all for the medieval open field system that was presumably associated with the settlement of Marchwiel. The elements of the field system are only noted in the southern half of the search area including an area within Marchwiel Covert (1420470) that was identified during a previous archaeological assessment (Kenny 2009³) surviving as several low ridges up to 0.1m high and about 7m wide. As the wood is believed to have been present since at least 1600 they are likely to be part of the medieval open fields.

² CPHER reference number

³ Kenny, J 2009 *Five Fords Waste Water Treatment Works, Marchwiel, Wrexham* GAT report 759

Other areas of ridge and furrow are concentrated in the southeast part of the search area where they survived as earthworks the full extent of which was largely plotted from Lidar data. In each instance the ridges were 6-7m wide and up to 0.4m high (67701, 82606-82608, 82610-82612, 82634-82635, 82639 and 82641-82643).

The parish of Marchwiell was part of the lordship of Bromfield and documentary research has traced the place name back as far as thirteenth century although the settlement may be much earlier. The location of the village on the edge of the Cheshire Plain is thought to be the reason why the fields are more akin to English open field systems than the uneven small fields more typical of the Welsh uplands (Kenny 2009).

One further entry is for the grave of Daniel Lloyd (26984) a Dissenter and supporter of Cromwell who refused burial in consecrated ground. His grave, whilst originally marked by an inscribed stone, is now under Lloyds warehouses.

2.2.4 Post medieval

A further four entries recording post medieval ridge and furrow are also present in the south eastern part of the study area (55253, 82633, 82636, 82637): two of them have been destroyed or built over and one is only known from aerial photographic evidence.

The study area is dominated by ponds which are described as possibly originating as clay or marl pits for building materials or fertiliser. These cover 34 separate entries for ponds (55240-55244, 61442-61460 and 61465-61472) and one for a marl pit (82615) (presumably so called because it had not subsequently filled with water). The ponds are not shown on the tithe map of 1840 that depicts a myriad of fields deriving from enclosure (**Figure 8**).

One of the fields containing these ponds is named Marl Field and has a series of ponds along its eastern edge. Marling was particularly common as a method of soil improvement from the sixteenth to eighteenth centuries (Kenny 2009).

Several of the ponds are still extant but a number are recorded only from historic maps. The ponds may have helped water livestock grazing in the fields.

Two further records relate to orchards (55237, 67702), both depicted on nineteenth century Ordnance Survey maps.

2.2.5 Buildings and infrastructure

A number of buildings are recorded within the CPHR. They range from Bedwell Hall (41778) a seventeenth to eighteenth century grade II listed building (18057) and Pum-rhyd (41779) a largely eighteenth century grade II listed farmhouse (18058) to sites of buildings recorded on early Ordnance Survey maps but now gone. Examples of these vanished structures include a smithy (104511) recorded on the 1879 mapping but gone by 1961 and a mill (104512) again present in 1879 but of which no trace survives.

Other building groups are recorded such as Five Fords farmstead (55236) within which the farmhouse (102868) was demolished in 1972-3 and which lies in the north of the PDA, but outside the proposed extent of construction.

A number of other structures are present within the study area including a footbridge and a ford to the north of the study area (86011 and 55238). A railway (86017) and associated

station (72334), crossing the southern part of the study area from northwest to southeast was part of the Wrexham and Ellesmere railway which opened in 1895 and finally closed in 1981, although effectively it ceased operating in 1962, and now little evidence remains.

The largest complex of activity within the study area is the Marchwiell Five Fords water treatment plant (142046) where development commenced in 1863. The fields to its east were used as an outfall area with sewage being spread across the fields.

Other isolated records include one for a milestone shown on the Ordnance Survey (86018) and for a standing stone (86014) both of which are shown on late nineteenth century maps but no trace now remains. Three sluices (86012, 86013 and 86016), shown on the Ordnance Survey maps to manage water flow in field ditches are also recorded '*but the location of none has been inspected*'

On the very northeast limit of the study area lay the Royal Ordnance Factory Marchwiell, erected in 1940 and originally covering about 1330 acres. The site included railway sidings and various factory buildings of which only a single concrete and brick munitions store (26979) now remains.

2.2.6 Archaeological events and investigations

Within the study area and just beyond only five Events are recorded in the CHER (26978, 110508, 118085, 118718 and 142045). All appear to be predominantly limited assessment exercises. Two are associated with the Five Fords Sewage treatment works (118718, 142045), two more with assessment of aspects of the Wrexham industrial estate to the north (108085, 110508) and one assessment of the Five Fords Industrial estate (26978), which only recovered evidence for the former munitions factory.

2.2.7 Discussion

It is possible the absence of evidence for earlier than medieval activity in this area is the result of a lack of fieldwork rather than a reflection of a genuine gap. Whilst it is recognised that evidence for prehistoric and Roman activity is sparse to the east of Wrexham, although some sites are known generally in the region, it is unlikely the gap is a true reflection of past activity over such a large study area.

The evidence for the fragments of medieval fields system probably associated with Marchwiell and the subsequent farming into the post medieval period demonstrate that the area was fertile. Extraction of clay either for marling or brick making reflects another significant activity in the area.

2.3 GEOPHYSICAL SURVEY

2.3.1 Introduction

Detailed geophysical survey of the whole PDA was undertaken by Tigergeo in June 2020. The report is appended (**Appendix B**) and has been provided to the CPAT Planning Archaeologist.

2.3.2 Data

The data quality is high, free of significant collection artefacts and with reasonable contrast throughout. Confidence is boosted in part by the presence of a correlation between cropmarks

typical of ditch fills and coincident magnetic anomalies. Overall anomaly strength is weak with former cultivation contributing 0.5 nT or less to the ambient field although ditch fills, presumably due to depositional remnant magnetisation, tend to contribute more, up to about 2.5 nT although strengths vary widely.

The use of non-gradiometric caesium vapour instrumentation at this site in combination with pseudo-gradient modelling has allowed increased confidence in the amplitude resolution of the data and hence the detectability of features of potential interest.

2.3.3 Geology

Anomaly strengths associated with former cultivation tend to be highest on the higher ground near the south-east corner of the site which reinforces the overall impression that hydrology is a factor in magnetic character at this site.

Much of the site is founded on Quaternary Devensian - Diamicton till and this has the characteristic slightly speckled magnetic texture of this area due to magnetic materials brought to here from north-west Wales. The northwards transition to undifferentiated River Terrace Deposits is not evident within the data except perhaps as a tiny decrease in background magnetic susceptibility. In contrast, the smooth background texture in the northernmost field is typical of deep alluvium, seen here to be cut by former river channels with till and boulder fills.

Overall there seems little reason to suspect changes in the detectability of features of interest on the basis of variations in the superficial geology.

2.3.4 Land use

In the northernmost field much of the area is affected by the magnetic field from two steel pipelines that presumably connect with the sewage works and a third was noted crossing the river but not seen within the data.

Much of the evidence for land use confirms the long existence of the land for arable purposes with ponds, field boundaries and former cultivation. Whether the ponds are natural or flooded marl pits is conjectural but given the superficial geology is till deposits maybe marl digging is less likely? Known ponds include debris filled areas [15⁴], [17] and several of the smaller patches of magnetic debris could have a similar origin.

There was once a stream, diverted after 1914, flowing south to north across the site and it formed part of the system of field boundaries. It is apparent as a fill at [16] and then at [10] but at some point it appears to have been canalised as [11], maybe during use of the area as a sewage farm, before being moved.

Other former field boundaries include [22] and a group at [23], all being ditch fills. These, with another at [30], seem directly associated with adjacent ridge and furrow cultivation with [30] being perhaps along a headland at the end of [26]. This medieval cultivation, so [24] and [26], is only evident on the higher ground, but whether this is due to variable magnetic contrast, incidence or survival is not clear. It is possible the lower ground, being likely wetter here, may not have been cultivated at this time.

⁴ [n] refers to the catalogue number

Of the sewage farm little seems to have survived below ground, however, with the exception of pipes of unknown material and brick built free-standing sluice structures, maybe there was little to find. At [13] there appears to be an intact pipe run and more must survive below the hedges where some sluice structures still survive, however, of the sluices known to have existed out in the fields nothing magnetic appears to have survived. There is the occasional scatter of debris that might be the ploughed out remains of some of these structures.

2.3.5 Archaeology

There is little of obvious archaeological interest within the magnetic data and much that is possible could be of almost any date and origin, comprising in the main a number of non-diagnostic possible ditch fills, e.g. [7] – [9]. Some, e.g. [15] and [22], seem to be elements of a former field system and indeed [22] appears to be plotted as such on the Tithe Map. It is also evident as a cropmark which likely confirms the existence of a ditch.

A probable fill at [14] is less easily explained in this manner and does not appear on the Tithe Map and is not aligned with any of the ridge and furrow so remains undated but potentially pre-dates the Tithe Map.

Other small linear anomalies, e.g. [25] and [29], may be land drains.

There is no evidence for settlement or other focused activity.

2.3.6 Anomalies identified

Table 5 Geophysical Survey Catalogue

ID	Data Class	Anomaly Class	Form Class	Feature Class	Feature Sub-Class	Comments
1	TMI	Strong enhanced	Linear continuous	- Utility		
2	TMI	Strong enhanced	Linear continuous	- Utility		
3	TMI	Strong enhanced	Linear continuous	- Utility		
4	TMI	Strong enhanced	Linear continuous	- Utility		
5	TMI	Strong variable	Area	Debris		May be associated with adjacent manure storage.
6	TMI	Enhanced	Linear continuous	- Fill	Ditch	Probable ditch fill, not a known field boundary.
7	TMI	Enhanced	Linear continuous	- Fill?	?	A small group of linear anomalies like ditch fills but otherwise undiagnostic and potentially cultivation-related.
8	TMI	Enhanced	Linear continuous (group)	- Fill	Ditch	Within a small group comprising [7], [8] and [9] and of uncertain nature.
9	TMI	Enhanced	Linear continuous (group)	- Fill	Ditch	Within a small group comprising [7], [8] and [9] and of uncertain nature.

ID	Data Class	Anomaly Class	Form Class	Feature Class	Feature Sub-Class	Comments
10	TMI	Enhanced	Linear continuous	- Fill		Former stream channel, maybe partly canalised, once also a field boundary. This channel is the downstream continuation of [16].
11	TMI	Enhanced	Linear continuous	- Fill		Possible canalised version of [10], also partly extant as a cropmark.
12	TMI	Variable	Linear continuous	- Debris		Probable former field boundary, also evident as a cropmark and therefore likely a ditch fill. See also [13].
13	TMI	Strong enhanced	Linear continuous	- Ferrous?	?	Possible sewerage distribution pipe remaining from the sewerage farm, maybe ceramic rather than steel, but uncertain.
14	TMI	Enhanced	Linear continuous	- Fill	Ditch	Probable ditch fill, uncertain relationship with former pond [15], maybe a relict of a former field system?
15	TMI	Strong enhanced	Area	Fill	Pond	
16	TMI	Enhanced	Linear continuous	- Fill		Former stream course and also field boundary, this stream being moved westwards after 1914 to a location east of and parallel to the track dividing the two fields.
17	TMI	Variable	Area	Fill	Pond	
18	TMI	Variable	Area	Debris?	Structure?	Old OS map editions seem to indicate a small close here, although what is enclosed is uncertain and is now marked by a rectangular area of debris, as if a fill within something or material spread from something.
19	TMI	Strong enhanced	Linear continuous (group)	- Utility	Drain	This appears to be an area of land drains, probably ceramic.
20	TMI	Enhanced	Linear continuous	- Fill?	Ditch?	Ditch fill or drain, uncertain
21	TMI	Enhanced	Linear continuous	- Fill?	Ditch?	See also [20]

ID	Data Class	Anomaly Class	Form Class	Feature Class	Feature Sub-Class	Comments
22	TMI	Enhanced	Linear continuous (group)	- Fill	Ditch	The northern of these two probable fills is also apparent as a cropmark which likely confirms the identification. Neither are known former field boundaries but seem likely to be part of a former field system pre-dating that in use at the time of the sewerage farm.
23	TMI	Enhanced	Linear continuous (group)	- Fill	Ditch	These are all elements of a field system that existed prior to the first OS map edition but were removed prior to use of the land as a sewage farm. They are presumably post-medieval enclosure of medieval arable land given their apparent relationship to adjacent possible ridge and furrow [24].
24	TMI	Enhanced	Linear continuous (group)	- Fill	Cultivation	Possible ridge and furrow cultivation.
25	TMI	Enhanced	Linear continuous (group)	- Fill?	?	Maybe land drains.
26	TMI	Enhanced	Linear continuous (group)	- Fill	Cultivation	Probable ridge and furrow cultivation on the higher ground.
27	TMI	Enhanced	Linear continuous (group)	- Fill		May be land drains.
28	TMI	Strong enhanced	Area	Ferrous		The southern part of this field has something massively magnetic buried beneath it with no surface traces. The narrowness of the survey means that it is not possible to be sure whether this is steel service crossing it or a discrete structure or fill.
29	TMI	Enhanced	Linear continuous	- Fill?	Ditch?	Possible ditch or drain.
30	TMI	Enhanced	Linear continuous	- Fill	Ditch	Probable former field boundary.

2.4.7 Conclusions

There is little of archaeological interest within the magnetic data except slight evidence for former field systems that predate the earliest OS map editions and which are hinted at on the Tithe Map of the 1840s. They seem more complex than depicted. The presence of ridge and furrow cultivation confirms the nearby presence of medieval settlement and the entries in the CPHR. While there is potential for the small number of minor ditch fills to be ancient, none form a coherent layout and given the previously wet nature of the land there could be many generations worth of drainage features.

3. Direct Impacts and Mitigation

3.1 DIRECT IMPACTS

Built development can result in the loss of the archaeological resource wherever ground disturbance takes place, and the potential loss or damage in other areas associated with infrastructure and landscaping.

The PDA lies within an area very modest in pre-medieval archaeology, although this could be a reflection of a lack of development within the rural landscape and therefore a lack of archaeological investigation. The geophysical survey equally points to a low potential for archaeology within the PDA. Ploughing will also have truncated the archaeology.

3.2 MITIGATION OF DIRECT IMPACTS

In accordance with planning policy, loss of archaeology needs to be offset by a programme of mitigation. Although the geophysical survey located only a handful of possible anomalies that could be representative of archaeology, a precautionary approach should be adopted. *Planning Policy Wales* proposes that an appropriate approach to mitigation is to ensure preservation by record through archaeological excavation, recording, analysis and publication appropriate to significance of the archaeological resource.

The nature of the development is however different from the typical large-scale project. Impacts would be limited to areas of cut, reservoirs and pipe- trenches. Prior to greenhouse construction the site is levelled to create a platform. Some of the site is therefore surcharged and the other part cut.

The foundations are very minimal and consist of a peripheral concrete plinth at ground level set on piles. Within the greenhouse piling is necessary to support metal poles but these are lightweight being drilled on a grid of 8 x 5m by a tractor mounted with a screw auger comprising a 700mm diameter drill piece. The continuous flight auger technique employed results in minimal disturbance outside the 700mm drilled core.

It has been calculated that piling causes disturbance to approximately 0.5% of the sub-surface.

It was agreed with the Development Control Archaeologist, Clwyd-Powys Archaeological Trust (CPAT), as advisor to Wrexham County Borough Council, that further discussions would take place pre-development (subject to planning consent) to agree a scope of low-level mitigation (such as targeted trenching) where areas of disturbance coincided with possible archaeological anomalies identified by the geophysical survey.

These works would be undertaken by suitably qualified archaeologists. trenches may need to be expanded to record any archaeology found.

Details of methodologies, in the form of a Written Scheme of Investigation, would be agreed with Wrexham County Borough Council. The work would be secured via a planning condition.

4. Assessment of Indirect Effects upon Designated Assets

4.1 SCOPE

Indirect impacts are those that do not physically affect a cultural heritage asset or landscape, but that alter the context or setting. Such impacts can be difficult to define and should take into account a number of factors including:

- The type and significance of asset or landscape
- The nature and scale of the development
- Working methodology
- Temporality
- Topography
- Visibility, screening and physical separation
- Proximity
- The critical views of, and from the asset or landscape
- Accessibility, interpretation and public appreciation

4.2 ASSESSMENT

A site visit could not be carried out due to Covid-19 restrictions, but sufficient information could be obtained from the Landscape and Visual Impact Assessment⁵ and assessment of Google Earth and Streetview to be confident in the conclusion that no adverse effects of any magnitude would be experienced by any designated assets.

The PDA is situated in a rural landscape, with, locally, strong influences of large-scale commercial development to the west (the water treatment works) and to the east (Wrexham Industrial Restate). Woodland and topography, as well as residential development also serve to screen the PDA from most directions.

The rationale is set out in **Table 6** below.

A single asset was examined in more detail due to it being closer to the PDA than the other asset: Pum-Rhyd – see **Section 4.3**.

⁵ LVIA: Five Fords Glasshouse, land west of Sesswick Way, Marchwiel, LL13 0TF Greenlight Environmental Consultancy

Table 6 Assets scoped out of assessment due to existing factors

Name	Grade	Distance from PDA	Current setting in relation to PDA
Church of SS Marcella and Deiniol	II*	685m WSW	Within Marchwiel village. No views at ground level due to intervening development. Long-distance views may be possible from tower, although existing water treatment works and 1970s development lie between church and PDA
Churchyard walls etc	II	700m WSW	Within Marchwiel village. No views at ground level due to intervening development.
Bedwell Hall	II	600m SE	Orientated south. Set within a modern development built in the Hall's gardens and grounds. No views at ground level due to intervening development.
Pum-Rhyd	II	320m E	See below, section 4.3
Parkey Farm	II	900m E	Topography. No views of PDA
Milestone	II	960m W	Within Marchwiel village. No views at ground level due to intervening development.
Ivydale	II	725m SW	Topography. No views of PDA

4.3 ASSESSMENT OF SETTING OF PUM-RHYD

A single asset was examined in more detail due to it being closer to the PDA than the other assets and in a more rural environment. Pum-Rhyd is situated 320 east of the PDA and 365m east of the greenhouse development (the nearest upstanding part of the development)

It is separated from it by trees and hedging, built development (notably within its own farmyard) and the Bedwell Road and Sessick Way.

Figure 9 shows its context and relationship to the PA. **Figures 10** and **11** show views to and from the house at a mid-point between.

It is concluded that in winter views may be possible through trees devoid of leaves, but that these would be from first floor windows. At ground level, intervening farmbuildings and vegetation would block views.

5. Assessment of Effects

In accordance with the best practice the significance of an effect should be identified taking into account implementation of the proposed mitigation (i.e. the residual effects). This is achieved using policy, guidance and methodology set out in Sections 1.4 and 1.5, above.

The results of the evaluation of significance are drawn together in **Table 7**, below, together with the rationale behind the evaluation.

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Table 7 **Effects and Evaluation of Significance**

	Type of Effect	Probability of Effect Occurring	Sensitivity	Magnitude of Effect	Significance	Rationale
Adverse direct effects upon statutorily designated assets of the historic environment	None	Certain	High	None	Neutral	There are designated assets within the PDA.
Direct effects upon buried archaeology within PDA	Negative	Likely	Low	Medium	Not significant	The PDA lies within an area very modest in pre-medieval archaeology (although that could partly be from a lack of investigation) and the geophysical survey points to a continuation of this. Ploughing will have truncated any archaeology. Mitigation could include targeted trenching.
Indirect effects upon setting of designated heritage assets (except Pum-Rhyd)	None	Certain	Medium (4 assets) High (Grade II* church)	None	Neutral	A combination of topography, intervening built development, woodland and distance will combine to prevent any adverse effects.
Indirect effects upon setting of Pum-Rhyd, Grade II	Negative	Likely	Medium	None	Neutral	Although filtered views may be possible in winter from upstairs windows, this would have no discernible effect upon the setting of the asset, or our ability to understand the resource and its historical context.

6. Summary and Conclusions

6.1 SCOPE OF WORK AND RESULTS

This report presents the findings of a cultural heritage assessment for a proposed glasshouse development on 44ha of land to the east of Five Fords Sewage Facility, Marchwiel, near Wrexham. The majority of the PDA is under arable agriculture

Cultural heritage is represented by a wide range of assets that result from past human use of the landscape. These include historic structures, many still in use, above ground and buried archaeological monuments and remains of all periods, artefacts of anthropological origin and evidence that can help reconstruct past human environments. In its broadest form cultural heritage is represented by the landscape and townscape itself.

This assessment considers both direct and indirect effects upon cultural heritage. Direct effects are those that physically affect a cultural heritage asset. Indirect effects can occur as a result of significant changes to the setting of a cultural heritage landscape or asset, whether permanent or temporary. This is particularly relevant to designated assets such as Scheduled Monuments, Listed Buildings, Conservation Areas, Registered Parks and Gardens and Registered Historic Landscapes.

Desk-based research and a geophysical survey was undertaken of the whole PDA.

6.2 DIRECT EFFECTS UPON ARCHAEOLOGY AND MITIGATION

The PDA lies within an area very modest in pre-medieval archaeology, although this could be a reflection of a lack of development within the rural landscape and therefore a lack of archaeological investigation. The geophysical survey equally points to a low potential for archaeology within the PDA. Ploughing will also have truncated the archaeology.

In accordance with planning policy, loss of archaeology needs to be offset by a programme of mitigation. Although the geophysical survey located only a handful of possible anomalies that could be representative of archaeology, a precautionary approach should be adopted. *Planning Policy Wales* (PPW) proposes that an appropriate approach to mitigation is to ensure preservation by record through archaeological excavation, recording, analysis and publication appropriate to significance of the archaeological resource.

Pre-development trenching would be targeted at geophysical anomalies within areas to be disturbed by the development (notably areas of cut, the reservoirs and pipelines). This approach has been agreed with the Development Control Archaeologist, Clwyd-Powys Archaeological Trust (CPAT), as advisor to Wrexham County Borough Council.

These works would be undertaken by suitably qualified archaeologists. Details of methodologies, in the form of a Written Scheme of Investigation, would be agreed with Wrexham County Borough Council. The work would be secured via a planning condition.

The direct effects upon archaeology are assessed as of low sensitivity and medium magnitude. Taking into account the proposed mitigation the effects are not significant.

6.3 INDIRECT EFFECTS

Indirect impacts are those that do not physically affect a cultural heritage asset or landscape, but that alter the context or setting.

A site visit could not be carried out due to Covid-19 restrictions, but sufficient information could be obtained from the Landscape and Visual Impact Assessment and assessment of Google Earth and Streetview to be confident in the conclusion that no adverse effects of any magnitude would be experienced by any designated assets.

The PDA is situated in a rural landscape, with, locally, strong influences of large-scale commercial development to the west (the water treatment works) and to the east (Wrexham Industrial Restate). Woodland and topography, as well as residential development also serve to screen the PDA from most directions.

There would be no effect upon assets within 1km, including the Grade II* of Church of Saint Marcella and Deiniol due to a combination of intervening development, topography, distance and woodland.

A single asset was examined in more detail due to it being closer to the PDA than the other assets and in a more rural environment. Pum-Rhyd is situated 320 east of the PDA and 365m east of the greenhouse development (the nearest upstanding part of the development). It is separated from it by trees and hedging, built development (notably within its own farmyard) the Bedwell Road and Sessick Way.

It is concluded that in winter views may be possible through trees devoid of leaves, but that these would be from first floor windows. At ground level, intervening farmbuildings would probably block views. The effect is so negligible in magnitude and there would no discernible effect upon setting.

6.4 CONCLUSION

Having regard to the baseline conditions and the nature of the proposed development, there would be no residual effects upon known cultural heritage assets. The proposed development therefore fully accords with both local and national cultural heritage policy.

Figures



Figure 1 **Location of the PDA** © Crown copyright. All rights reserved. Licence number 100043831

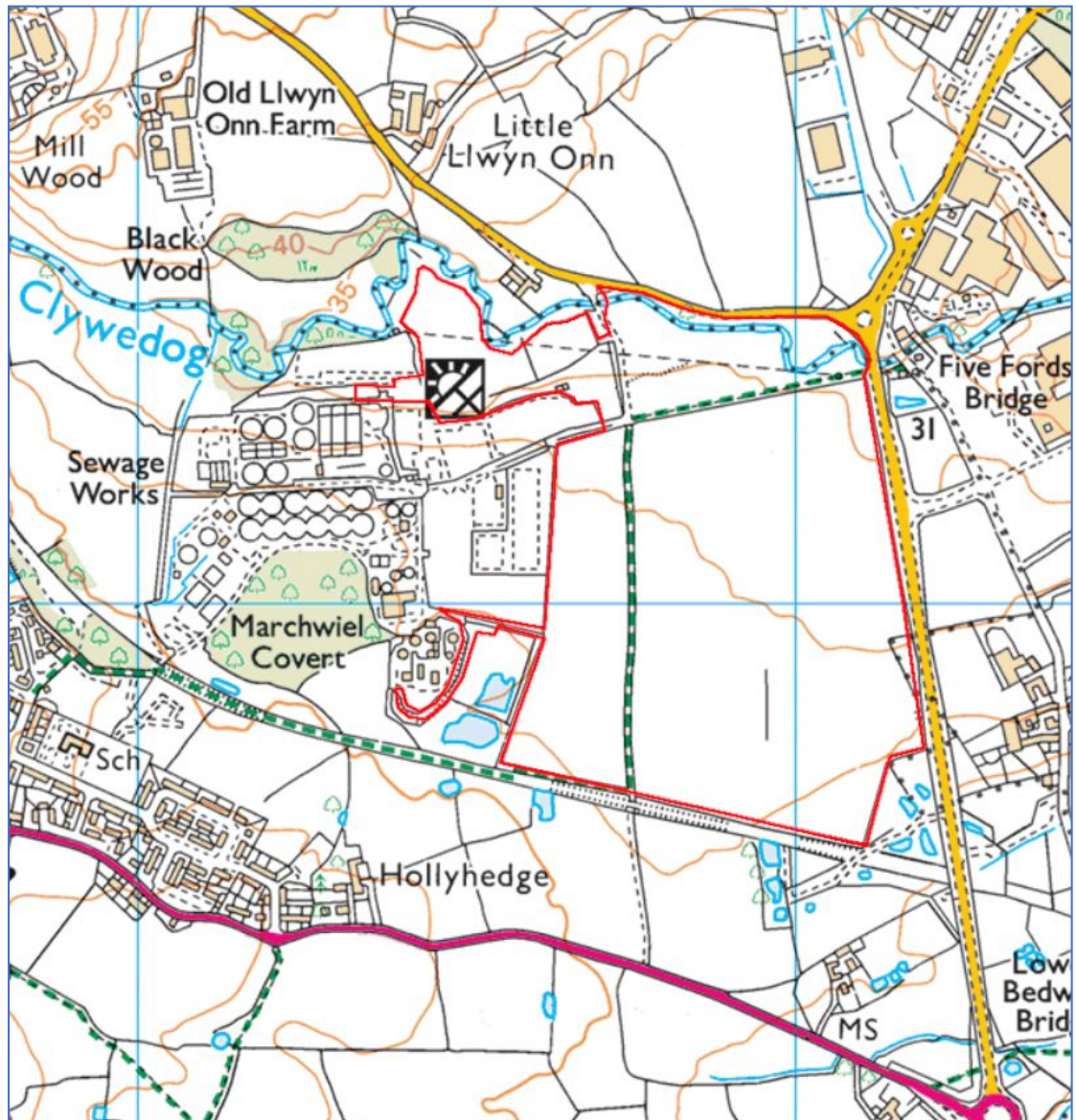


Figure 2 **Application boundary** © Crown copyright. All rights reserved. Licence number 100043831

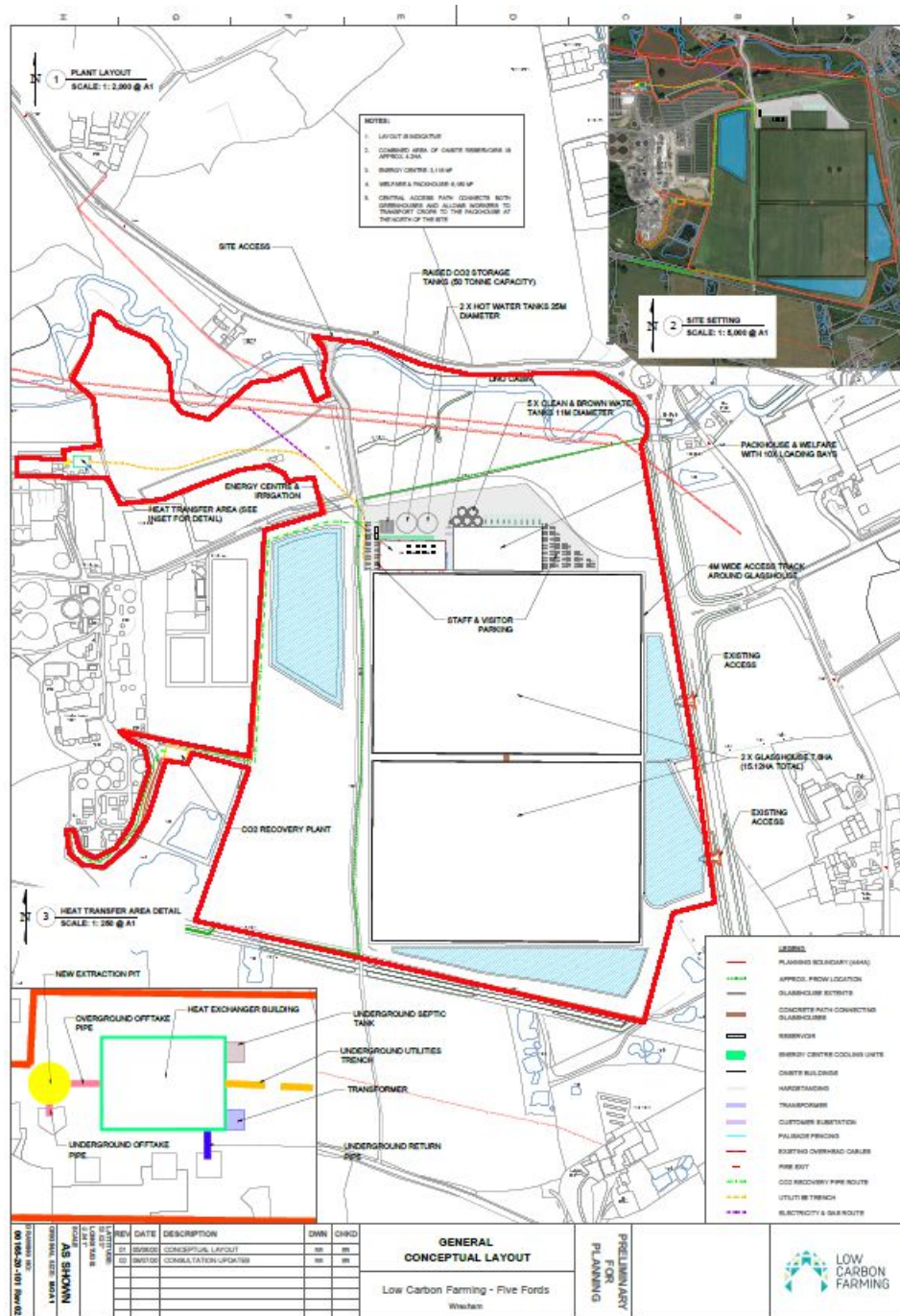


Figure 3 Layout of the proposed development



Figure 4 Designated Heritage Assets within 1km of PDA © Google earth base photo

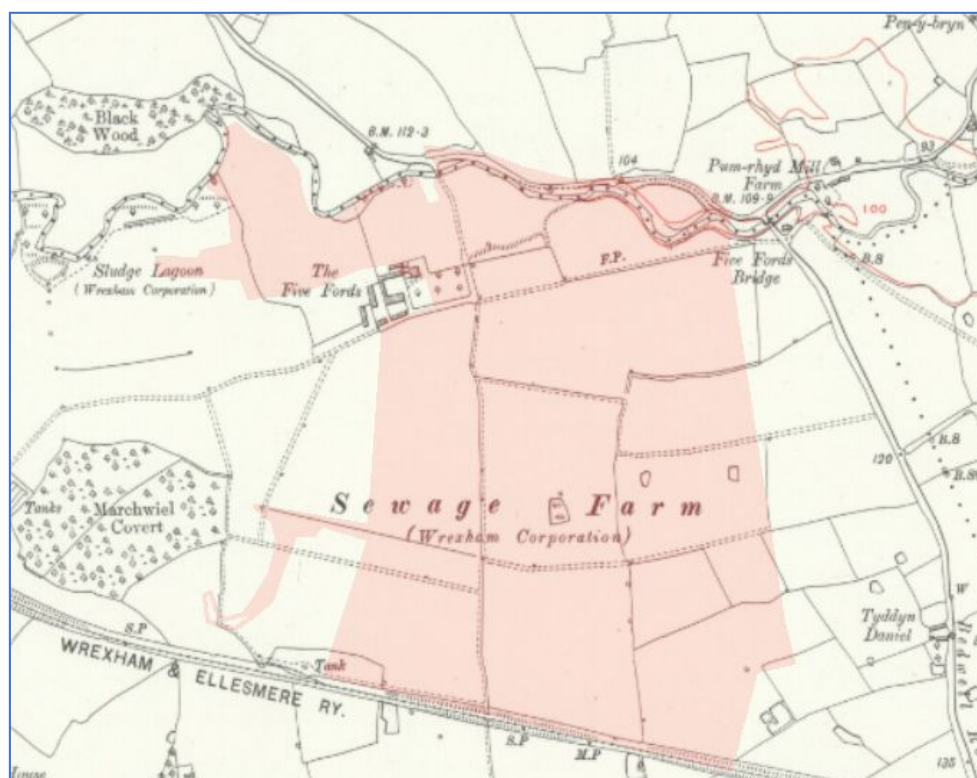


Figure 5 Ordnance Survey 1909

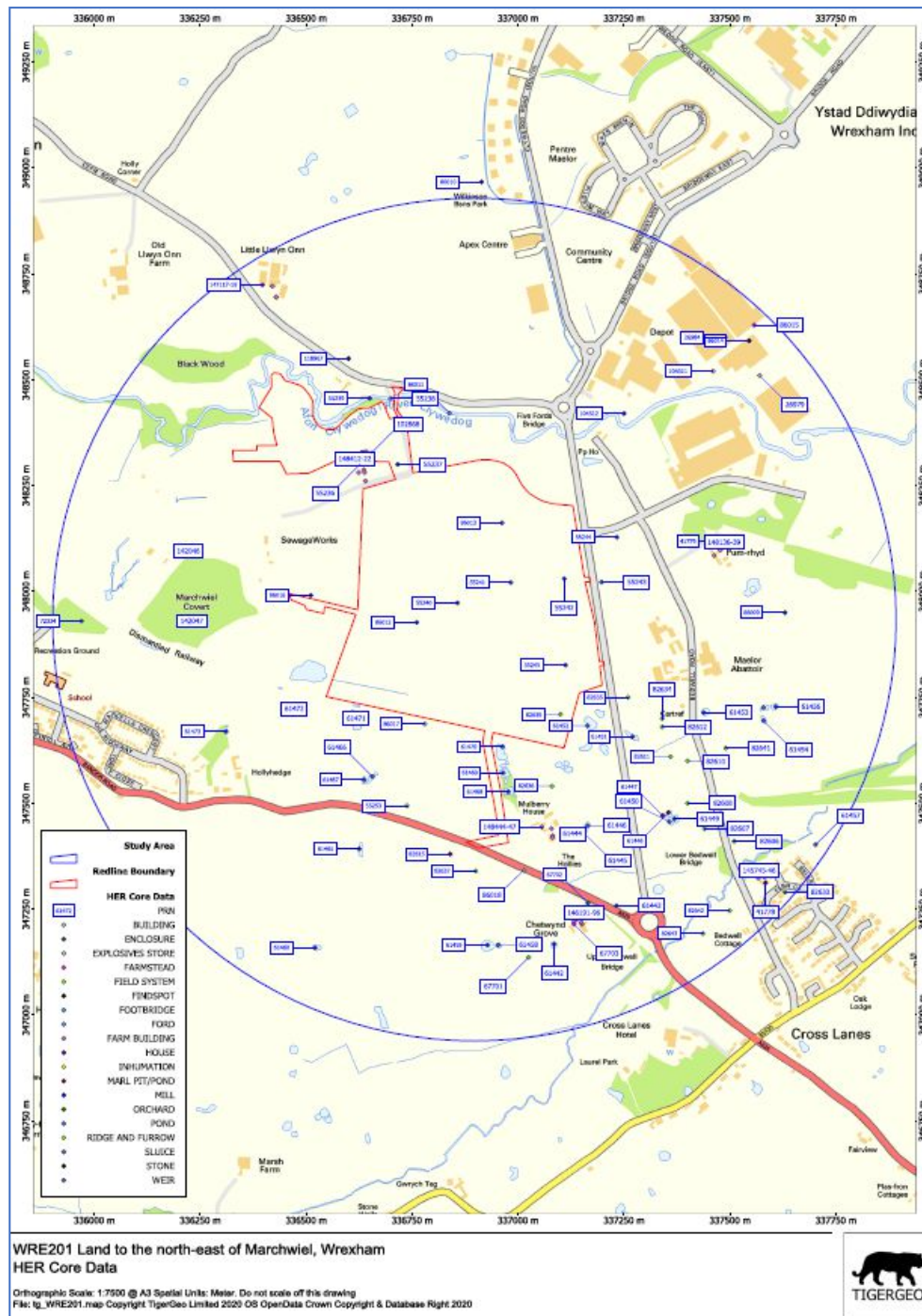


Figure 6 CPAT HER Sites and Monuments within 1km of PDA
 (note: the application boundary has changed since the HER search was commissioned)
 © as shown



Figure 7 CPAT HER Events and Investigations within 1km of PDA
(note: the application boundary has changed since the HER search was commissioned)
© as shown

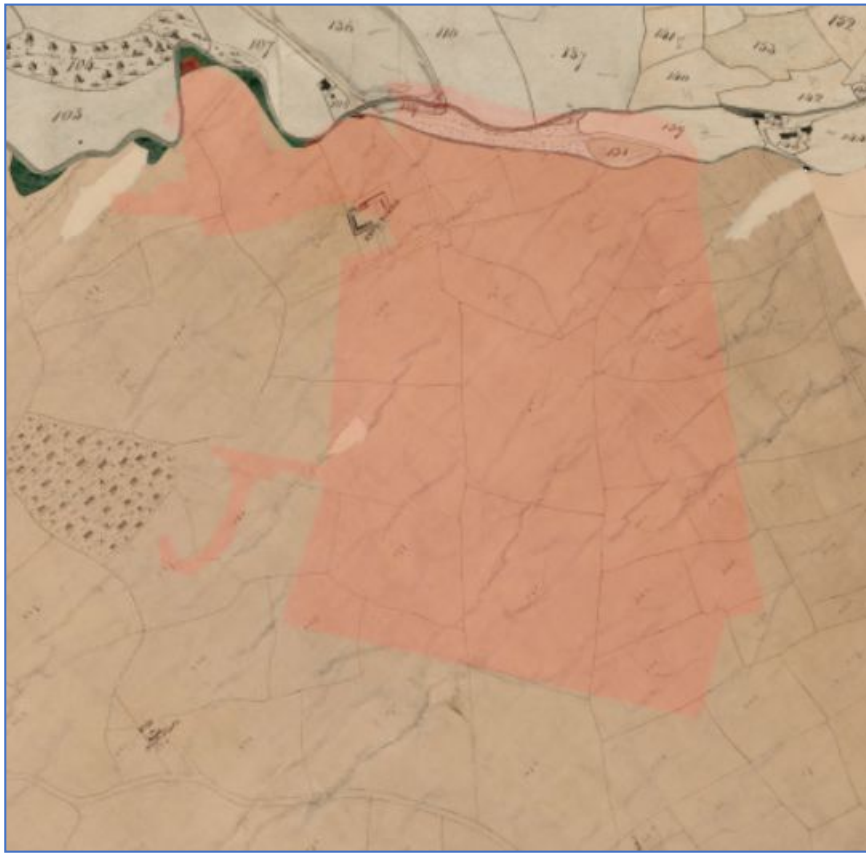


Figure 8 **Tithe Map of Marchwiell parish, 1840**



Figure 9 Context of Pum-Rhyd © Google earth base photo



Figure 10 View east to Pum-Rhyd from Bedwell Road © Google earth



Figure 11 View west from Bedwell Road towards PDA (red line) © Google earth

Appendix A

Description of the proposed development

The proposed project involves the installation of the following components:

Glasshouse buildings

The development will consist of 2no. 7.6 ha glasshouses, comprised of structural steelwork and high specification glass designed for maximum light transmission and covering a total of 15.2 ha of land, each having a maximum gutter height of 7 m and gable apex height of 8 m, inclusive of the 30 cm high concrete perimeter foundations. Internally, the buildings will contain a steel support post mounted on pre-cast concrete pile and a 5 m wide reinforced concrete path running centrally along the length of the glasshouse. With the exception of the concrete path and foundation posts, the internal glasshouse floor remains soil. Other features of the glasshouse buildings include matte aluminium growing gutters hung from the roof, installed at approximately 4 m intervals across the width of the buildings and elevated from the soil floor. Around the outside perimeter of the glasshouse a 4 m wide stone access road is used for construction purposes and is retained during operations for maintenance

Packing and welfare building

The packing and welfare building, located to the north of the glasshouse building, will cover an area of approximately 0.6 ha and comprise elements including the packing area, canteen/toilets, irrigation, storage rooms and site offices. The building will be 8 m high and clad externally with a mix of profiled and flat panel coated steel cladding, with an architectural grey finish to blend into the existing skyline when viewed from distance. The floor will be concrete slab and the packing area will include 10 loading docks.

Energy centre / heating system

Ground source heat pumps will be located in the energy centre, connected to the nearby WwTW through underground closed-loop high-density polyethylene (HDPE) pipes. In addition to the heat pumps, gas combined heat and power (CHP) units will be installed to provide supplementary high temperature water for heating, carbon dioxide and electricity, with air inlet and outlets located on the roof to provide air flow for the CHP. Conventional gas boilers will be installed purely for redundancy purposes.

For maintenance and safety purposes, 6no. electrical transformers surrounded by palisade fencing and 8no. dry air coolers will be located outside the energy centre building.

Two insulated vertical heat store tanks will be located adjacent to the energy centre building, mounted on reinforced concrete base. These tanks will have an above ground side height of 10 m, a 12.5 m apex height and a 25 m diameter.

Five water silos will also be installed adjacent to the energy centre and be mounted on concrete tiles. The silos will have an 11 m diameter and be 6 m high with a flat roof.

CO₂ storage tanks

Currently the adjacent WwTW is venting CO₂ into the atmosphere as a waste product. This CO₂ will be captured, cleaned and transferred via an HDPE pipe buried underground to the glasshouse. It is estimated this captured CO₂ will amount to approximately 5,000 tonnes per annum.

Three stainless steel vacuum CO₂ tanks, 14 m length and 2.5 m diameter, will be installed externally near the energy centre building, with buried mains pipes supplying CO₂ to growing gutters within the glasshouses.

Customer substation

An on-site substation for the supply of electricity to the project, approximately 3 m in height, 10 m in length and 3 m in width, will be installed externally near the energy centre building.

DNO substation

The Distribution Network Operator (DNO) will install an on-site substation for the supply of electricity to the project. The substation design will be dependent on the specific requirements of the DNO, but will typically be dark green GRP construction, approximately 3.5 m in height, 7.5 m in length and 3 m in width.

It should be noted that final equipment suppliers and contractors for the project have yet to be selected. Whilst some variation in the equipment may be necessary we do not envisage significant variation in the presented elevations and footprints.

Access and parking

All areas on site to be used by HGVs will be concrete, including the access road, turning area and 10no. HGV loading bays adjacent to the packhouse. A staff and visitor parking area will be surfaced with compacted stone hardstanding.

Access to the site will be required for project vehicles during the proposed daily operational hours of 0600 to 1800 on weekdays and occasional weekend work 0600 to 1500.

Approximately 150 members of staff will be employed at the facility, of which around 125 will be employed in the glasshouse and 25 in the packhouse and offices; all staff will travel to and from work daily from the local area and no on-site living accommodation will be required in relation to the development.

Closed irrigation system

Irrigation of crops in the glasshouse will comprise a closed system, requiring external supply of mains water only as emergency back-up when the normal working system is off-line. The system comprises two main elements, described as follows:

Rainwater Reservoir: Fall pipes will be attached to the gutters at each gable end (north and south), channelling rainwater from the glasshouse roof to buried drainage pipes. This water will supply lined storage reservoirs adjacent to the glasshouse and is then pumped back to the irrigation room upon demand. The reservoirs will be sized to meet not only the glasshouse irrigation requirements but also have adequate spare attenuation capacity at all times to meet a 1 in 100 storm event. Depending on the local water table, the reservoirs may be raised up to approximately 1 m in height.

Recycled irrigation water: Internal condensation will be captured via internal gutters on the roof and side walls. In addition, water not absorbed by the plant will be collected at either end of the growing gutters and pumped to “brown” water silos, before being fed to the irrigation room for filtration and UV treatment. The treated water will be blended with

reservoir water and stored in clean water silos. Upon irrigation demand the plant nutrients are added in the irrigation room before being gifted back to the plants via the growing gutters; the process is repeated in a loop. A maximum of 5no. water storage silos with approximately 6 m height and 11 m diameter will be installed adjacent to the energy centre buildings.

A small amount of external mains water supply is used for the washing of produce prior to packing.

Utilities trench

The utilities trench will run underground for approximately 465 m from the glasshouse development to the Five Fords WwTW. The underground closed-loop HDPE pipes will connect the ground source heat pumps located in the energy centre to the proposed heat exchanger building (see below).

The utilities trench will incorporate the following elements:

- Trench 2 m depth, 4.2 m width
- 2no. 630 mm HDPE pipes with 500 mm between them to prevent thermal transfer
- 1no. 33 kV 300 mm private electricity cable from energy centre to heat exchanger building transformer
- 1no. 150 mm ducted private fibre communications cable

Branching off to the north, the trench includes:

- 1 no. 33 kV 300 mm ducted mains electricity connection from the electricity network to the DNO substation.
- 1 no. 300 mm steel gas pipe from intermediate gas pipeline to site.

Manholes will be installed along the route (subject to detailed design) to enable access to the pipeline should maintenance be required. Small (knee height) concrete markers will be installed at the side of fields to show the route once installed.

The National Joint Utilities Group (NJUG) code of practice will be employed throughout the entirety of the route, ensuring farming practices can continue, including deep ploughing over the pipeline once installed.

Heat exchanger building

The proposed heat exchanger building will be located within the Five Fords WwTW site. The mono pitch steel framed building will be 19.4 m in length, 14.4 m in width, with eaves height 6 m on the low side and 8 m on the high side, with a mono pitch of 7.5°. The eaves will have galvanised steel box gutters with PVC downpipes. A roller shutter door will be located on the long side, with an adjacent steel personnel door.

Adjacent to the heat exchanger building will be a small outdoor electrical transformer and an underground septic tank to collect any water used in cleaning the heat exchangers. The building would allow for the extraction of heat only from final effluent; the final effluent is not altered or transported from site but passes through the heat exchangers and out the other side. Heat transfer fluid, which is food safe and approved by the Environment Agency, is hydraulically separated from the final effluent by the heat exchanger. The heat transfer fluid is circulated between the heat exchanger and the glasshouse site, where it will be used to heat the glasshouses.

Within the WwTW site, a concrete chamber will be constructed to facilitate the extraction of water from the final effluent pipe. Water will flow from the final water effluent pipe via an underground 700 mm pipe and into the new circular concrete offtake chamber. It will then be pumped out of the chamber via 5no. overground 500 mm steel pipes before entering the heat exchangers housed within the heat exchanger building. Once the heat has been transferred via the heat exchangers into the closed-loop heat water circuit (going back to the glasshouse) the same final effluent water (now colder in temperature) will then flow through 1no. steel 700 mm underground return pipe and back into the final water effluent pipe, downstream from where it was originally extracted. Isolation valves will be installed on both the underground offtake pipe leading to the offtake chamber and underground return pipe.

These isolation valves enable Welsh Water to turn off/bypass the heat exchanger system should it be required.

The offtake connection to the final water effluent pipe will occur within one circular concrete chamber of approximately 6500 mm diameter that will be raised to approximately 1500 mm above ground level. The return connection will be an underground pipe connected to the existing final effluent pipe.

CO₂ Recovery plant

Situated to the southeast of the Welsh Water WwTW facility will be:

- A CO₂ recovery plant measuring 6 m x 12 m and 6.35 m in height.
- 2no. air coolers situated at ground level either side of the recovery plant measuring 8.8m in length, 1.47m in width and 1.32m in height.
- A small gas booster of 1.4 x 2 x 1.6 m in height

The CO₂ recovery plant harvests all waste CO₂ emissions from the Five Fords WwTW anaerobic digester facility. The cleaning process inside the recovery plant upgrades the CO₂ to food grade standard. This clean CO₂ is then transported via an underground pipe to the glasshouse for enhancing the growing environment.

Appendix B: Geophysical Survey



Land to the North-east of Marchwiell, Wrexham

Geophysical Survey Report

(Caesium Vapour Magnetic – Archaeology)

Version 1.0

Project code: WRE201

Produced for:

Andrew Josephs Associates

Lead Author:

MJ Roseveare, Senior Geophysicist

BSc(Hons) MSc MEAGE FGS MCIfA



18th June 2020



Land to the North-east of Marchwiell, Wrexham

Digital data

Item and version	Sent to	Sent date
CAD – Vector Elements 1.0	Andrew Josephs	18 th June 2020

Audit

Version	Author	Checked	Date
Interim			
1.0	MJ Roseveare	ACK Roseveare	18 th June 2020

Project metadata

Project Code	WRE201
Client	Andrew Josephs Associates
Fieldwork Dates	2nd - 4th June 2020
Field Personnel	ACK Roseveare, MJ Roseveare
Data Processing Personnel	ACK Roseveare
Reporting Personnel	MJ Roseveare
Report Date	18th June 2020
Report Version	1.0

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Non-Technical Summary

TigerGeo was commissioned by Andrew Josephs Associates to undertake a geophysical survey for features of archaeological interest of land near Marchwiel on behalf of Low Carbon Farming to support a planning application to construct greenhouses heated using waste heat from the adjacent sewage works plus utilise carbon dioxide from the same. An area of approximately 33.3 hectares across three fields was surveyed using an array of caesium vapour magnetometers, GNSS tracked and towed by an ATV. A non-gradiometric configuration to measure total magnetic intensity and from this was then modelled a 1m vertical pseudogradient data set and the two used to generate the interpretation presented in this report.

Ground conditions were ideal and survey was able to proceed across young maize and through maturing barley without impediment.

Little of archaeological interest was detected with the majority of anomalies being associated with known ponds, former field boundaries and areas of ridge and furrow type cultivation.

Crynodeb Annhechnegol

Comisiynwyd TigerGeo gan Andrew Josephs Associates i gynnal arolwg geoffisegol ar gyfer nodweddion o ddiddordeb archaeolegol o dir ger Marchwiel ar ran Low Carbon Farming er mwyn cefnogi cais cynllunio ar gyfer adeiladu tai gwydr wedi'u gwresogi gan ddefnyddio gwres gwastraff o'r gwaith carthffosiaeth cyfagos, yn ogystal â defnyddio carbon deuocsid o'r un tarddiad. Arolygwyd ardal o tua 33.3 hectar ledled tri chae gan ddefnyddio ystod o fagtometau anwedd caesiwm, wedi'u tracio gan GNSS a'u tynnu gan ATV. Cyfluniad nad yw'n raddiometrig er mwyn mesur cyfanswm dwysedd magnetig ac o hyn wedyn modelwyd set ddata pseudograddiant fertigol 1m a defnyddiwyd y ddau i gynhyrchu'r dehongliad a gyflwynir yn yr adroddiad hwn.

Roedd amodau'r tir yn ddelfrydol a gallai'r arolwg barhau drwy india-corn ifanc a thrwy barlys a oedd yn aeddfedu yn ddi-rwyst.

Ychydig o ddiddordeb archaeolegol a ganfuwyd, ac roedd y rhan fwyaf o'r anomaledau yn gysylltiedig â phyllau hysbys, hen ffiniau caeau ac ardaloedd o amaethu grwn a rhych.



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Drawing	Title
DWG 01	Site Location
DWG 02, a-e	Total Magnetic Intensity
DWG 03, a-e	1m Vertical Pseudogradient
DWG 04, a-e	Interpretation

1 Introduction

TigerGeo was commissioned by Andrew Josephs Associates to undertake a geophysical survey for features of archaeological interest of land near Marchwiell on behalf of Low Carbon Farming to support a planning application to construct greenhouses heated using waste heat from the adjacent sewage works plus utilise carbon dioxide from the same. The survey area is located to the west of Sesswick Way and occupies an area bounded by a solar farm and sewage plant to the west and the River Clywedog to the north. An area of approximately 33.3 hectares across three fields was surveyed, part of the originally specified area, including the site of demolished Five Fords Farm, now being within the fence of the solar farm and hence unavailable for survey.

Survey was undertaken using an array of caesium vapour magnetometers, GNSS tracked and towed by an ATV. Advanced processing was undertaken to allow use of the resulting total magnetic intensity data plus a modelled vertical pseudogradient to assist interpretation.

Country	Wales
County	Wrexham
Nearest Settlement	Marchwiell
Central Co-ordinates	336998, 348000

2 Context

2.1 Environment

Soilscapes Classification	Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils (18)
Superficial 1:50000 BGS	Till, Devensian – Diamicton (TILLD) River Terrace Deposits (undifferentiated) - Sand And Gravel (RTD) Alluvium - Clay, Silt, Sand And Gravel (ALV)
Bedrock 1:50000 BGS	Salop Formation - Mudstone, Sandstone And Conglomerate (SAL)
Topography	Impeded drainage
Hydrology	Impeded drainage
Current Land Use	Arable
Historic Land Use	Mixed agricultural then a sewage farm from late 1800s
Vegetation Cover	Maize (recently planted) and maturing barley

The soil iron content (1.9%) recorded on the British Geological Survey 5km G-Base is below the national average but should be sufficient for the detection of anomalies of potential archaeological interest. Allowance needs to be made for the wet nature of the local soils which can have a variable effect upon the availability of iron for modification to more magnetic forms through anthropogenic processes. Here the alluvial deposits close to the river are likely to produce the weakest anomalies, however, much of this area is in any case obscured by ferrous pipelines to the sewage works.

2.2 Heritage

The proposed survey area lies in a medieval to post-medieval agricultural landscape, with data contained within the Clwyd-Powys Historic Environment Record (HER) showing the location of the former Five Fords Farm in the north-west of the proposed survey area. The HER shows the central area scattered with former clay or marl pits, not depicted on the Marchwiell Tithe Map, but as ponds on early editions of the Ordnance Survey, and several sluices that relate to use of the site as a sewage farm.

Underlying this there may be potential for medieval agricultural activity, with Marchwiell Covert, to the east of the site, being part of a medieval open field system, and medieval or later ridge and furrow cultivation is also recorded in the wider environs of the site.

3 Discussion

3.1 Character & Principal Results

3.1.1 Introduction

The following paragraphs represent an interpretive summary of the survey. The numbers in square brackets refer to individual anomalies described in detail in the catalogue below and shown on DWG 04.

3.1.2 Data

The data quality is high, free of significant collection artefacts and with reasonable contrast throughout. Confidence is boosted in part by the presence of a correlation between cropmarks typical of ditch fills and coincident magnetic anomalies. Overall anomaly strength is weak with former cultivation contributing 0.5 nT or less to the ambient field although ditch fills, presumably due to depositional remanent magnetisation, tend to contribute more, up to about 2.5 nT although strengths vary widely.

The use of non-gradiometric caesium vapour instrumentation at this site in combination with pseudo-gradient modelling has allowed increased confidence in the amplitude resolution of the data and hence the detectability of features of potential interest.

3.1.3 Geology

Anomaly strengths associated with former cultivation tend to be highest on the higher ground near the south-east corner of the site which reinforces the overall impression that hydrology is a factor in magnetic character at this site.

Much of the site is founded on Quaternary Devensian - Diamicton till and this has the characteristic slightly speckled magnetic texture of this area due to magnetic materials brought to here from north-west Wales. The northwards transition to undifferentiated River Terrace Deposits is not evident within the data except perhaps as a tiny decrease in background magnetic susceptibility. In contrast, the smooth background texture in the northernmost field is typical of deep alluvium, seen here to be cut by former river channels with till and boulder fills.

Overall there seems little reason to suspect changes in the detectability of features of interest on the basis of variations in the superficial geology.

3.1.4 Land use

In the northernmost field much of the area is affected by the magnetic field from two steel pipelines that presumably connect with the sewage works and a third was noted crossing the river but not seen within the data.

Much of the evidence for land use confirms the long existence of the land for arable purposes with ponds, field boundaries and former cultivation. Whether the ponds are natural or flooded marl pits is conjectural but given the superficial geology is till deposits maybe marl digging is less likely? Known ponds include debris filled areas [15], [17] and several of the smaller patches of magnetic debris could have a similar origin.

There was once a stream, diverted after 1914, flowing south to north across the site and it formed part of the system of field boundaries. It is apparent as a fill at [16] and then at [10] but at some point it appears to have been canalised as [11], maybe during use of the area as a sewage farm, before being moved.

Other former field boundaries include [22] and a group at [23], all being ditch fills. These, with another at [30], seem directly associated with adjacent ridge and furrow cultivation with [30] being perhaps along a headland at the end of [26]. This medieval cultivation, so [24] and [26], is only evident on the higher ground, but whether this is due to variable magnetic contrast, incidence or survival is not clear. It is possible the lower ground, being likely wetter here, may not have been cultivated at this time.

Of the sewage farm little seems to have survived below ground, however, with the exception of pipes of unknown material and brick built free-standing sluice structures, maybe there was little to find. At [13] there appears to be an intact pipe run and more must survive below the hedges where some sluice structures still survive, however, of the sluices known to have existed out in the fields nothing magnetic appears to have survived. There is the occasional scatter of debris that might be the ploughed out remains of some of these structures.

3.1.5 Archaeology

There is little of obvious archaeological interest within the magnetic data and much that is possible could be of almost any date and origin, comprising in the main a number of non-diagnostic possible ditch fills, e.g. [7] – [9]. Some, e.g. [15] and [22], seem to be elements of a former field system and indeed [22] appears to be plotted as such on the Tithe Map. It is also evident as a cropmark which likely confirms the existence of a ditch.

A probable fill at [14] is less easily explained in this manner and does not appear on the Tithe Map and is not aligned with any of the ridge and furrow so remains undated but potentially pre-dates the Tithe Map.

Other small linear anomalies, e.g. [25] and [29], may be land drains.

There is no evidence for settlement or other focused activity.

3.2 Catalogue

ID	Data Class	Anomaly Class	Form Class	Feature Class	Feature Sub-Class	Comments
1	TMI	Strong enhanced	Linear continuous	- Utility		
2	TMI	Strong enhanced	Linear continuous	- Utility		
3	TMI	Strong enhanced	Linear continuous	- Utility		
4	TMI	Strong enhanced	Linear continuous	- Utility		
5	TMI	Strong variable	Area	Debris		May be associated with adjacent manure storage.
6	TMI	Enhanced	Linear continuous	- Fill	Ditch	Probable ditch fill, not a known field boundary.
7	TMI	Enhanced	Linear continuous	- Fill?	?	A small group of linear anomalies like ditch fills but otherwise undiagnostic and potentially cultivation-related.
8	TMI	Enhanced	Linear continuous (group)	- Fill	Ditch	Within a small group comprising [7], [8] and [9] and of uncertain nature.
9	TMI	Enhanced	Linear continuous (group)	- Fill	Ditch	Within a small group comprising [7], [8] and [9] and of uncertain nature.
10	TMI	Enhanced	Linear continuous	- Fill		Former stream channel, maybe partly canalised, once also a field boundary. This channel is the downstream continuation of [16].
11	TMI	Enhanced	Linear continuous	- Fill		Possible canalised version of [10], also partly extant as a cropmark.

ID	Data Class	Anomaly Class	Form Class	Feature Class	Feature Sub-Class	Comments
12	TMI	Variable	Linear continuous	- Debris		Probable former field boundary, also evident as a cropmark and therefore likely a ditch fill. See also [13].
13	TMI	Strong enhanced	Linear continuous	- Ferrous?	?	Possible sewerage distribution pipe remaining from the sewerage farm, maybe ceramic rather than steel, but uncertain.
14	TMI	Enhanced	Linear continuous	- Fill	Ditch	Probable ditch fill, uncertain relationship with former pond [15], maybe a relict of a former field system?
15	TMI	Strong enhanced	Area	Fill	Pond	
16	TMI	Enhanced	Linear continuous	- Fill		Former stream course and also field boundary, this stream being moved westwards after 1914 to a location east of and parallel to the track dividing the two fields.
17	TMI	Variable	Area	Fill	Pond	
18	TMI	Variable	Area	Debris?	Structure?	Old OS map editions seem to indicate a small close here, although what is enclosed is uncertain and is now marked by a rectangular area of debris, as if a fill within something or material spread from something.
19	TMI	Strong enhanced	Linear continuous (group)	- Utility	Drain	This appears to be an area of land drains, probably ceramic.
20	TMI	Enhanced	Linear continuous	- Fill?	Ditch?	Ditch fill or drain, uncertain
21	TMI	Enhanced	Linear continuous	- Fill?	Ditch?	See also [20]
22	TMI	Enhanced	Linear continuous (group)	- Fill	Ditch	The northern of these two probable fills is also apparent as a cropmark which likely confirms the identification. Neither are known former field boundaries but seem likely to be part of a former field system pre-dating that in use at the time of the sewerage farm.
23	TMI	Enhanced	Linear continuous (group)	- Fill	Ditch	These are all elements of a field system that existed prior to the first OS map edition but were removed prior to use of the land as a sewage farm. They are presumably post-medieval enclosure of medieval arable land given their apparent relationship to adjacent possible ridge and furrow [24].
24	TMI	Enhanced	Linear continuous (group)	- Fill	Cultivation	Possible ridge and furrow cultivation.

ID	Data Class	Anomaly Class	Form Class	Feature Class	Feature Sub-Class	Comments
25	TMI	Enhanced	Linear continuous (group)	- Fill?	?	Maybe land drains.
26	TMI	Enhanced	Linear continuous (group)	- Fill	Cultivation	Probable ridge and furrow cultivation on the higher ground.
27	TMI	Enhanced	Linear continuous (group)	- Fill		May be land drains.
28	TMI	Strong enhanced	Area	Ferrous		The southern part of this field has something massively magnetic buried beneath it with no surface traces. The narrowness of the survey means that it is not possible to be sure whether this is steel service crossing it or a discrete structure or fill.
29	TMI	Enhanced	Linear continuous	- Fill?	Ditch?	Possible ditch or drain.
30	TMI	Enhanced	Linear continuous	- Fill	Ditch	Probable former field boundary.

3.3 Conclusions

There is little of archaeological interest within the magnetic data except slight evidence for former field systems that predate the earliest OS map editions and which are hinted at on the Tithe Map of the 1840s but seem more complex than depicted. The presence of ridge and furrow cultivation confirms the nearby presence of medieval settlement. While there is potential for the small number of minor ditch fills to be ancient, none form a coherent layout and given the previously wet nature of the land there could be many generations worth of drainage features.

3.4 Caveats

Geophysical survey is reliant upon the detection of anomalous values and patterns in physical properties of the ground, e.g. magnetic, electromagnetic, electrical, elastic, density and others. It does not directly detect underground features and structures and therefore the presence or absence of these within a geophysical interpretation is not a direct indicator of presence or absence in the ground. Specific points to consider are:

- some physical properties are time variant or mutually interdependent with others;
- for a buried feature to be detectable it must produce anomalous values of the physical property being measured;
- any anomaly is only as good as its contrast against background textures and noise within the data.

TigerGeo will always attempt to verify the accuracy and integrity of data it uses within a project but at all times its liability is by necessity limited to its own work and does not extend to third party data and information. Where work is undertaken to another party's specification any perceived failure of that specification to attain its objective remains the responsibility of the originator, TigerGeo meanwhile ensuring any possible shortcomings are addressed within the normal constraints upon resources.

4 Methodology

4.1 Magnetic Principles

4.1.1 Physical concepts

Magnetic survey for any purpose relies upon the generation of a clear magnetic anomaly at the surface, i.e. strong enough to be detected by instrumentation and exhibiting sufficient contrast against background variation to permit diagnostic interpretation. The anomaly itself is dependent upon the chemical properties of a particular volume of ground, its magnetic susceptibility and hence induced magnetic field, the strength of any remanent magnetisation, the shape and orientation of the volume of interest and its depth of burial. Finally the choice and configuration of measurement instrumentation will affect anomaly size and shape.

Sites present a complex mixture of these factors and for some the causative affects are not known. However, depth of burial and size are usually fairly constrained and background susceptibility can be estimated (or measured). The degree of remanent magnetisation is harder to predict and depends on both the natural magnetic properties of the soil and any chemical processes to which it has been subjected. Fortunately heat will raise the susceptibility of most soils and topsoil tends to be more magnetic than subsoil, by volume.

It is hard to draw reliable conclusions about what sort of geology is supportive of magnetic survey as there are many factors involved and in any case magnetic response can vary across geological units as well as being dependent upon post-deposition and erosional processes. In general a relatively non-magnetic parent material contrasting with a magnetisable erosion product, i.e. one which contains iron in the form of oxides and hydroxides, will allow archaeological structures to exhibit strong magnetic contrast against their surroundings and especially if the soil has been heated or subjected to certain processes of fermentation. In the absence of either, magnetic enhancement becomes entirely reliant upon the geochemistry of the soil and enhancement will often be weaker and more variable.

Analysis of the British Geological Survey (BGS) Geochemical Atlas (G-Base) for total soil iron reveals that for England and Wales 50% of the samples (the interquartile range) lie between 1.9% and 3.6% percentage iron with the median at 2.7%.

The principal magnetic iron mineral is the oxide magnetite which sometimes occurs naturally but is more often formed during the heating of soil. Subsequent cooling yields a mixture of this, non-magnetic oxide haematite and another magnetic oxide, maghaemite. Away from sources of heat, other magnetic iron minerals include the sulphides pyrite and greigite while in damp soils complex chemistry involving the hydroxides goethite and lepidocrocite can create strong magnetic anomalies. There are thus a number of different geochemical reaction pathways that can both augment and reduce the magnetic susceptibility of a soil. In addition, this susceptibility may exhibit depositional patterns unrelated to visible stratigraphy.

Most structures of archaeological interest detected by magnetic survey are fills within negative or cut features. Not all fills are magnetic and they can be more magnetic or less magnetic than the surrounding ground. In addition, it is common for fills to exhibit variable magnetic properties through their volume, basal primary silt often being more magnetic than the material above it due to the increased proportion of topsoil within it. However, a fill containing burnt soil may be much more magnetic than this primary silt and sometimes a feature that has contained standing water can produce highly magnetic silts through mechanical depositional processes (depositional remanent magnetisation, DRM).

A third structural factor in the detection of buried structures is the depth of topsoil over the feature. As fills sink, the hollow above accumulates topsoil and hence a structure can be detected not through its own magnetisation but through the locally deeper topsoil above it. The volume of soil required depends upon the magnetic susceptibility of the soil but just a few centimetres are often sufficient. Such a thin deposit can, however, easily be lost through subsequent erosion by natural factors or ploughing.

4.1.2 Instrumentation

The use of the magnetic sensors in non-gradiometric (vertical) configuration avoids measurement sensitisation to the shallowest region of the soil, allowing deeper structures, whether natural or otherwise to

be imaged within the sensitivity of the instrumentation. This also allows the detection of shallow broad variations in magnetic susceptibility that might have archaeological significance. Suppression of ambient noise and temporal trends is reduced and therefore need reduction during processing.

The theoretical slightly reduced lateral resolution inherent to using non-gradiometric sensor arrays is practically not an issue and especially if processing includes a vertical pseudo-gradient conversion. The non-gradiometric system is thus overall a more capable configuration than the short gradiometers often used for archaeological studies.

Caesium instrumentation has a greater sensitivity than fluxgate instruments, however, at the 10 Hz sampling rate used here this increase in sensitivity is limited to about one order of magnitude. Greater benefit is obtained from a better signal-to-noise ratio meaning that sub-nanoTesla measurement is more practically achieved.

The array system is designed to be non-magnetic and to contribute virtually nothing to the magnetic measurement, whether through direct interference or through motion noise.

4.2 Magnetic Survey

4.2.1 Technical equipment

Measured variable	Magnetic flux density / nT (Total Magnetic Intensity / nT after removal of regional trend)
Instrument	Array of Geometrics G858 Magmapper caesium magnetometers
Configuration	Non-gradiometric transverse array (6 sensors, ATV towed)
Sensitivity	0.03 nT @ 10 Hz (manufacturer's specification)
QA Procedure	Continuous observation
Spatial resolution	1.0m between lines, 0.25m mean along line interval

4.2.2 Monitoring & quality assessment

The system continuously displays all incoming data as well as line speed and spatial data resolution per acquisition channel during survey. Rest mode system noise is therefore easy to inspect simply by pausing during survey, and the continuous display makes monitoring for quality intrinsic to the process of undertaking a survey. Rest mode test results (static test) are available from the system.

4.3 Magnetic Data Processing

4.3.1 Procedure

All data processing is minimised and limited to what is essential for the class of data being collected, e.g. reduction of orientation effects, suppression of single point defects (drop-outs or spikes) etc. The processing stream for this data is as follows:

Process	Software	Parameters
Measurement & GNSS receiver data alignment	Proprietary	
Temporal reduction, regional field suppression	Proprietary	Bandpassed 0.3 – 10.0s
Gridding	Surfer	Kriging, 0.25m x 0.25m
Smoothing	Surfer	Gaussian lowpass 3x3 data (0.75m)
Pseudo-gradient conversion	Proprietary	1m vertical

Potential field processing procedures are used where possible on gridded data from the above processing, allowing simulation of vertical gradient data, separation of deep and shallow magnetic sources, etc. The initial processing uses proprietary software developed in conjunction with the multisensor acquisition system. Gridded data is ported as data surfaces (not images) into Manifold GIS for final imaging, contouring and detailed analysis. Specialist analysis is undertaken using proprietary software.

4.4 Magnetic Interpretation

4.4.1 Introduction

Numerous sources are used in the interpretive process, which takes into account shallow geological conditions, past and present land use, drainage, weather before and during survey, topography and any previous knowledge about the site and the surrounding area. Old Ordnance Survey mapping is consulted and also older sources if available. Geological information (for the UK) is sourced only from British Geological Survey resources and aerial imagery from online sources. LiDAR data is usually sourced from the Environment Agency or other national equivalents, SAR from NASA and other topographic data from original survey.

Information from nearby surveys is consulted to inform upon local data character, variations across soils and near-surface geological contexts. Published data from other surveys may also be used if accompanied by adequate metadata.

Interpretation of magnetic data is undertaken using total intensity data, vertical pseudo-gradient and where relevant, shallow field, component models in parallel although for clarity only a subset of these may be presented in the report.

4.4.2 The contribution from geology and soils

On some sites, e.g. some gravels and alluvial contexts, there will be anomalies that can obscure those potentially of archaeological interest. They may have a strength equal to or greater than that associated with more relevant sources, e.g. ditch fills, but can normally be differentiated on the basis of anomaly form coupled with geological understanding. Where there is ambiguity, or relevance to the study, these anomalies will be included in this category.

Not all changes in geological context can be detected at the surface, directly or indirectly, but sometimes there will be a difference evident in the geophysical data that can be attributed to a change, e.g. from alluvium to tidal flat deposits, or bedrock to alluvium. In some cases the geophysical difference will not exactly coincide with the geological contact and this is especially the case across transitions in soil type.

Geophysical data varies in character across areas, due to a range of factors including soil chemistry, near surface geology, hydrology and land use past and present. These all contribute to the texture of the data, i.e. a background character against which all other anomalies are measured.

4.4.3 Agricultural inputs

Coherent linear dipolar enhancement of magnetic field strength marking ditch fills, narrow bands of more variable magnetic field or changes in apparent magnetic susceptibility, are all included within the category of former field boundaries if they correlate with those depicted on the Tithe Map or early Ordnance Survey maps. If there is no correlation then these anomaly types are not categorised as a field boundaries.

Banded variations in apparent magnetic susceptibility caused by a variable thickness of topsoil, depositional remanent magnetisation of sediments in furrows or susceptibility enhancement through heating (a by product of burning organic matter like seaweed) tend to indicate past cultivation, whether ridge-based techniques, medieval ridge and furrow or post medieval 'lazy beds'. Modern cultivation, e.g. recent ploughing, is not included.

In some cases it is possible to identify drainage networks either as ditch-fill type anomalies (typically 'Roman' drains), noisy or repeating dipolar anomalies from terracotta pipes or reduced magnetic field strength anomalies from culverts, plastic or non-reinforced concrete pipes. In all cases identification of a herring bone pattern to these is sufficient for inclusion within this category.

4.4.4 Features of archaeological interest

Any linear or discrete enhancement of magnetic field strength, usually with a dipolar character of variable strength, that cannot be categorised as a field boundary, cultivation or as having a geological origin, is classified as a fill potentially being of archaeological interest. Fills are normally earthen and include an often

invisible proportion of heated soil or topsoil that augments local magnetic field strength. Inverted anomalies are possible over non-earthen fills, e.g. those that comprise peat, sand or gravel within soil. This category is subject to the 'habitation effect' where, in the absence of other sources of magnetic material, anomaly strength will decrease away from sources of heated soil and sometimes to the extent of non-detectability.

Former enclosure ditches that contained standing water can promote enhanced volumetric magnetic susceptibility through depositional remanence and remain detectable regardless of the absence of other sources of magnetic enhancement.

Anything that cannot be interpreted as a fill tends to be a structure, or in archaeological terms, a feature. This category is secondary to fills and includes anomalies that by virtue of their character are likely to be of archaeological interest but cannot be adequately described as fills. Examples include strongly magnetic bodies lacking ferrous character that might indicate hearths or kilns. In some cases anomalies of ferrous character may be included.

On some sites the combination of plan form and anomaly character, e.g. rectilinear reduced magnetic field strength anomalies, might indicate the likely presence of masonry, robber trenches or rubble foundations. Other types of structure are only included if the evidence is unequivocal, e.g. small ring ditches with doorways and hearths. In some circumstances a less definite category may be assigned to the individual anomalies instead.

It is sometimes possible to define different areas of activity on the basis of magnetic character, e.g. texture and anomaly strength. These might indicate the presence of middens or foci within larger complexes. This category does not indicate a presence or absence of discrete anomalies of archaeological interest.

4.5 Glossary

Acronym / term	Type	Definition
A	Physical quantity	SI unit Amp of electric current
BGS	Organisation	British Geological Survey
CIfA	Organisation	Chartered Institute for Archaeologists
dB	Physical quantity	Decibel, unit of amplification / attenuation
DRM	Process	Depositional Remanent Magnetisation
EAGE	Organisation	European Association of Geoscientists and Engineers
EGNOS	Technology	European Geostationary Navigation Overlay Service
ERT	Technology	Electrical resistivity tomography
ETRS89	Technology	European Terrestrial Reference System (defined 1989)
ETSI	Organisation	European Telecommunications Standards Institute
EuroGPR	Organisation	European Ground Penetrating Radar Association, the trade body for GPR professionals
G-BASE	Data	British Geological Survey Geochemical Atlas
GeoSoc	Organisation	Geological Society of London, the chartered body for the geological profession
GNSS	Technology	Global Navigation Satellite System
GPR	Technology	Ground penetrating radar
GPS	Technology	Global Positioning System (US)
inversion	process	A combination of forward and backward modelling intended to construct a 2D or 3D model of the physical distribution of a variable from data measured on a 1D or 2D surface. It is fundamental to ERT survey
IP	Physical quantity	Induced polarisation (or chargeability) units mV/V or ms
m	Physical quantity	SI unit metres of distance
mbgl	Physical quantity	Metres below ground level
MHz	Physical quantity	SI unit mega-Hertz of frequency
MS	Physical quantity	Magnetic susceptibility, unitless
mS	Physical quantity	SI unit milli-Siemens of electrical conductivity
nT	Physical quantity	SI unit nano-Tesla of magnetic flux density

Acronym / term	Type	Definition
OFCOM	Organisation	The Office of Communications, the UK radio spectrum regulator
Ohm	Physical quantity	SI unit Ohm of electrical resistance
OS	Organisation	Ordnance Survey of Great Britain
OSGB36	Data	The OS national grid (Great Britain)
OSTN15	Technology	Current coordinate transformation from ETRS89 to OSGB36 co-ordinates
RDP	Physical quantity	Relative Dielectric Permittivity, unitless
RTK	Technology	Real Time Kinematic (correction of GNSS position from a base station)
s	Physical quantity	SI unit seconds of time
TMI	Physical quantity	Total magnetic intensity (measured flux density minus regional flux density)
TRM	Process	Thermo-Remanent Magnetisation
V	Physical quantity	SI unit Volt of electric potential
WGS84	Data	World Geodetic System (defined 1984)

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4.7 Archiving and dissemination

An archive is maintained for all projects, access to which is permitted for research purposes. Copyright and intellectual property rights are retained by TigerGeo on all material it has produced, the client having full licence to use such material as benefits their project. Where required, digital data and a copy of the report can be archived in a suitable repository, e.g. the Archaeology Data Service, in addition to our own archive.

The archive contains all survey and project data, communications, field notes, reports and other related material including copies of third party data (e.g. CAD mapping, etc.) in digital form. Many are in proprietary formats while report components are available in PDF format.

The client will determine the distribution path for reporting, including to the end client, other contractors, local authority etc., and will determine the timetable for upload of the project report to the OASIS Grey Literature library or supply of report or data to other archiving services, taking into account end client confidentiality.

TigerGeo reserves the right to display data rendered anonymous and un-locatable on its website and in other marketing or research publications.

5 Supporting information

5.1 Standards and quality (archaeology)

TigerGeo is developing an Integrated Management System (IMS) towards ISO certification for ISO9001, ISO14001 and OHSAS18001/ISO45001. For work within the archaeological sector TigerGeo has been awarded CIfA (Chartered Institute for Archaeologists) Registered Organisation status.

A high standard of client-centred professionalism is maintained in accordance with the requirements of relevant professional bodies including the Geological Society of London (GeoSoc) and the Chartered Institute for Archaeologists (CIfA). Senior members of TigerGeo are professional members of the GeoSoc (FGS), CIfA (MCIfA & ACIfA grades) and other appropriate bodies, including the European Association of Geoscientists and Engineers (EAGE) Near Surface Division (MEAGE) and the Institute of Professional Soil Scientists (MISoilSci).

In addition TigerGeo is a member of EuroGPR and all ground penetrating and other radar work is in accordance with ETSI EG 202 730.

The management team at TigerGeo have almost 50 years of combined experience of near surface geophysical project design, survey, interpretation and reporting, based across a wide range of shallow geological contexts. Added to this is the considerable experience of our lead geophysicists in a variety of commercial and academic roles. All geophysical staff have graduate and in many cases also post-graduate relevant qualifications pertaining to environmental geophysics from recognised centres of academic excellence.

During fieldwork there is always a fully qualified (to graduate or post-graduate level) supervisory geophysicist leading a team of other geophysicists and geophysical technicians, all of whom are trained and competent with the equipment they are working with. Data processing and interpretation is carried out by a suitably qualified and experienced geophysicist under the direct supervision and guidance of the Senior Geophysicist. All work is monitored and reviewed throughout by the Senior Geophysicist who will appraise all stages of a project as it progresses.

Data processing and interpretation adheres to the scientific principles of objectiveness and logical consistency. A standard set of approved external sources of information, e.g. from the British Geological Survey, the Ordnance Survey and similar sources of data, in addition to previous TigerGeo projects, guide the interpretive process. Due attention is paid to the technical constraints of method, resolution, contrast and other geophysical factors.

There is a strong culture of internal peer-review within TigerGeo, for example, all reports pass through a process of authorship, technical review and finally proof-reading before release to the client. Technical queries resulting from TigerGeo's work are reviewed by the Senior Geophysicist to ensure uniformity of response prior to implementing any edits, etc.

Work is undertaken in accordance with the high professional standards and technical competence expected by the Geological Society of London and the European Association of Geoscientists and Engineers.

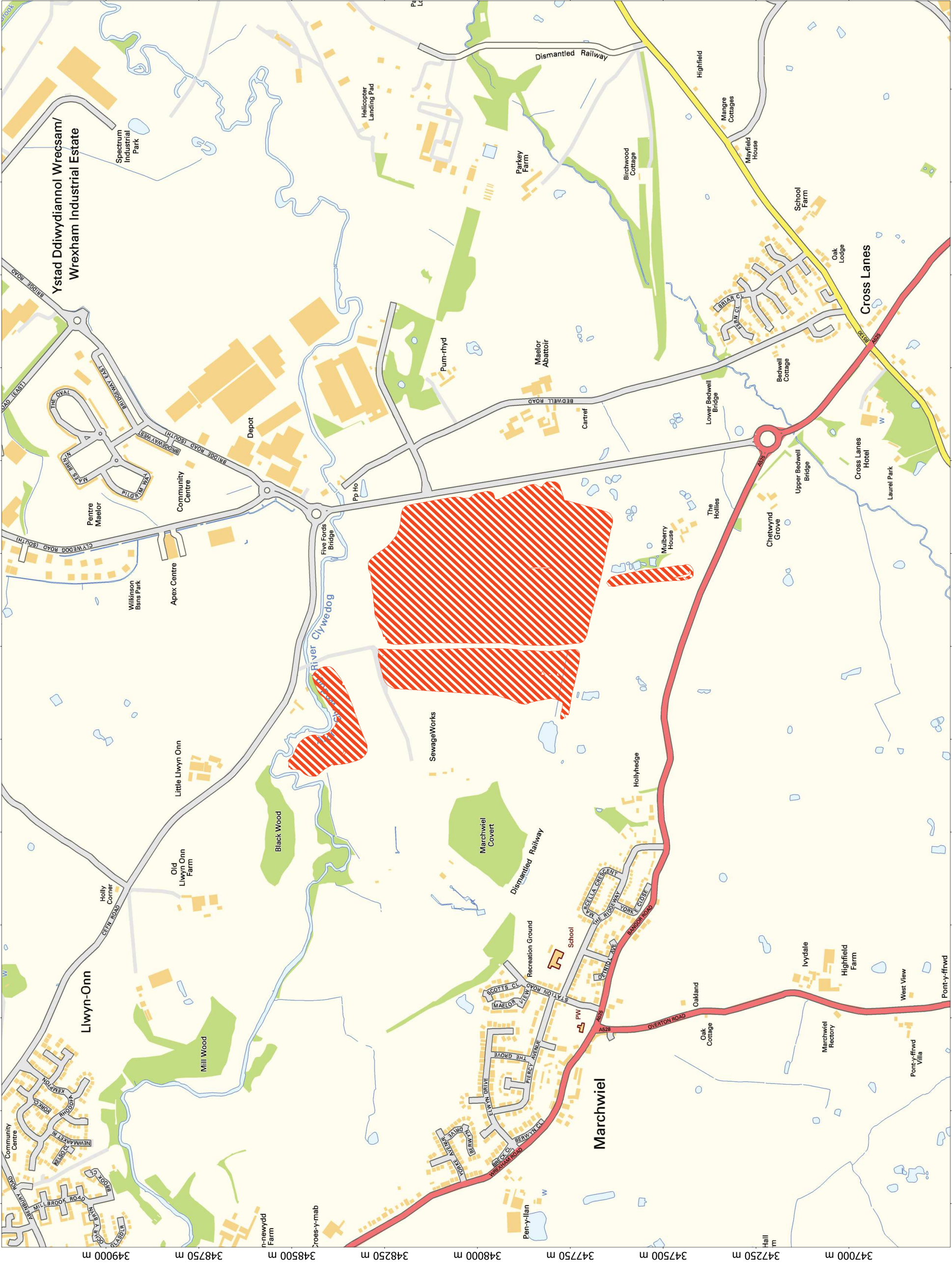
All work for archaeological projects is also conducted in accordance with the following standards and guidance:

- David et al, "Geophysical Survey in Archaeological Field Evaluation", English Heritage, 2008;
- "Standard and guidance for Archaeological Geophysical survey", Chartered Institute for Archaeologists, 2014 (Updated 2016);

and TigerGeo meets with ease the requirements of English Heritage in their 2008 Guidance "Geophysical Survey in Archaeological Field Evaluation" section 2.8 entitled "Competence of survey personnel".

5.2 Key personnel

Martin Roseveare, MSc BSc(Hons) MEAGE FGS MCIfA	Senior Geophysicist, Director
Martin specialised (MSc) in geophysical prospection for shallow applications and since 1997 has worked in commercial geophysics. Elected a GeolSoc Fellow in 2009 he is now working towards achieving CSci. A member of the European Association of Geoscientists & Engineers, he has served on the EuroGPR and CIfA GeoSIG committees and on the scientific committees of the 10th and 11th Archaeological Prospection conferences. He has reviewed papers for the EAGE Near Surface conference, was a technical reviewer of the Irish NRA geophysical guidance and is a founding member of the ISSGAP soils group. Professional interests include the application of geophysics to agriculture and the environment, e.g. groundwater and geohazards. He is also a software writer and equipment integrator with significant experience of embedded systems.	
Anne Roseveare, BEng(Hons) DIS MISoilSci	Operations Manager, Environmental Geophysicist - Data Analyst
On looking beyond engineering, Anne turned her attention to environmental monitoring and geophysics. She is a Member of the British Society of Soil Science (BSSS) and has specific areas of interest in soil physics & hydrology, agricultural applications and industrial sites. Amongst other contributions to the archaeological geophysics sector over the last 18 years, Anne was the founding Editor of the International Society for Archaeological Prospection (ISAP) and is a founding member of the ISSGAP soils group. Specifications, logistics, safety, data handling & analysis are integral parts of her work, though she is happily distracted by the possibilities of discovering lost cities, hillwalking and good food.	
Daniel Lewis, MA BA(Hons) ACIfA	Consultant Archaeologist
Daniel studied archaeology at the University of Nottingham and worked in field archaeology for many years, managing urban and rural fieldwork projects in and around Herefordshire. When the desk became more appealing he jumped into the world of consulting, working on small and large multi-discipline projects throughout England and Wales. At the same time, he returned to University, gaining an MA in Historic Environment Conservation. With over 15 years' experience in the heritage sector, Daniel has a diverse portfolio of skills. Here he ensures that geophysical work within the heritage sector is well grounded in the archaeology. His spare time includes much running up mountains	
Alexandra Gereia, MSc, BSc, PhD Candidate	Geophysical Processor & Analyst
Alexandra has a BSc in Geophysics and an MSc in Applied Geo-biology and started a PhD in the UK after living in Portugal for six months working on her master's degree. Since 2008 she has used most mainstream processing applications across electrical, magnetic and radar methods. She combines a love of nature and science and is currently studying plant roots in agricultural environments using geophysical methods. When not doing that she enjoys travelling, hiking, nature, yoga, books, foreign languages and cats. Two years ago she found a passion for electronics and started building different devices including intelligent gardening systems and coding in Python.	



WRE201 Marchwiel, Wrexham, Wales
DWG 01 Site Location

Orthographic Scale: 1:10000 @ A3 Spatial Units: Meter. Do not scale off this drawing
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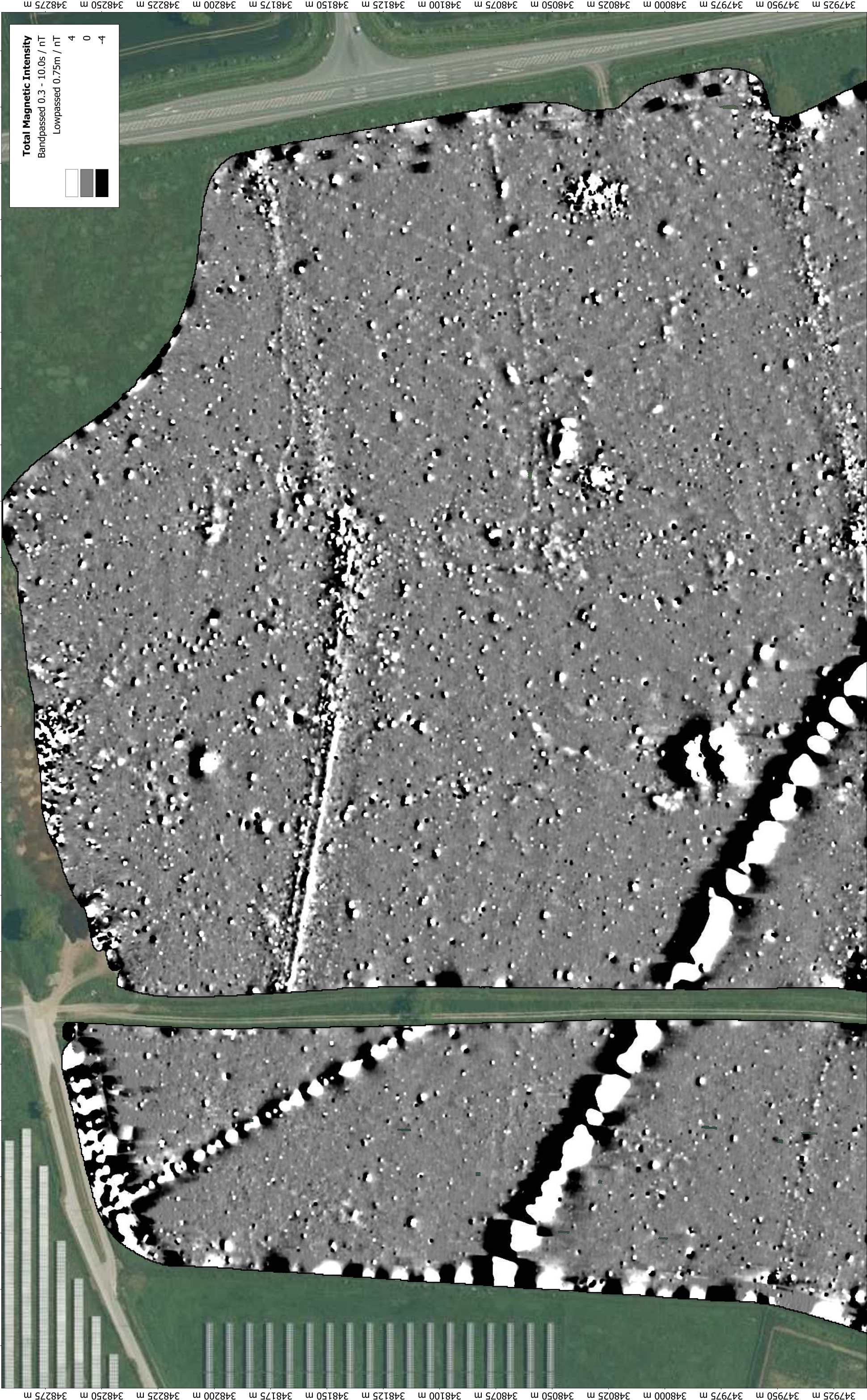




WRE201 Marchwiel, Wrexham, Wales
DWG 02a Total Magnetic Intensity - A

Orthographic Scale: 1:1500 @ A3 Spatial Units: Meter. Do not scale off this drawing
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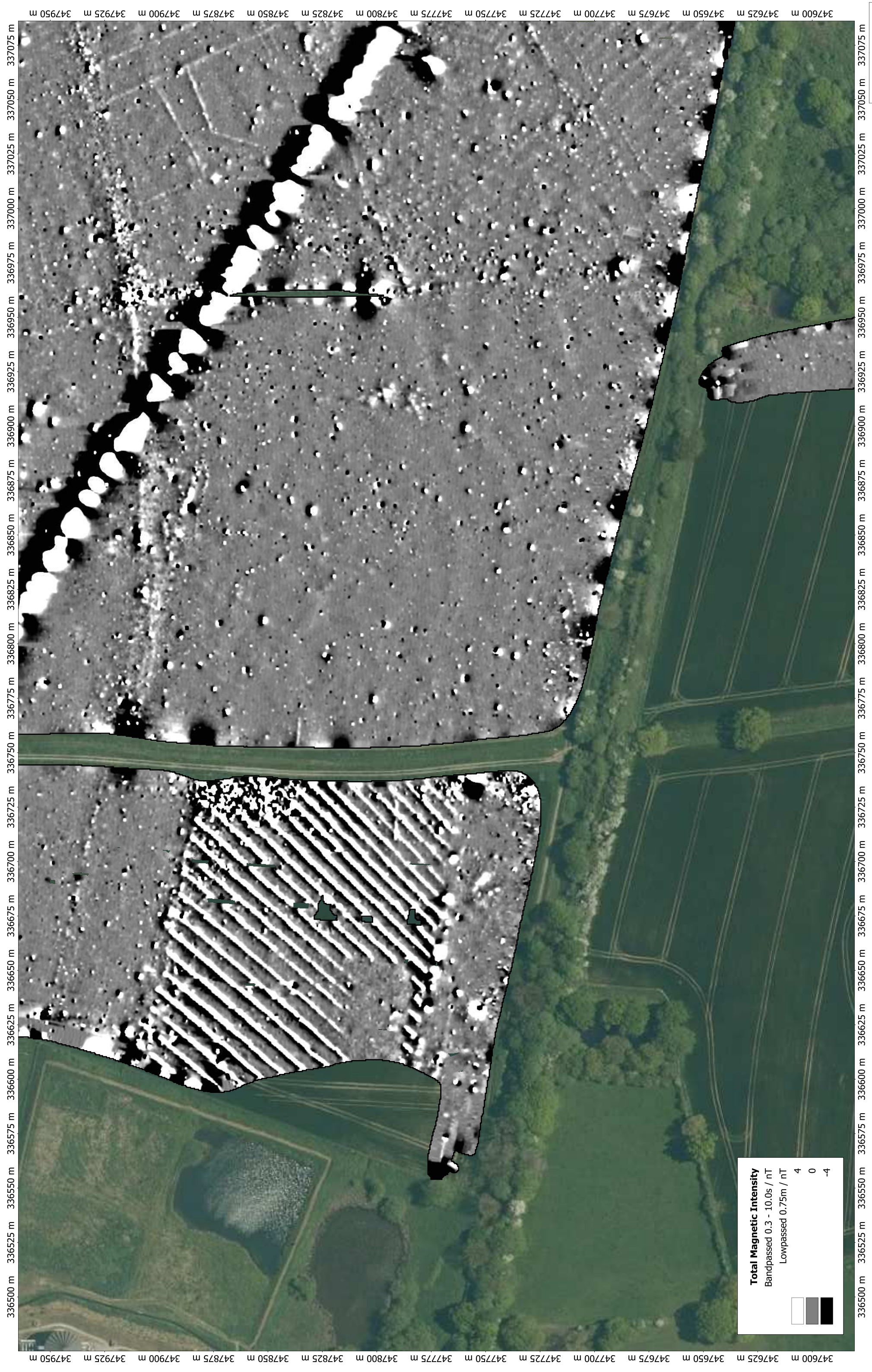




WRE201 Marchwiel, Wrexham, Wales
DWG 02b Total Magnetic Intensity - B

Orthographic Scale: 1:1500 @ A3 Spatial Units: Meter. Do not scale off this drawing
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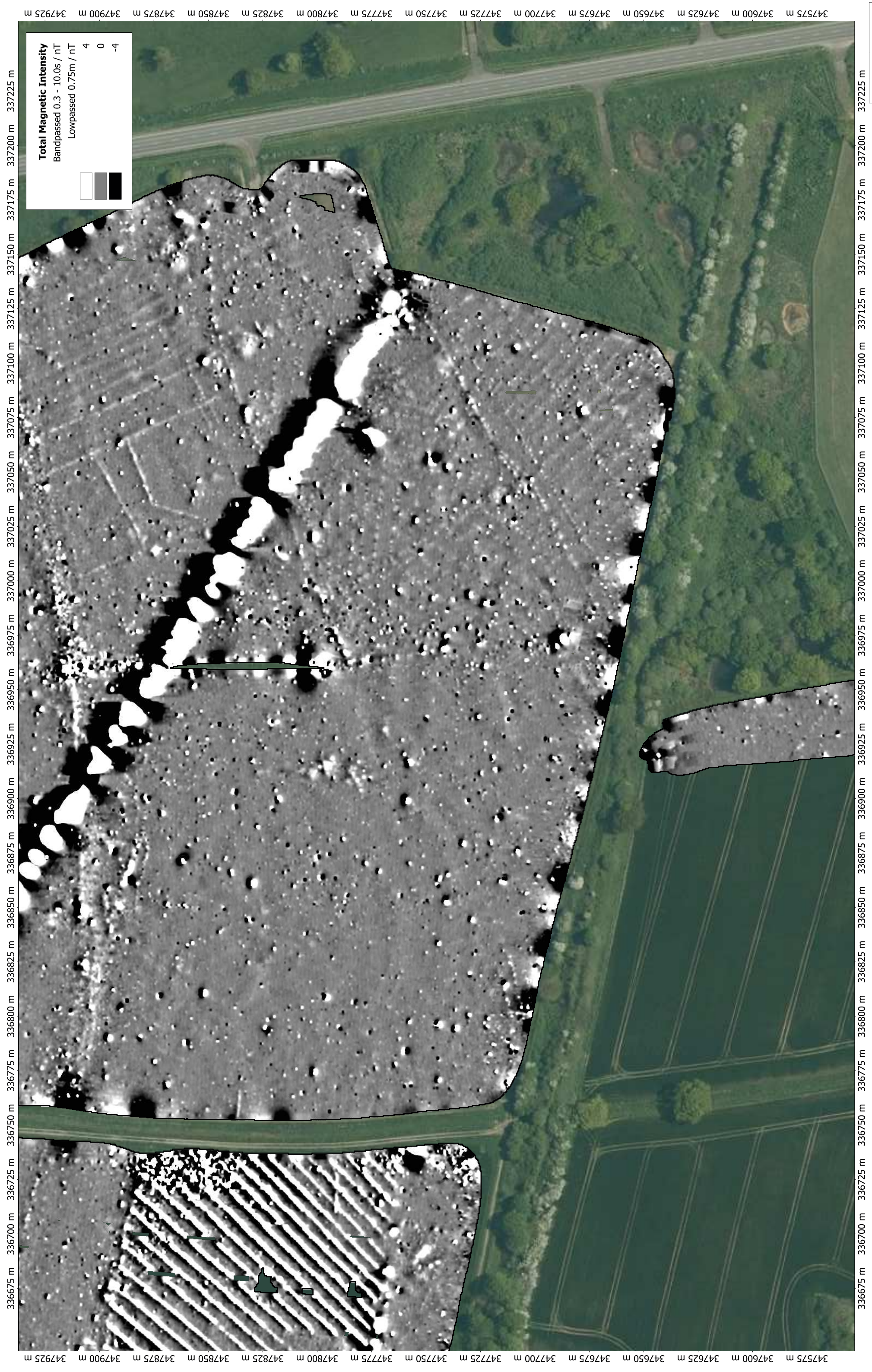


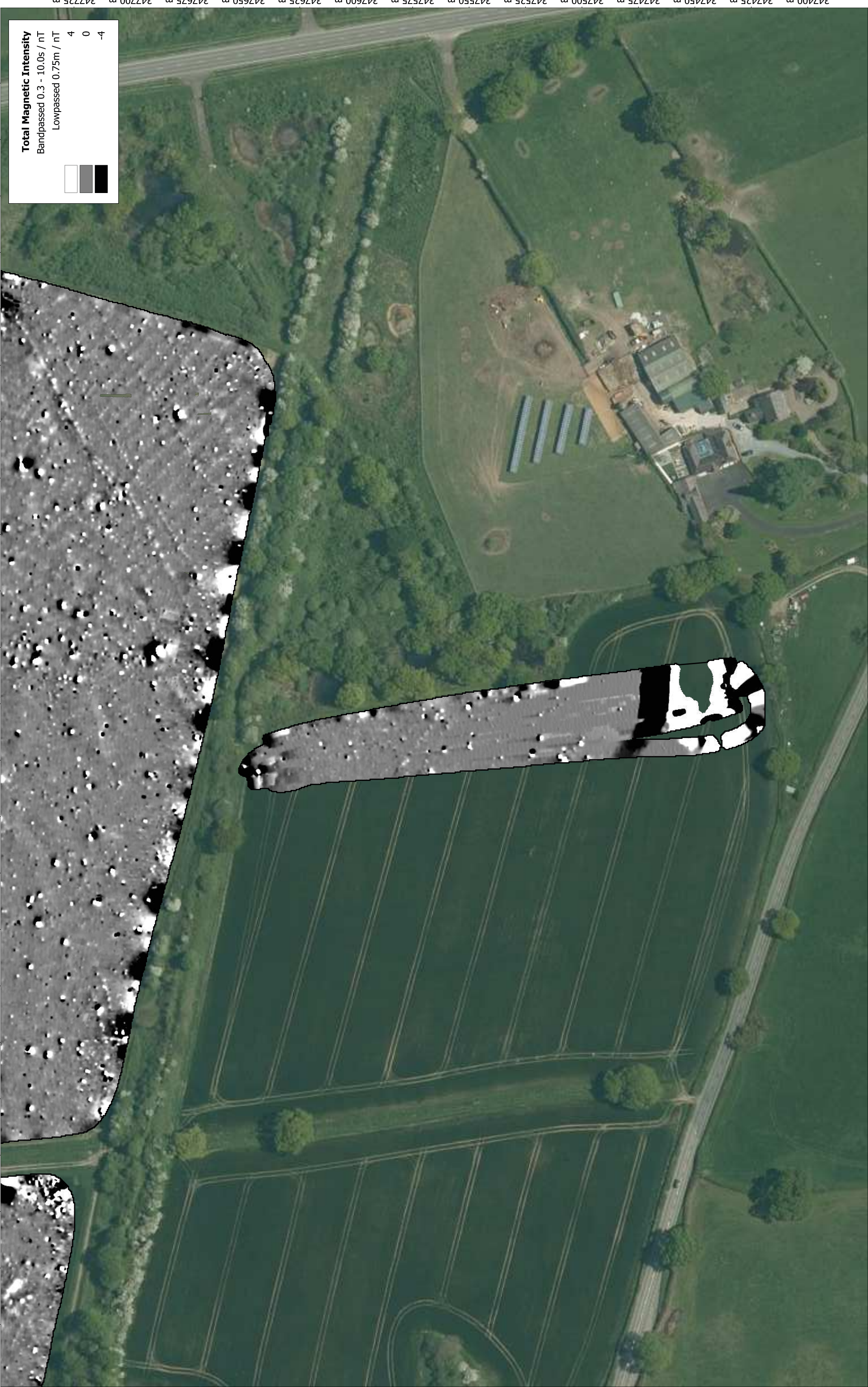


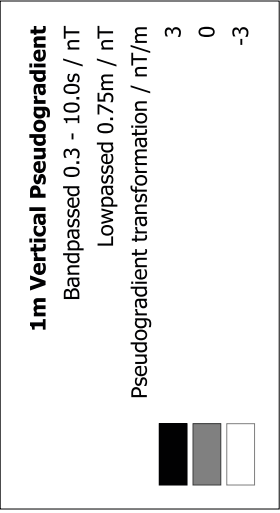
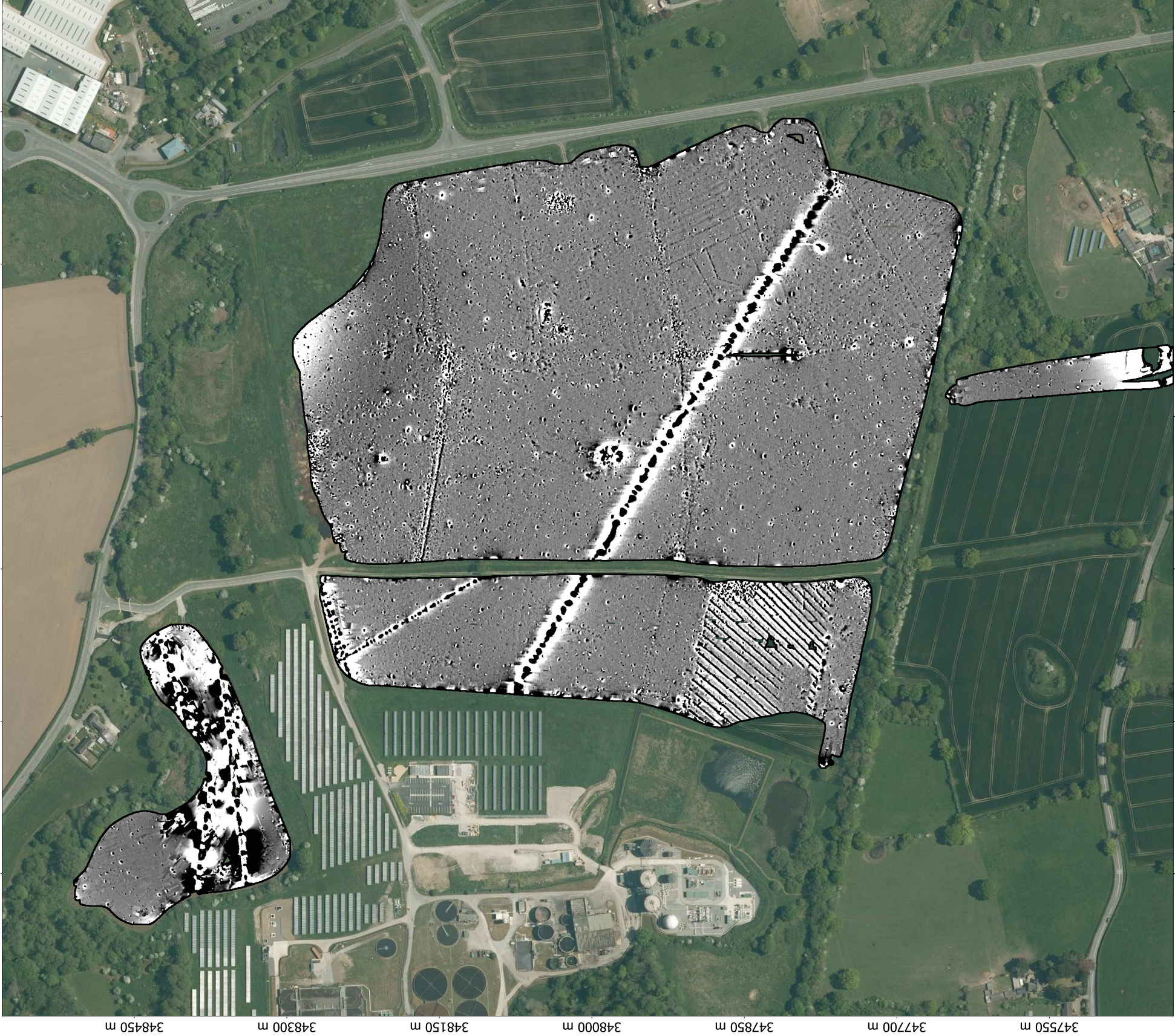
WRE201 Marchwiel, Wrexham, Wales
DWG 02c Total Magnetic Intensity - C

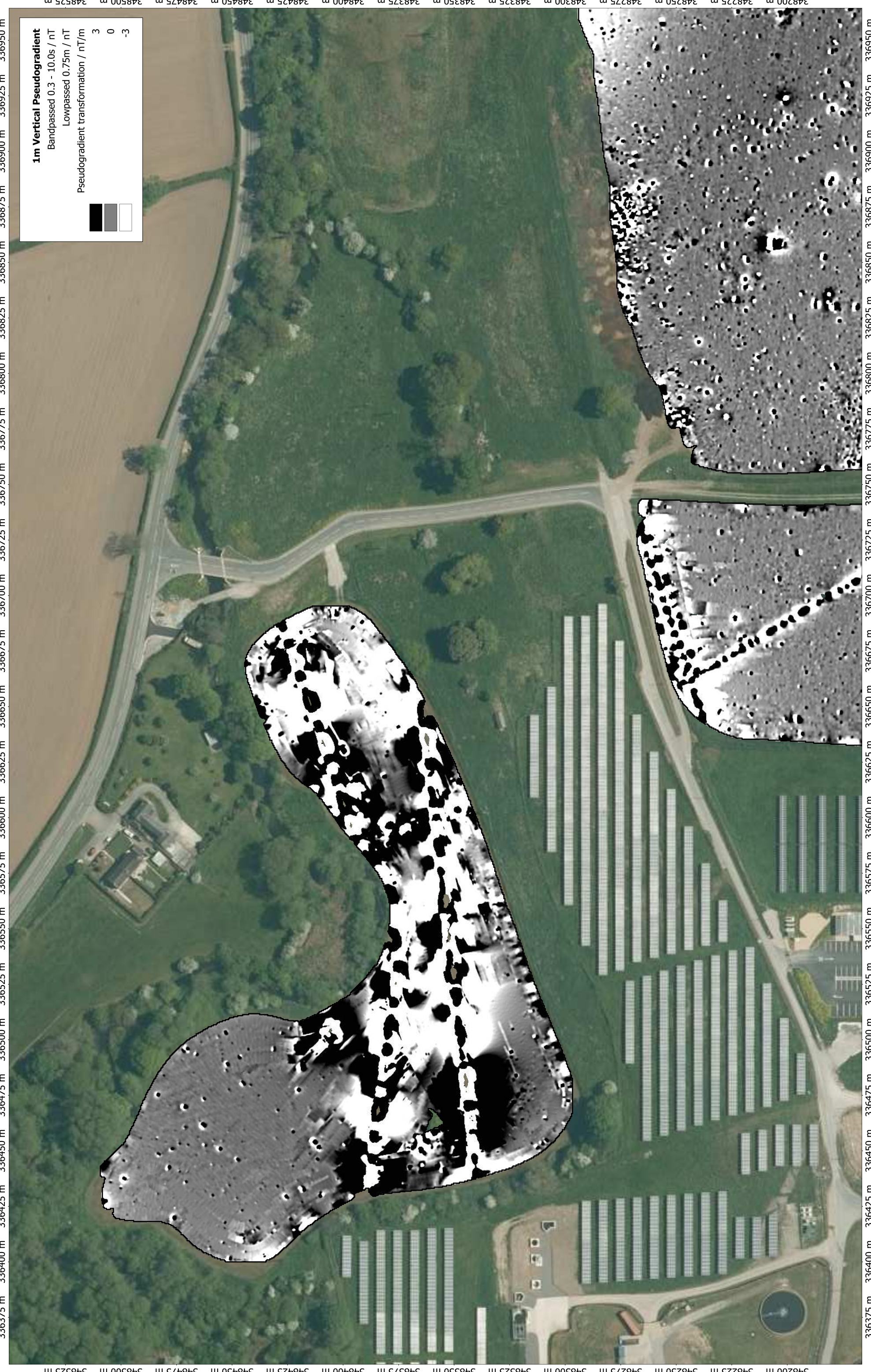
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1m Vertical Pseudogradient

Bandpassed 0.3 - 10.0s / nT

Lowpassed 0.75m / nT

Pseudogradient transformation / nT/m

3

0

-3

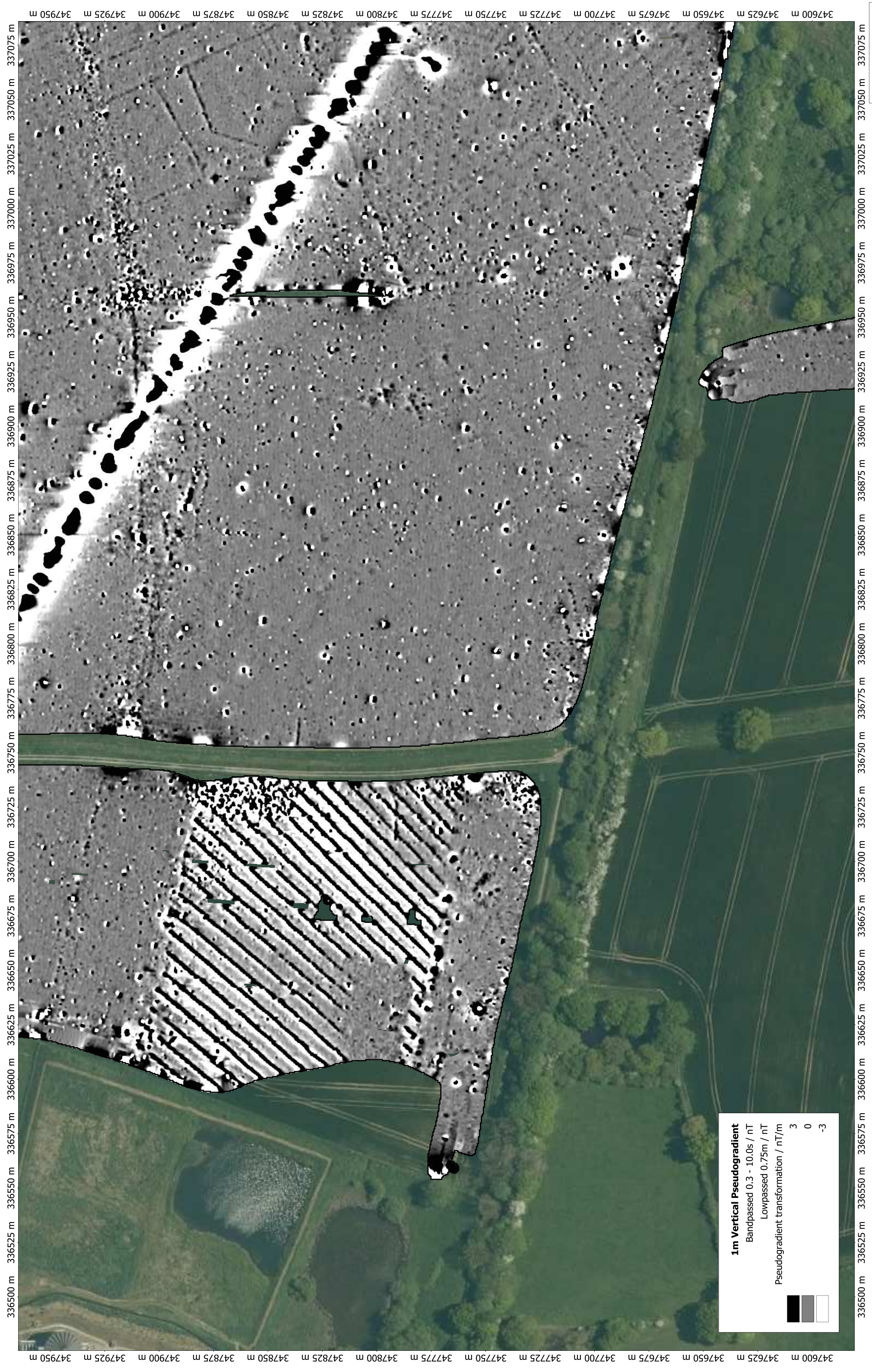
WRE201 Marchwiel, Wrexham, Wales

DWG 03a 1m Vertical Magnetic Pseudogradient - A

Orthographic Scale: 1:1500 @ A3 Spatial Units: Meter. Do not scale off this drawing
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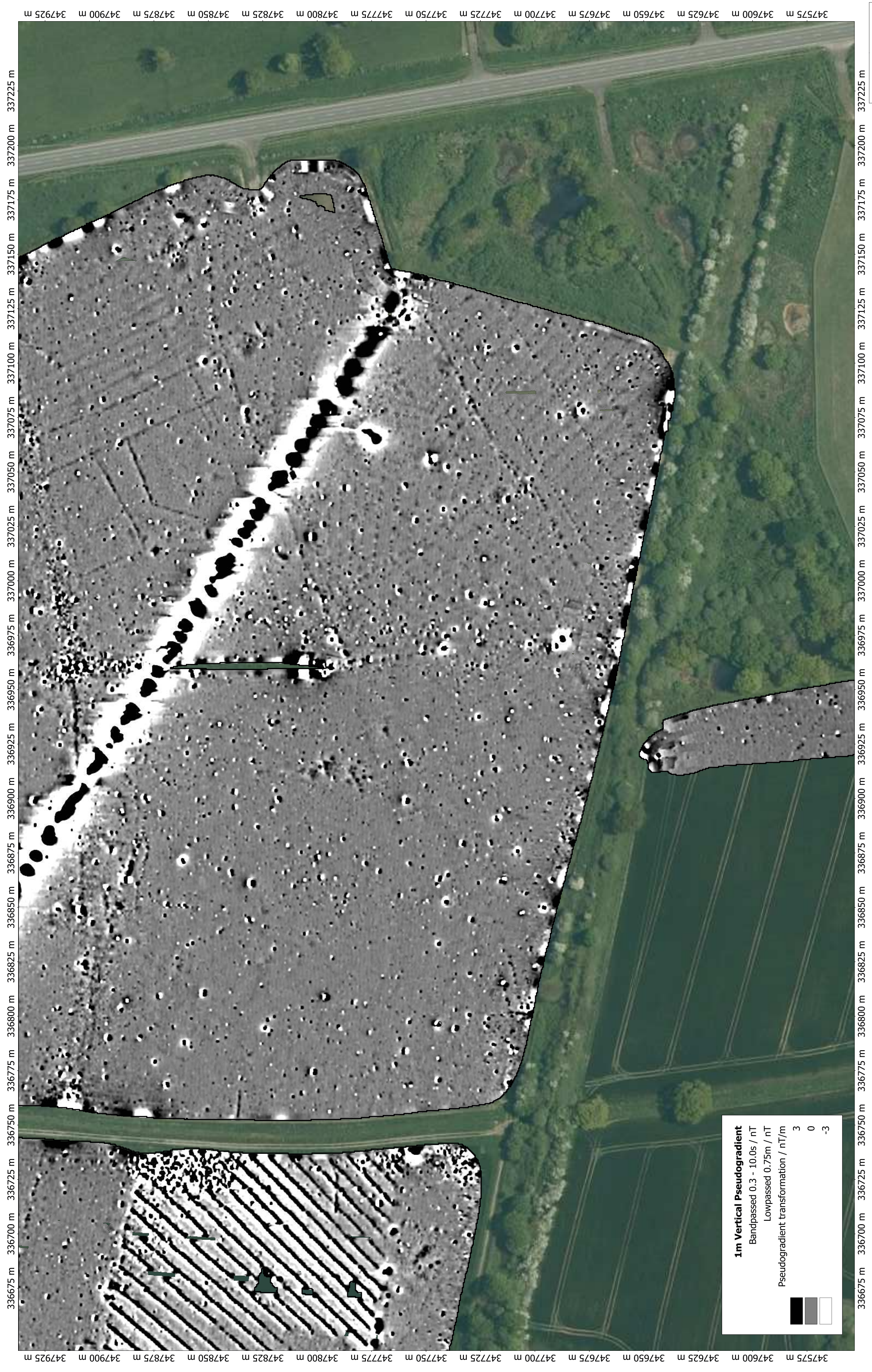


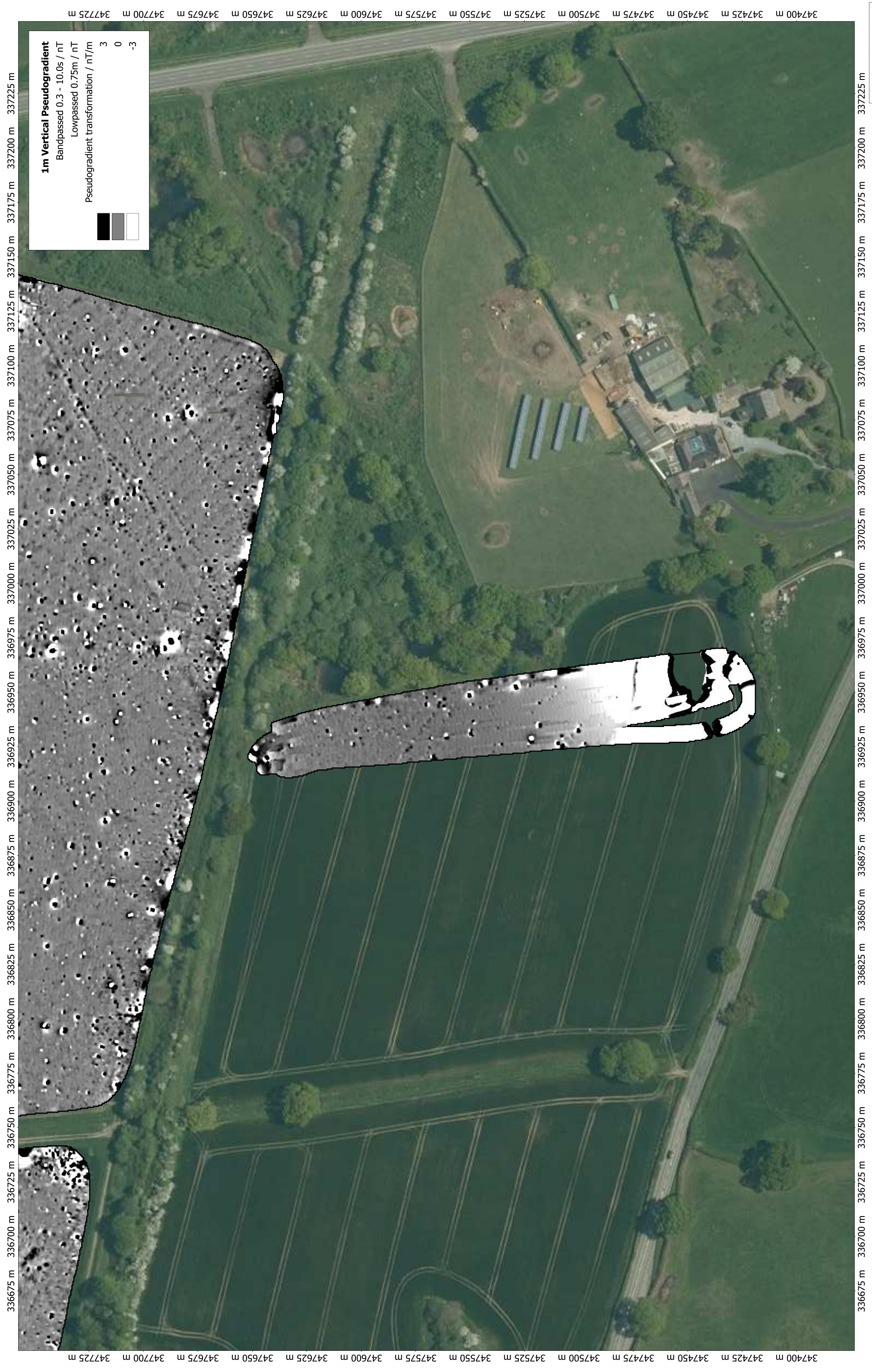
WRE201 Marchwiel, Wrexham, Wales

DWG 03c 1m Vertical Magnetic Pseudogradient - C

Orthographic Scale: 1:1500 @ A3 Spatial Units: Meter. Do not scale off this drawing
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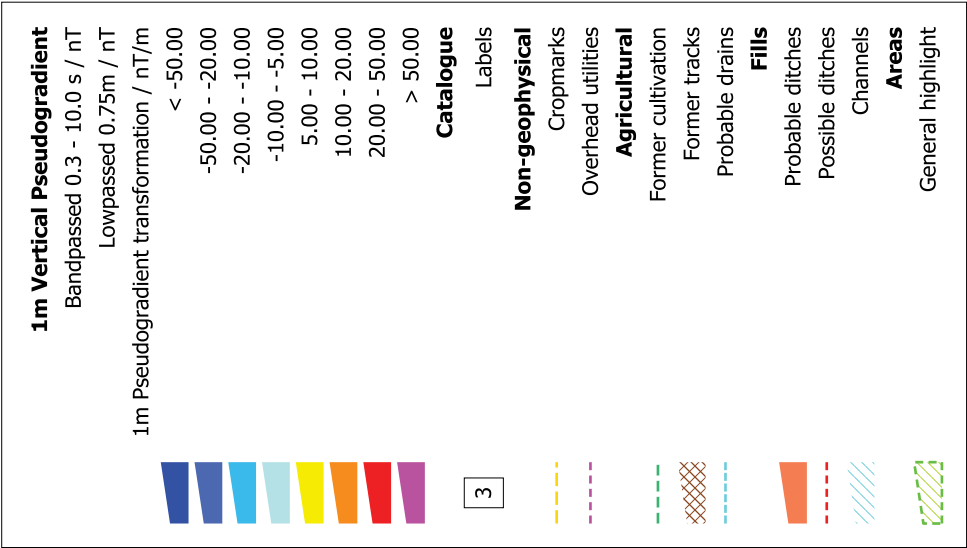
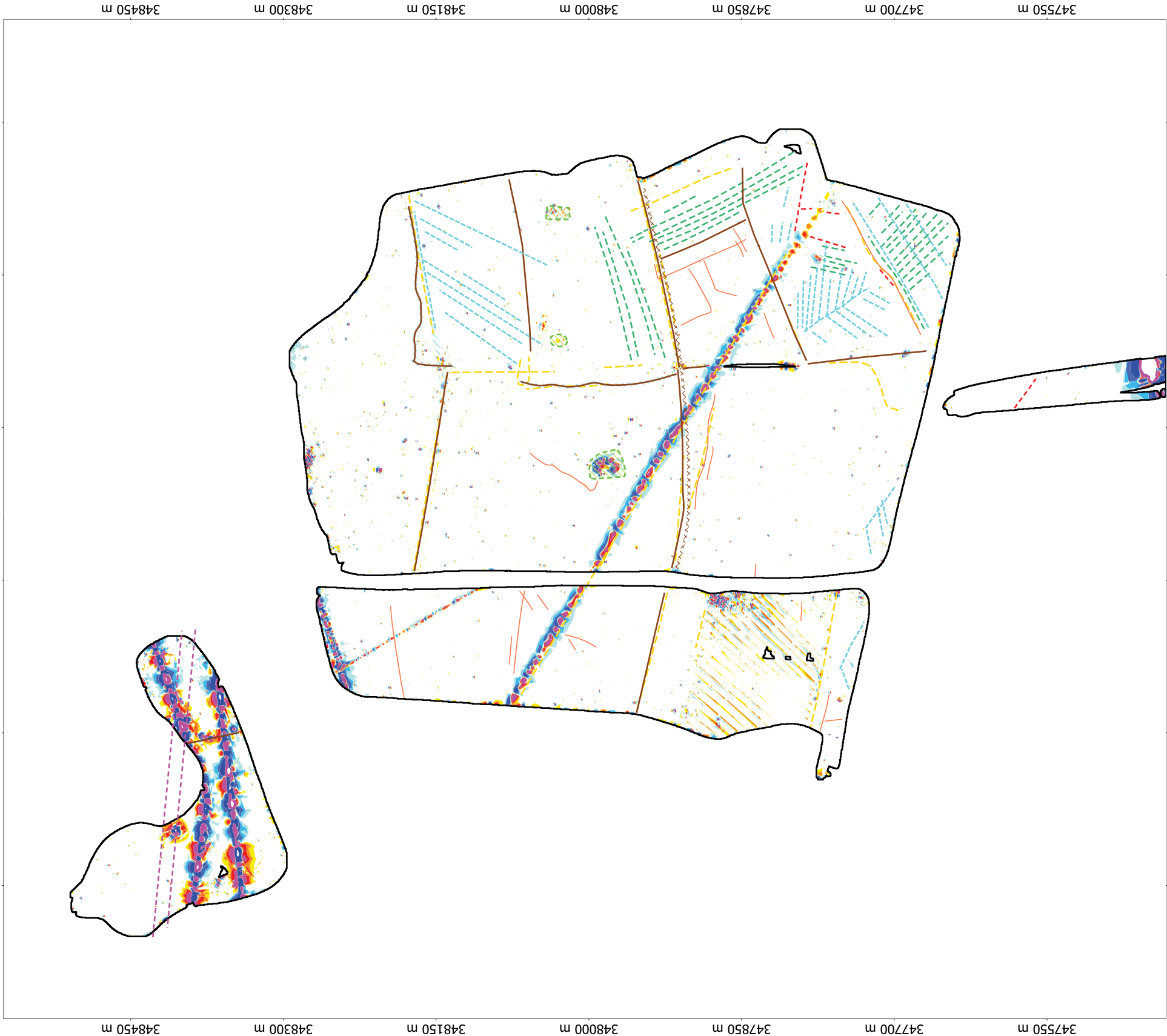


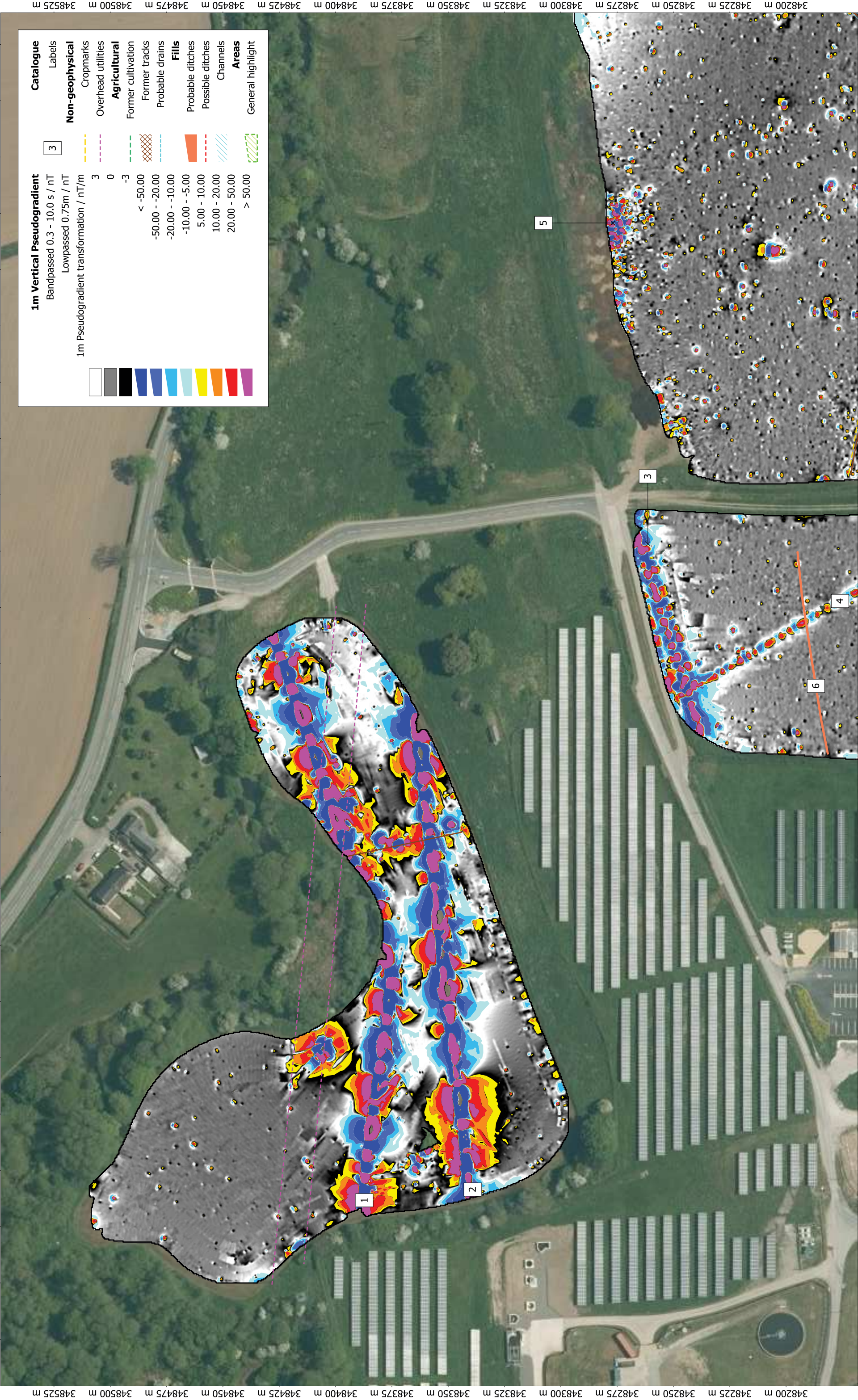
WRE201 Marchwiel, Wrexham, Wales

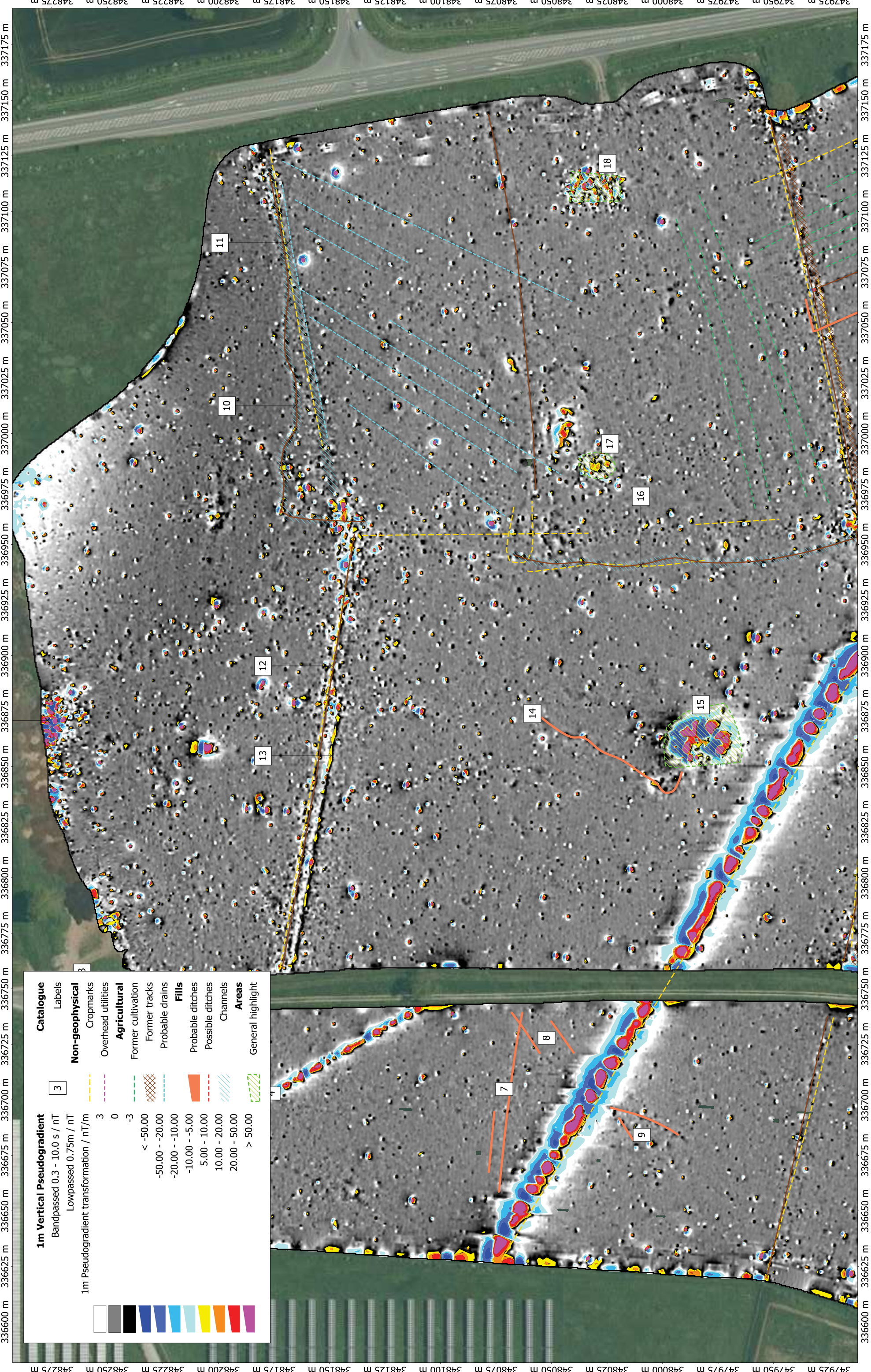
DWG 03e 1m Vertical Magnetic Pseudogradient - E

Orthographic Scale: 1:1500 @ A3 Spatial Units: Meter. Do not scale off this drawing
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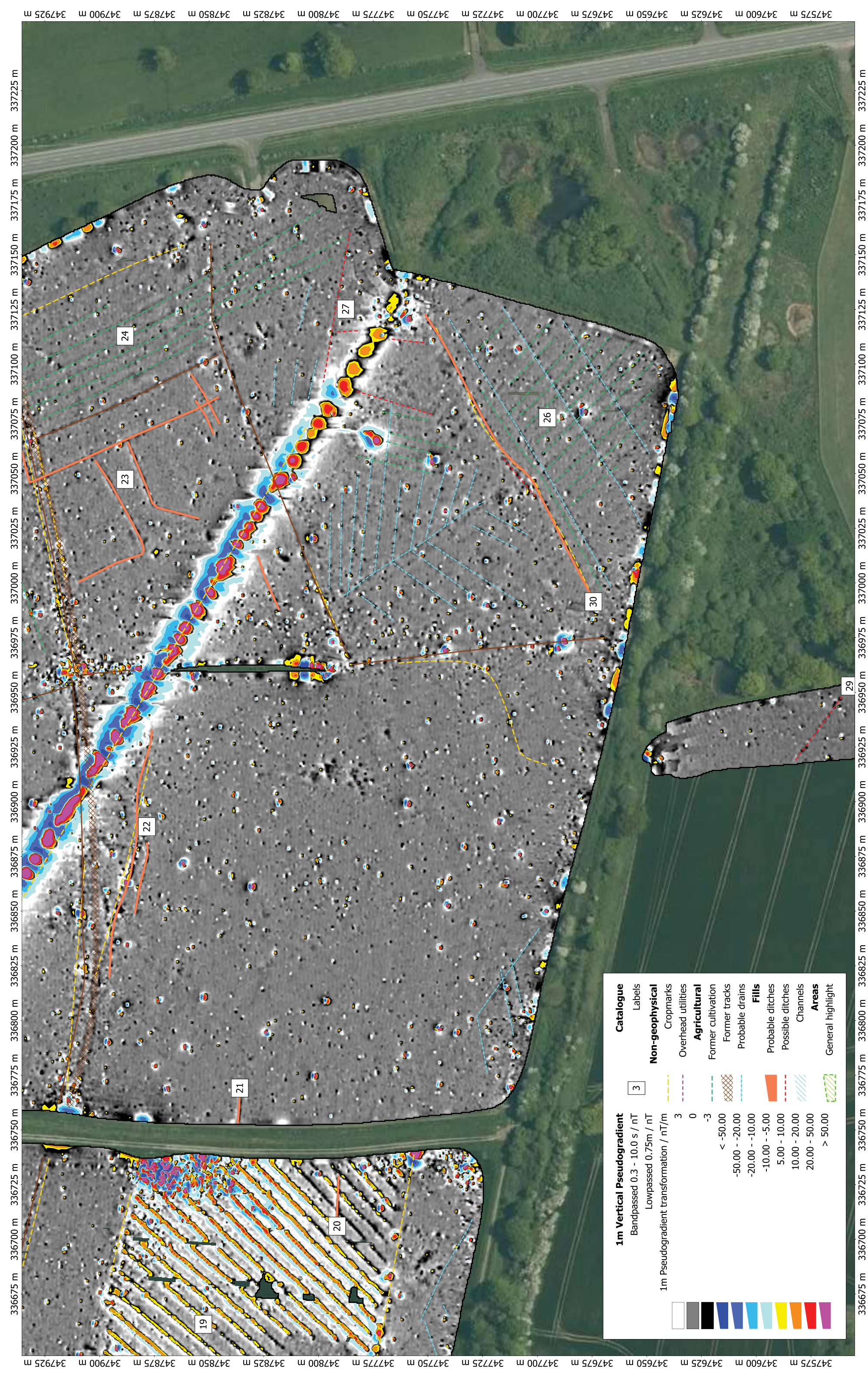




WRE201 Marchwiel, Wrexham, Wales
DWG 04b Interpretation - B

Orthographic Scale: 1:1500 @ A3 Spatial Units: Meter. Do not scale off this drawing
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WRE201 Marchwiel, Wrexham, Wales
DWG 04d Interpretation - D

Orthographic Scale: 1:1500 @ A3 Spatial Units: Meter. Do not scale off this drawing
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1m Vertical Pseudogradient

Bandpassed 0.3 - 10.0 s / nT

Lowpassed 0.75m / nT

1m Pseudogradient transformation / nT/m

3

Non-geophysical

Cropmarks

Overhead utilities

Agricultural

Former cultivation

Former tracks

Probable drains

Fills

Probable ditches

Possible ditches

Channels

Areas

General highlight

< -50.00

-50.00 - -20.00

-20.00 - -10.00

-10.00 - -5.00

5.00 - 10.00

10.00 - 20.00

20.00 - 50.00

> 50.00

3

0

-3

Probable ditches

Possible ditches

Channels

General highlight





consultancy | project management | expert witness

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