

Appendix 1: Heritage Data

Designated Heritage Assets within the 2km Study Area

Listed Buildings

ListEntry	Name	Grade	LegacyUID	NGR
1083734	SPRINGWOOD COTTAGE	II	165975	SE 95066 11064
1083736	BROUGHTON GRANGE FARMHOUSE	II	165983	SE 96985 10327
1083740	66, HIGH STREET	II	165992	SE 96194 08716
1083741	CHURCHGATES	II	165994	SE 96076 08640
1161801	CHURCH OF ST MARY	I	165995	SE 96036 08625
1310038	STABLE APPROXIMATELY 20 METRES NORTH EAST OF SPRINGWOOD COTTAGE	II	165976	SE 95042 11070
1309931	THE HOLLIES	II	165993	SE 96079 08683
1310013	STONE COTTAGE AND ADJOINING OUTBUILDINGS	II	165982	SE 95607 09138
1346807	RAVENTHORPE FARMHOUSE	II	165707	SE 93654 08114
1346496	COACH HOUSE/STABLES APPROXIMATELY 10 METRES EAST OF BROUGHTON GRANGE FARMHOUSE	II	165984	SE 97005 10340

1391424	BROUGHTON WAR MEMORIAL	II	493248	SE 96158 08664
1346494	Low Santon Farmhouse	II	165977	SE 94001 12784
1310004	Barn Approximately 30 Metres North of Low Santon Farmhouse	II	165978	SE 94001 12824

Scheduled Monuments

ListEntry	Name	LegacyUID	NGR
1016426	Raventhorpe medieval settlement earthworks immediately south west of Raventhorpe Farm	32621	SE 93595 07948

Data obtained from North Lincolnshire Historic Environment Record and Historic England AMIE Database

Monument Records Within the Site

NLHER MONUID/ HE AMIE REF.	PERIOD	MONTYPES	GRIDREF	NAME	DESCRIPTION
MLS22718 1576008	Bronze Age	ROUND BARROW	SE 9417 0980	ROUND BARROW, GOKEWELL	Possible round barrow identified from aerial photographs - not proven by fieldwork
MLS6695	Prehistoric	FINDSPOT	SE 940 100	FLINTS	Findspots of flints listed in a gazetteer of 1976. No value.
MLS20003 1035165	Early Neolithic to Roman	TRACKWAY	SE 922 097	JURASSIC WAY PREHISTORIC TRACKWAY	The line of the prehistoric Jurassic Way trackway from Lincoln to Winteringham. This is quite conjectural though the line of the track is shown passing High Santon and Gokewell on old Lincolnshire maps like Armstrong 1778.

MLS1805	Medieval	CISTERCIAN NUNNERY, PRIORY	SE 9412 1026	FORMER GOKEWELL PRIORY (SITE OF)	Site of a Cistercian Nunnery founded by William de Alta Ripa in 1148 or 1185. Dissolved in 1536. Earthworks remain to the south of the former Gokewell Farm. The earthworks are now gone, levelled by agriculture with little above ground evidence remaining. There is potential for survival in the area below the later farm buildings. Assessed for scheduling in 1998. not taken forward.
MLS1027/MLS25419	Post Medieval	FARMHOUSE	SE 940 103	GOKEWELL PRIORY FARMHOUSE (SITE OF)	This farmhouse is no longer extant, demolished in the 1980s. It was built on the site of the former Gokewell Priory, the site of a Cistercian Nunnery founded in the 12th century. It is possible the farm buildings incorporated fabric from the former priory.
MLS21408 1473342	Modern	HEAVY ANTI AIRCRAFT BATTERY	SE 944 100	HEAVY-ANTI AIRCRAFT BATTERY (SITE OF), GOKEWELL	Site of heavy anti-aircraft battery designated Scunthorpe H10 east of Gokewell. De-armed in 1942.
MLS24688	Modern	TRACKWAY	SE 944 091	TRACKWAY, WEST OF MANBY WOOD	Cropmark of a modern water main.
MLS21941	Undated	SQUARE ENCLOSURE	SE 9391 0926	SQUARE FEATURE, NORTH OF MANBY DMV	A closed square feature, too small for an enclosure identified north of Manby DMV. Probable medieval stock enclosure.
MLS21943	Undated	OVAL ENCLOSURE	SE 9371 0919	SMALL OVOID ENCLOSURE, NORTH OF MANBY DMV	Small ovoid enclosure north of Manby DMV on aerial photographs. Probable medieval stock enclosure.
MLS22780	Unknown	ENCLOSURE?	SE 9362 1018	POSSIBLE ENCLOSURE, LITTLE CROW COVERT	Site of an incomplete ovoid ditch within little Crow Covert visible as earthwork on LiDAR. Possible enclosure?
MLS2333	Unknown	FINDSPOT	SE 9405 1035	FINDS (DETAILS NOT RECORDED)	Finds listed in an old gazetteer - no value
MLS1806 63412	Medieval	DESERTED SETTLEMENT	SE 936 088	MANBY DMV (SITE OF)	Manby DMV mentioned in Domesday. Possible remains of ridge and furrow in the vicinity of the asset. Settlement located outside the Site, although former associated ridge and furrow is located within the Site.

MLS21242	Undated	Wall	SE 9549 1081 (point)	LIMESTONE WALL, WEST OF ROWLAND PLANTATION	A section of limestone wall was recorded during a watching brief on a water main replacement, on the B1207 west of Rowland Plantation, 2000. It was undated.
MLS100 1031689	Roman	ROAD	SE 951 091	ERMINE STREET	The line of Ermine Street Roman road. In this area, it runs on the west side of Broughton forming the modern road. It runs towards Winteringham to cross the Humber.
ELS2729	Medieval	Ridge and furrow	SE 9419 1047	Ridge and furrow	Area of former ridge and furrow earthworks recorded as part of the Ridge and Furrow Project (ELS2729). This former block of ridge and furrow does not have a MONUID reference number.

Additional features identified within Site

Reference	Description	Easting	Northing
A1	Circular cropmark identified from aerial photography	493702	409400
A2	Circular cropmark identified from aerial photography	493844	409508

Event Records Within the Site

EVUID	EVENTNAME	ORGANISATION	DISPLAY DATE	NGRQUALIFIER	EASTING	NORTHING
ELS800	Aerial photographic sortie	Cambridge University Air Committee	1956	Centred on	493320	410085

ELS800	Aerial photographic sortie	Cambridge University Air Committee	1956	Centred on	493320	410085
ELS808	Aerial photographic sortie	Cambridge University Air Committee	1984	Centred on	484400	412600
ELS922	Aerial photographic survey	Jasair	1989	-	498050	411900
ELS4211	Earthwork Survey, Gokewell Priory Farm	Keith Miller	1976-1982?	-	4940	4102
ELS3145	Watching brief on Sawcliffe area water mains replacement	Pre-Construct Archaeology	October 1999	-	-	-

Monument Records Beyond the Site

NLHER MONUID/ HE AMIE REF.	PERIOD	MONTYPES	GRIDREF	NAME	DESCRIPTION
MLS22657	Late Mesolithic	FINDSPOT	SE 931 082	MESOLITHIC FLINT, RAVENTHORPE	Findspot, single microlith at Raventhorpe
MLS26068	Late Mesolithic to Early Bronze Age	LITHIC SCATTER	SE 9404 0825	WORKED FLINT, NORTH & WEST OF STONEWALL RESERVOIR	48 pieces of worked flint found during fieldwalking to the north and west of Stonewall Reservoir in 2014 at Raventhorpe (ELS4274). Carried out by AOC archaeology prior to solar farm.
MLS1818 63339	Early Bronze Age to Roman	FINDSPOT	SE 9553 0863	POTTERY & BROOCH	Findspot of a Roman brooch and prehistoric pottery from the head of a stream on south side of mound near Ermine Street
MLS1822 63421	Bronze Age	FINDSPOT	SE 9470 0904	FLINT ARROWHEAD	Findspot of a flint arrowhead from 1950

MLS7556	Prehistoric	FINDSPOT	SE 9550 0911	FLINTS & POTTERY	Findspots of flints and pottery listed in a gazetteer of 1976. No value.
MLS7563	Prehistoric	FINDSPOT	SE 9370 0819	FLINTS	Findspots of flints listed in a gazetteer of 1976. No value.
MLS1819 63464	Roman	FINDSPOT	SE 942 084	RB POTTERY/GLASS & MASONRY, 1975	Findspot of Roman pottery and glass from ploughsoil
MSL26069	Prehistoric	Findspots	Centred SE 9426 0787	WORKED FLINT, SOUTH & EAST OF STONEWALL RESERVOIR	709 pieces of worked flint were collected during extensive fieldwalking to the north and west of Stonewall Reservoir, Raventhorpe, 2014 (ELS4274). They included three arrowheads.
MLS26070	Roman	ARTEFACT SCATTER	SE 9404 0822	ROMANO-BRITISH POTTERY, NORTH & WEST OF STONEWALL RESERVOIR	298 pieces of roman pottery recovered during fieldwalking north and west of Stonewall reservoir prior to solar farm. Arch evaluation discovered nothing in this location
MLS26071	Roman	ARTEFACT SCATTER	SE 9426 0787	ROMANO-BRITISH POTTERY, SOUTH & EAST OF STONEWALL RESERVOIR	276 pieces of Roman pottery recovered during field walking south and east of Stonewall reservoir prior to Solar farm.
MLS26072	Roman	ENCLOSURE, BUILDING	SE 9391 0781	ROMANO-BRITISH ENCLOSURE, WEST OF STONEWALL RESERVOIR	Roman enclosure identified to southwest of Stonewall Reservoir in 2014 prior to construction of solar farm.
MLS21187	Medieval	RIDGE AND FURROW, OPEN FIELD	SE 93 06	OPEN FIELD SYSTEM, HOLME	Area of ridge and furrow northeast of Twigmoor Grange in Holme parish. Also areas of ridge and furrow identified around the Raventhorpe DMV
MLS1806 63412	Medieval	DESERTED SETTLEMENT	SE 936 088	MANBY DMV (SITE OF)	Manby DMV mentioned in Domesday. Possible remains of ridge and furrow in the vicinity of the asset. Settlement located outside the Site, although former associated ridge and furrow is located within the Site.
MLS21642	Medieval to Post Medieval	BOUNDARY BANK	SE 9401 0842	LINEAR HEADLAND OR BANK	Section of linear headland between parish of Broughton and Holme.
MLS21643	Post Medieval	BOUNDARY BANK	SE 948 088	LINEAR BOUNDARY, MANBY WOOD	Section of linear cropmark on aerial photographs as a possible woodland feature?
MLS19488	Post Medieval	HOUSE	SE 9365 0875	MANBY HALL (SITE OF)	The site of Manby Hall as labelled on Ordnance survey mapping

MLS25150	Post Medieval to Modern	FARMSTEAD	SE 9403 1160	HIGH SANTON, APPLEBY	Partially extant farmstead, 19th century. Farmhouse and buildings around a courtyard. Some survival of historic fabric.
MLS21526	Post Medieval to Modern	LANDSCAPE PARK	SE 9365 0881	FORMER LANDSCAPE GARDEN, MANBY HALL	Location of the designed landscape of Manby Hall shown on 2nd Ed Ordnance Survey maps. Some areas still legible.
MLS25431	Post Medieval to Modern	FARMSTEAD	SE 9366 0871	MANBY HALL FARM, BROUGHTON	Partially extant 19th century farmhouse with some survival of original buildings. Located within a manor grouping
MLS22523 1474188	Modern	HEAVY ANTI AIRCRAFT BATTERY	SE 941 116	HEAVY ANTI AIRCRAFT BATTERY (SITE OF), HIGH SANTON	General location record for a WWI anti-aircraft battery at High Santon armed with an 18 pounder in 1917.
MLS22696	Modern	MILITARY DEPOT	SE 9554 1022	RAF BROUGHTON EQUIPMENT PARK (SITE OF)	Site of a military supply depot 209MU RAF Broughton opened in 1943 located within Far Wood. Closed in 1946. The site was investigated in 2013 which found concrete bases of 23 buildings.
MLS22710	Modern	DISPERSED SITE	SE 954 090	FORMER RAF CAMP, MANBY WOOD	Remains of a WWII accommodation site associated with 209 MU RAF Broughton. May have been used as emergency housing post-war. Located as two groups within Manby Wood with concrete foundations remaining in 2013. Some areas have been removed by development.
MLS19644 63291	Unknown	MOUND	SE 9557 0870	MOUND (NON ANTIQUITY)	Site of a former mound - not archaeological
MLS22666	Unknown	SPRING	SE 9553 0864	MANBY SPRINGS	Two springs located near a church. Possible ritual association? Run together to form Moor Beck
MLS22667	Unknown	SPRING	SE 9546 0964	SPRING, NEAR WESTWOOD LODGE	A spring within Manby Wood inside a stone circular basin likely to be a post-med estate management feature - possibly piped to Westwood Lodge to the north.
MLS1813	Unknown	NON ANTIQUITY	SE 9563 0896	MOUNDS & CROPMARKS, BROUGHTON VILLAGE	Site of a mound once thought to be an antiquity - now known to be a sand hill
MLS1828	Unknown (poss. Medieval)	Cropmarks	SE 9374 0801	Cropmarks	Outlying cropmarks possibly associated with Raventhorpe Deserted Medieval Village

MLS24695	Unknown	Enclosure? Quarry?	Centred to SE95601090	FORMER QUARRY, ROWLAND PLANTATION	A small, sub-rectangular earthwork? enclosure was visible on air photographs taken in 1976. Centred to SE95601090, it measured c. 35m by 30m, with an apparent entrance on the eastern side. There were other indistinct marks to the south-west, possibly denoting a larger, more irregular enclosure centred to SE95551086, perhaps 75m across. This area was under new tree planting on post-2010 air photographs. The small enclosure was shown as an 'Old Quarry' on the Ordnance Survey second edition map of 1908
MLS93	Unknown	LONG BARROW?	SE 9535 1120	POSSIBLE LONG BARROW (SITE OF), BROOM HILL	Two possible sites of a long barrow identified from aerial photography. Nothing confirmed through fieldwork.

Desk-Based Assessment Records Beyond the Site

TITLE	MONUID	EVENTUID	SOURCEUID	TECHNIQUE	MONTH YEAR	ORIGINATOR
Desk-Based Assessment of Forest Pines, Broughton		ELS2962	SLS3522	DbA	April 2005	Humber Field Archaeology
DBA, Lakeside, 2009		ELS3357	SLS3977	Desk based assessmen	October 2009	CgMs
Desk-based Assessment of land at Somervell Road		ELS3077	SLS2481	Desk	September 1994	Lindsey Archaeological Service
Raventhorpe Solar Farm		ELS4130	SLS6920	DBA	August 2014	AOC Archaeology
Archaeological DBA, land off Appleby Lane		ELS4160	SLS6964	DBA	January 2015	MOLA

A misplotted AMIE record for an archaeological excavation at Appleby Lane, Broughton, has not been included in the table above (AMIE ref. 1326286).

Event Point, Watching Brief Polyline and Watching Brief Event Region Records Beyond the Site

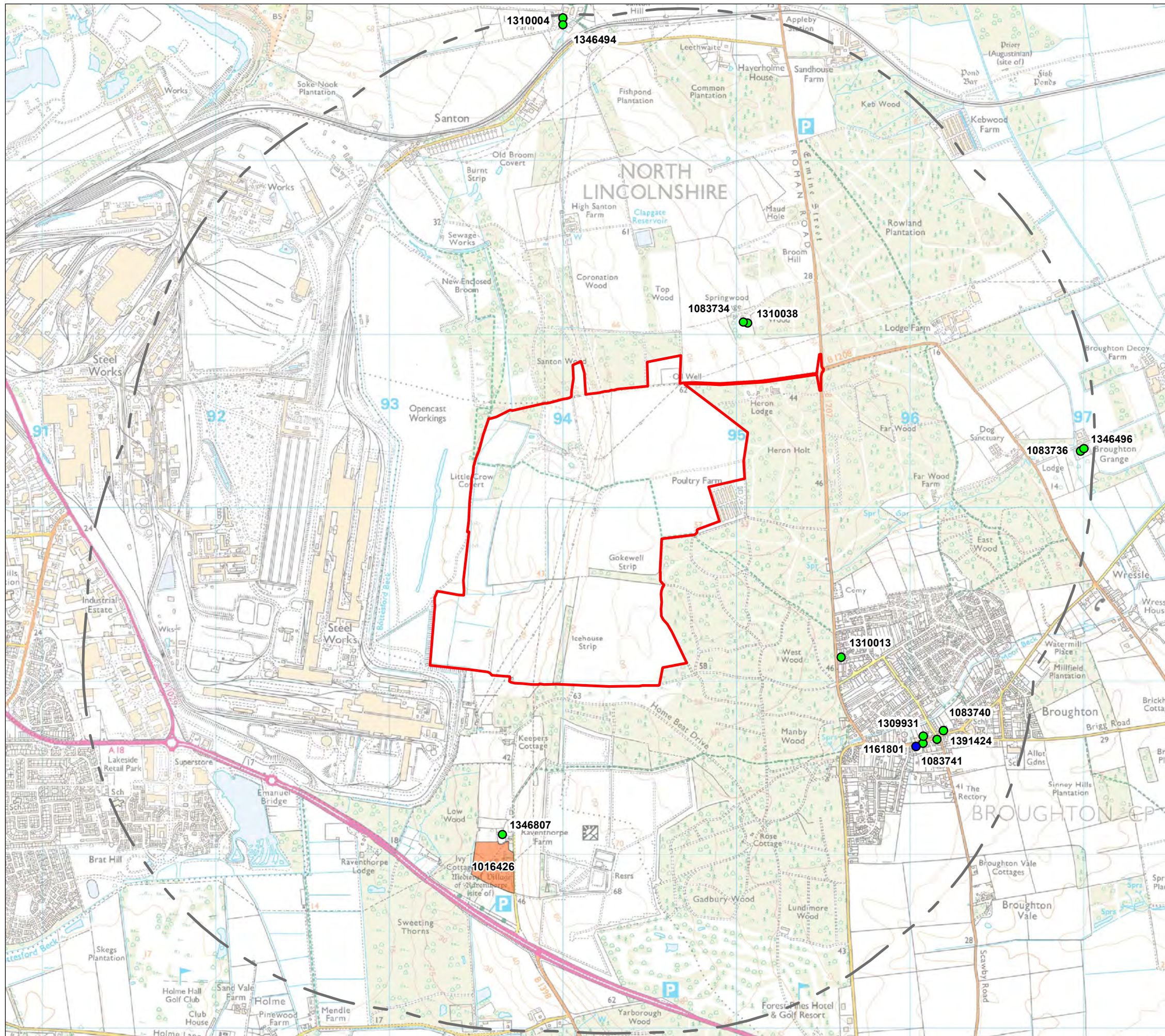
EVUID	EVENTNAME	ORGANISATION	DISPLAYDATE	NGRQUALIFIER	EASTING	NORTHING
ELS800	Aerial photographic sortie	Cambridge University Air Committee	1956	Centred on	493320	410085
ELS808	Aerial photographic sortie	Cambridge University Air Committee	1984	Centred on	484400	412600
ELS922	Aerial photographic survey	Jasair	1989		498050	411900
ELS2568	LIDAR survey flights, 2001	Environment Agency	2001		500000	412000
ELS2577	LIDAR survey flights, 2000	Environment Agency	2000		499077	418002
ELS2582	LIDAR survey flights, 2006	Environment Agency	2006		0	0
ELS2965	Walkover survey at Forest Pines Golf and Country Club, Broughton, North Lincolnshire, 2006	Humber Field Archaeology	2006		495306	408368
ELS3685	Yarborough Quarry, Scunthorpe	Wardell Armstrong	2003		493226	410449
ELS3871	Air photography	Innervisions Aerial Photography	2012		489850	417100
ELS3933	Flint collection by DN Riley, Raventhorpe	Unassigned	1939		493130	408208
ELS3980	Site visit, Manby Woods	North Lincolnshire Council	2013		495476	409139
ELS4112	Aerial photographic survey	Meridian Airmaps Ltd	1976		489750	409450
ELS4120	Raventhorpe, Scunthorpe - Archaeological Geophysical Survey	AOC Archaeology Group	2014		493973	408172
ELS4125	Aerial photographic survey	Hunting Surveys Ltd	1971		490200	411550
ELS4130	Solar Park on Land at Raventhorpe Farm, Scunthorpe	AOC Archaeology Group	2014		494172	408127
ELS4190	Historic building recording, former RAF accommodation, Manby Woods	Beckside Buildings & Installations Limited	2015		495499	408951
ELS4273	Archaeological Monitoring, Raventhorpe Solar Park, Raventhorpe Farm	AOC Archaeology Group	2015		493838	408222

ELS4274	Archaeological Evaluation, Raventhorpe Solar Park - Fieldwalking	AOC Archaeology Group	2014		494216	408145
ELS4275	Archaeological Evaluation, Raventhorpe Solar Park - Trial Trenching	AOC Archaeology Group	2014		494291	408051

Fieldwalking Survey Region Records Beyond the Site

TITLE	MONUID	EVENTUID	SOURCEUID	MONTHYEAR	ORIGINATOR
Raventhorpe Solar Park - Archaeological Evaluation	MLS	ELS	SLS7243	September 2014	AOC Archaeology Group

Appendix 2: Figures



Legend

- Site
- Study Area
- Scheduled Monuments

Listed Buildings Grade:

- I
- II

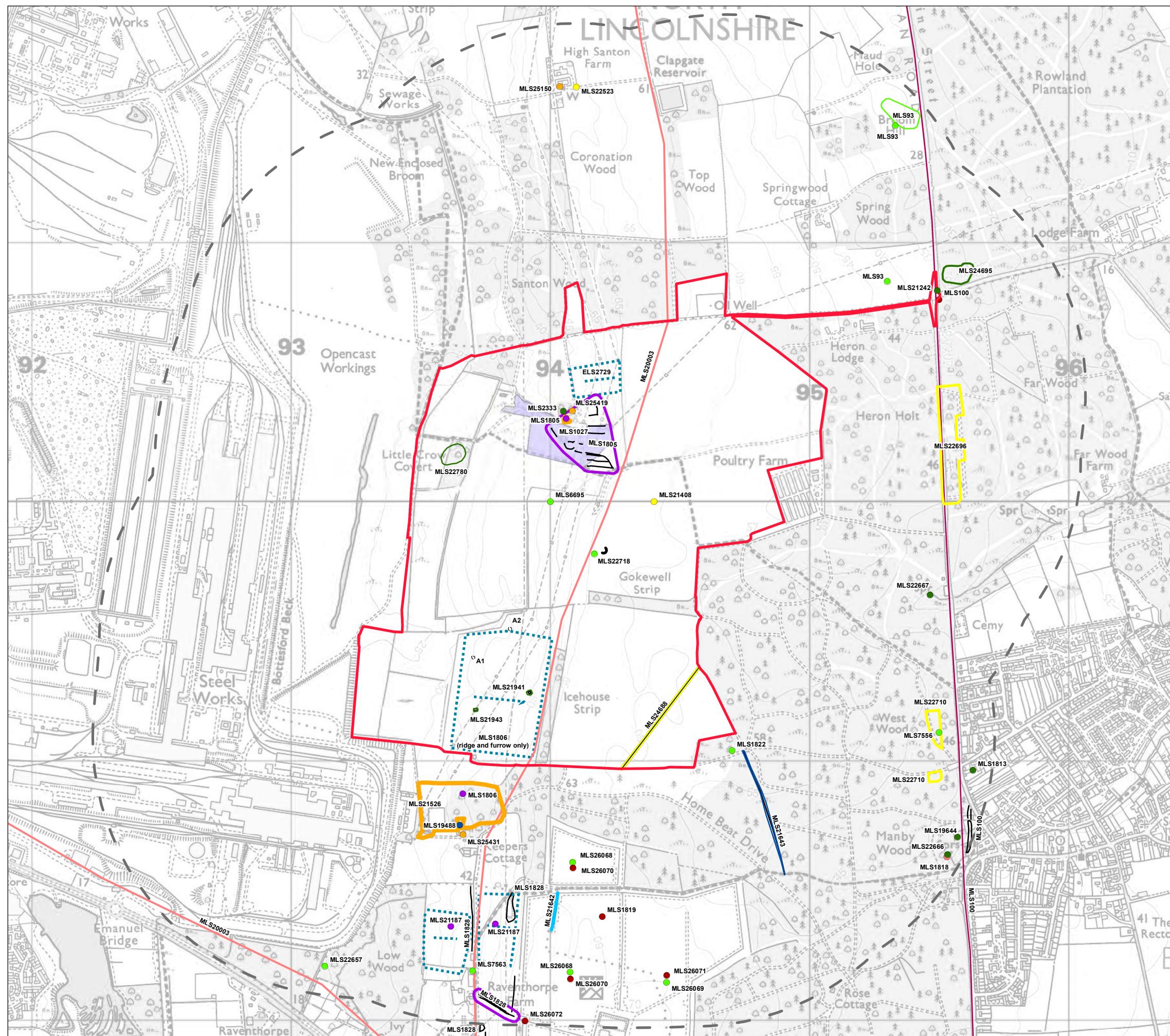
Revisions:
First Issue- 18/09/2017 RG
Second Issue - 06/02/2018 DL
Third Issue - 16/11/2018 RGO

Figure 1: Designated Heritage Assets

Little Crow Solar Park, North Lincolnshire

Client: INRG Solar
DRWG No: **P17-0718.7** Sheet No: - REV:C
Drawn by: DL / RGO Approved by: GS
Date: 16/11/2018
Scale: 1:22,500 @ A3





Legend

Site

Study Area

Undated

Modern

Post-medieval - modern

Post-medieval

Medieval - post-medieval

Medieval

Roman

Prehistoric - Roman

Prehistoric

Former ridge & furrow area

Cropmarks

Approximate extent of Gokewell earthworks survey

Revisions:
First Issue- 18/09/2017 RG
Second Issue - 06/02/2018 DL
Third Issue - 28/02/2018 DL
Fourth Issue - 05/04/2018 DL
Fifth Issue - 16/11/2018 RGO

Figure 2: North Lincolnshire HER Monument and Cropmark Data

Little Crow Solar Park, North Lincolnshire

Client: INRG Solar

DRWG No: **P17-0718.8**

Drawn by: RG/DL/RGO

Date: 16/11/2018

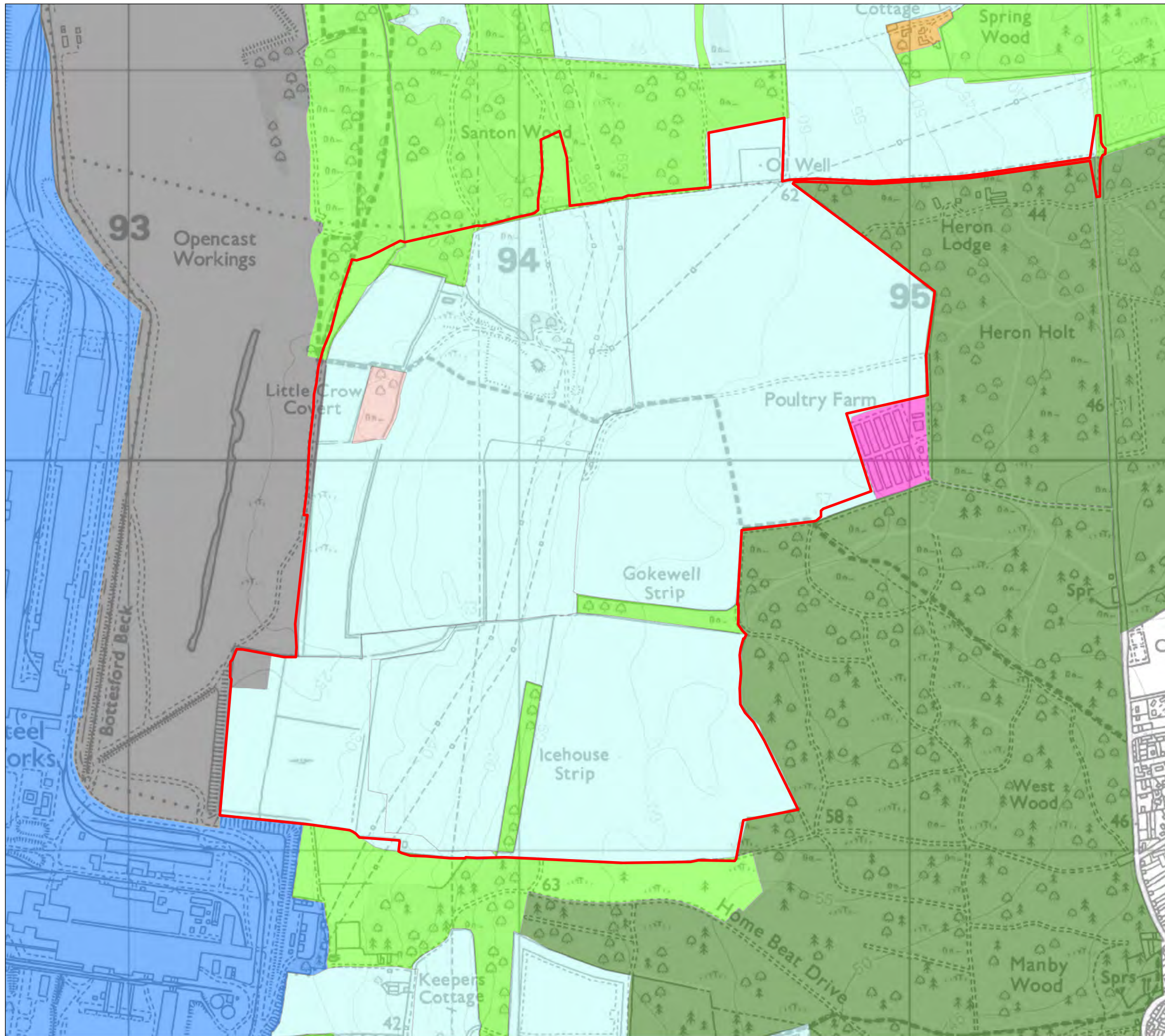
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Sheet No: - REV:C

Approved by: GS

Pegasus
Planning





Legend

Site

HLCTYPE

- Ancient/Semi Natural Woodland (early medieval to modern)
- Fox Coverts (post-medieval to modern)
- Ironstone Quarry (modern)
- Isolated Farmstead (post-medieval to modern)
- Livestock Rearing (modern)
- Modern Fields
- Other Factory (post-medieval to modern)
- Plantation Woodland (post-medieval to modern)

Revisions:
First Issue- 18/09/2017 RG
Second Issue - 06/02/2018 DL
Third Issue - 16/11/2018 RGO

Figure 4: Historic Landscape Characterisation Data

Little Crow Solar Park, North Lincolnshire

Client: INRG Solar
DRWG No: **P17-0718.10** Sheet No: - REV: C
Drawn by: DL/RGO Approved by: GS
Date: 16/11/2018
Scale: 1:10,000 @ A3





Legend



Revisions:
First Issue- 18/09/2017 RG
Second Issue - 06/02/2018 DL
Third Issue - 16/11/2018 RGO

Figure 5: LiDAR Data

Little Crow Solar Park, North Lincolnshire

Client: INRG Solar
DRWG No: **P17-0718.11** Sheet No: - REV: **C**
Drawn by: DL/RGO Approved by: GS
Date: 16/11/2018
Scale: 1:8,000 @ A3

Pegasus
Planning





Legend

Approx. Site area

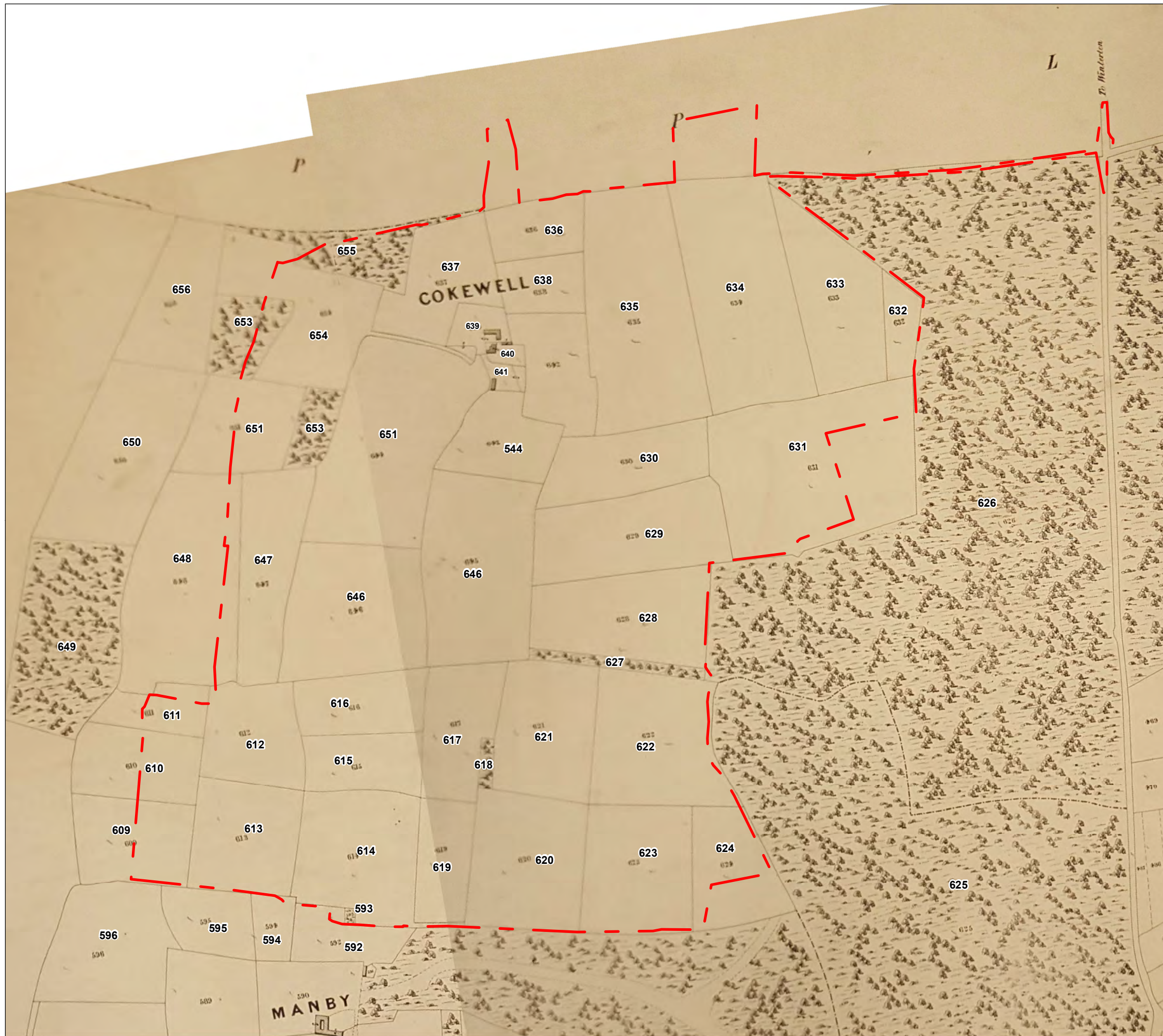
Revisions:
First Issue- 18/09/2017 RG
Second Issue - 06/02/2018 DL
Third Issue - 16/11/2018 RGO

Figure 6: 1824 Ordnance Survey Map

Little Crow Solar Park,
North Lincolnshire

Client: INRG Solar
DRWG No: **P17-0718.12** Sheet No: - REV: C
Drawn by: DL/RGO Approved by: GS
Date: 16/11/2018
Scale: 1:9,000 @ A3





Legend

Approx. Site area

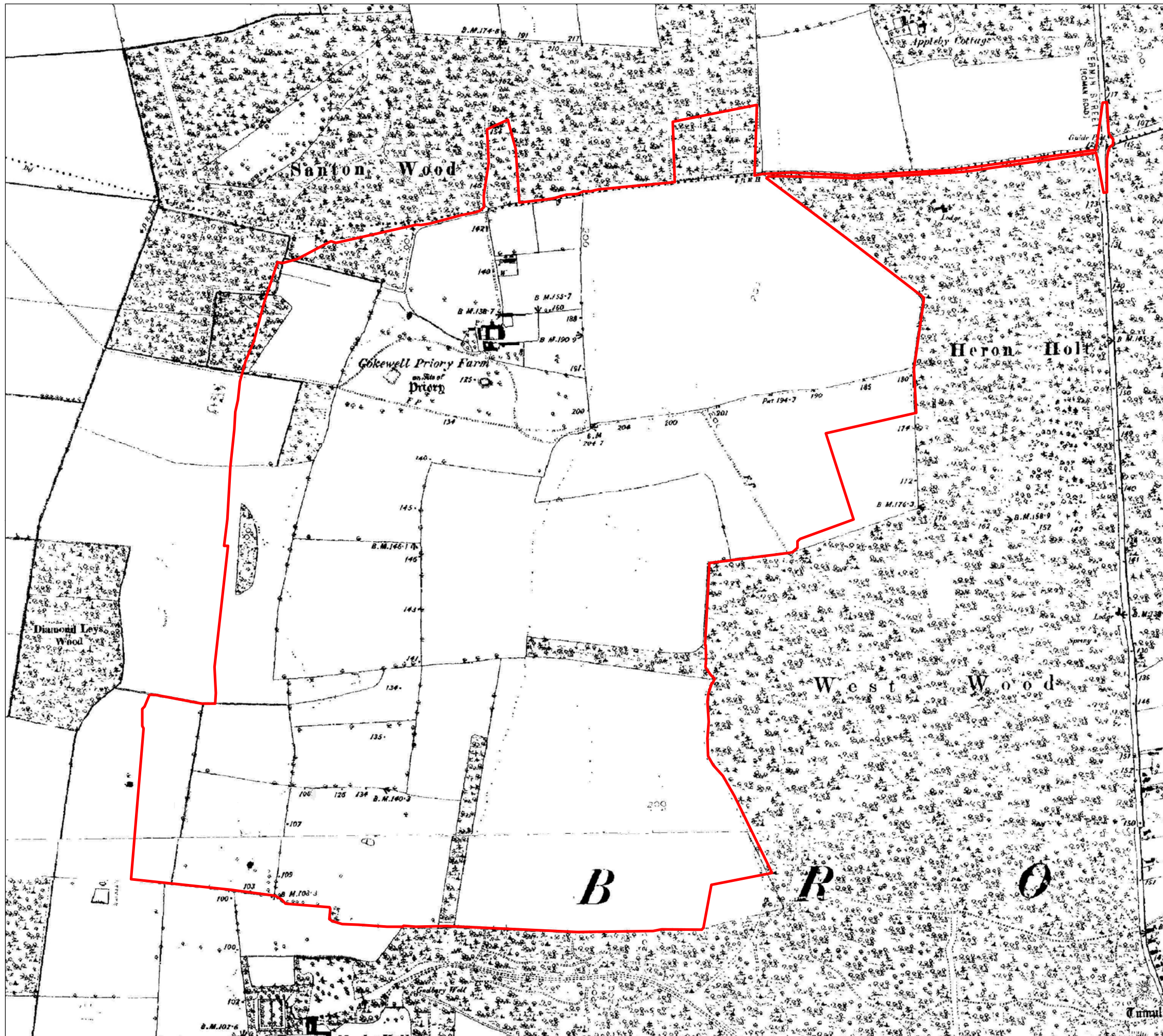
Revisions:
First Issue- 18/09/2017 RG
Second Issue - 06/02/2018 DL
Third Issue - 16/11/2018 RGO

Figure 7: 1842 Broughton Tithe Map

Little Crow Solar Park,
North Lincolnshire

Client: INRG Solar
DRWG No: **P17-0718.13** Sheet No: - REV: C
Drawn by: DL/RGO Approved by: GS
Date: 16/11/2018
Scale: 1:9,000 @ A3





Legend



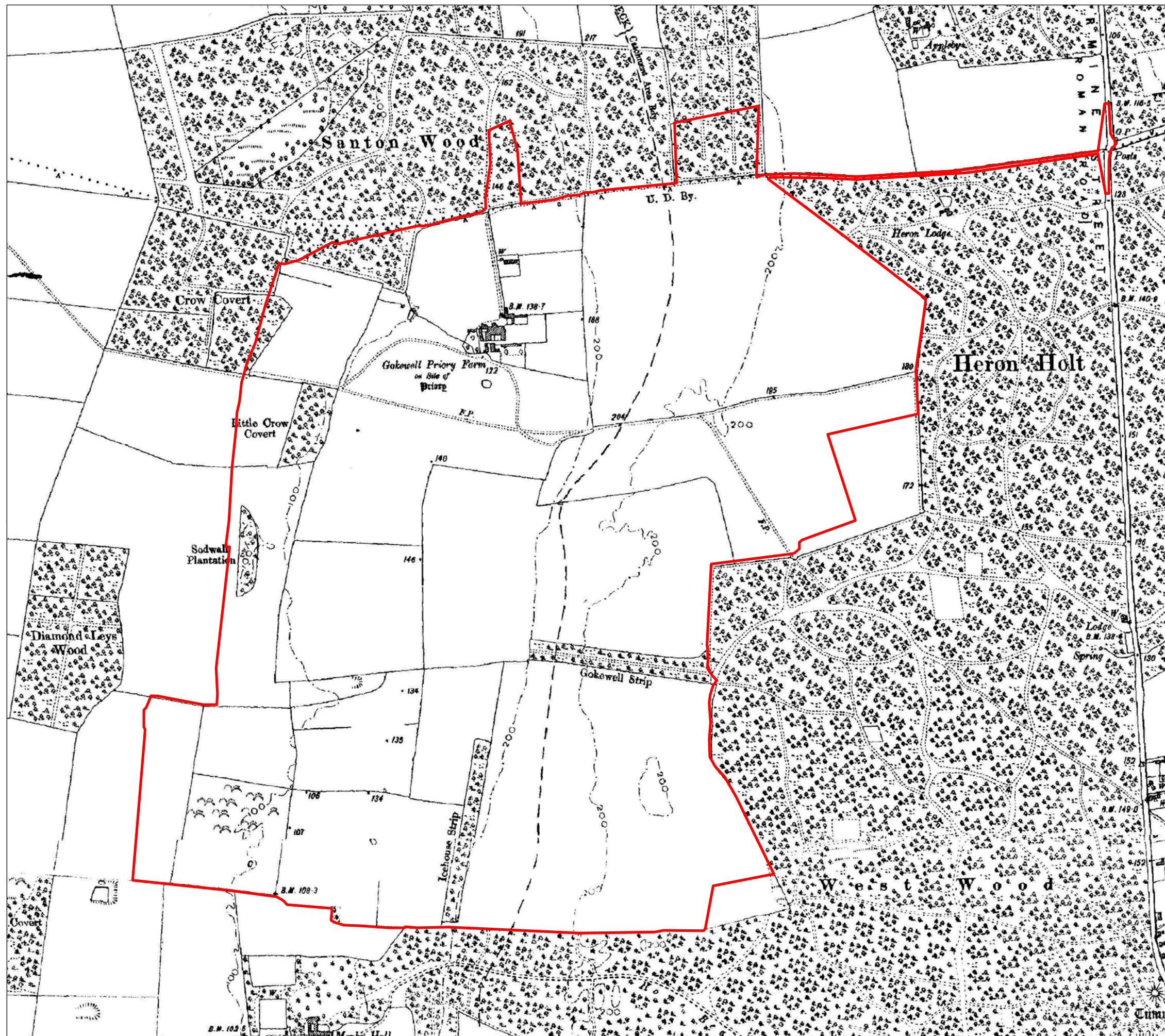
Revisions:
First Issue- 18/09/2017 RG
Second Issue - 06/02/2018 DL
Third Issue - 16/11/2018 RGO

Figure 8: 1889 Ordnance Survey Map

Little Crow Solar Park,
North Lincolnshire

Client: INRG Solar
DRWG No: **P17-0718.14** Sheet No: - REV: C
Drawn by: DL/RGO Approved by: GS
Date: 16/11/2018
Scale: 1:9,000 @ A3





Legend



Revisions:
First Issue- 18/09/2017 RG
Second Issue - 06/02/2018 DL
Third Issue - 16/11/2018 RGO

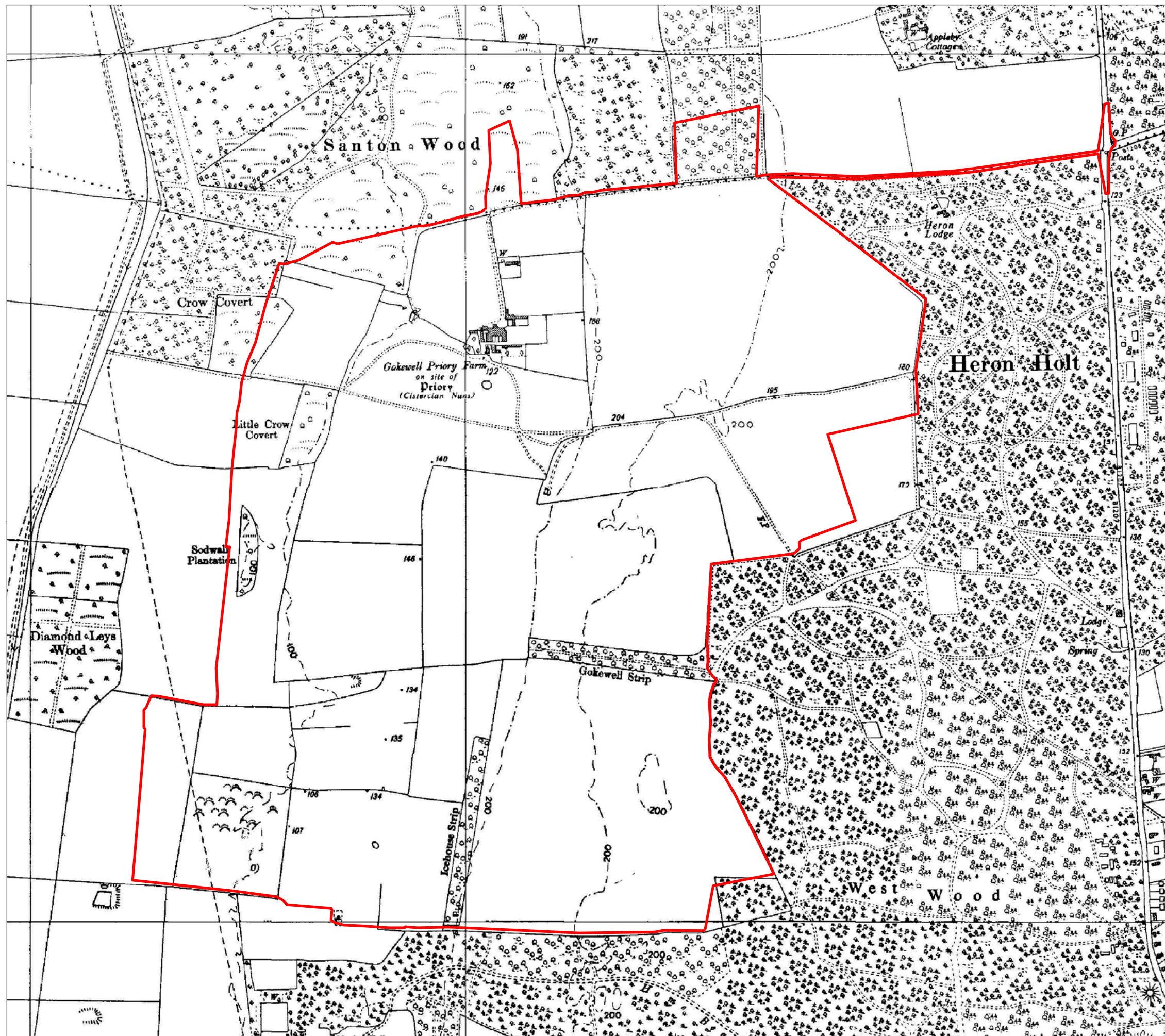
Figure 9: 1908 Ordnance Survey Map

Little Crow Solar Park, North Lincolnshire

Client: INRG Solar
DRWG No: **P17-0718.15** Sheet No: - REV: C
Drawn by: DL/RGO Approved by: GS
Date: 16/11/2018
Scale: 1:9,000 @ A3

Pegasus
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Legend



Revisions:
First Issue- 18/09/2017 RG
Second Issue - 06/02/2018 DL
Third Issue - 19/11/2018 RGO

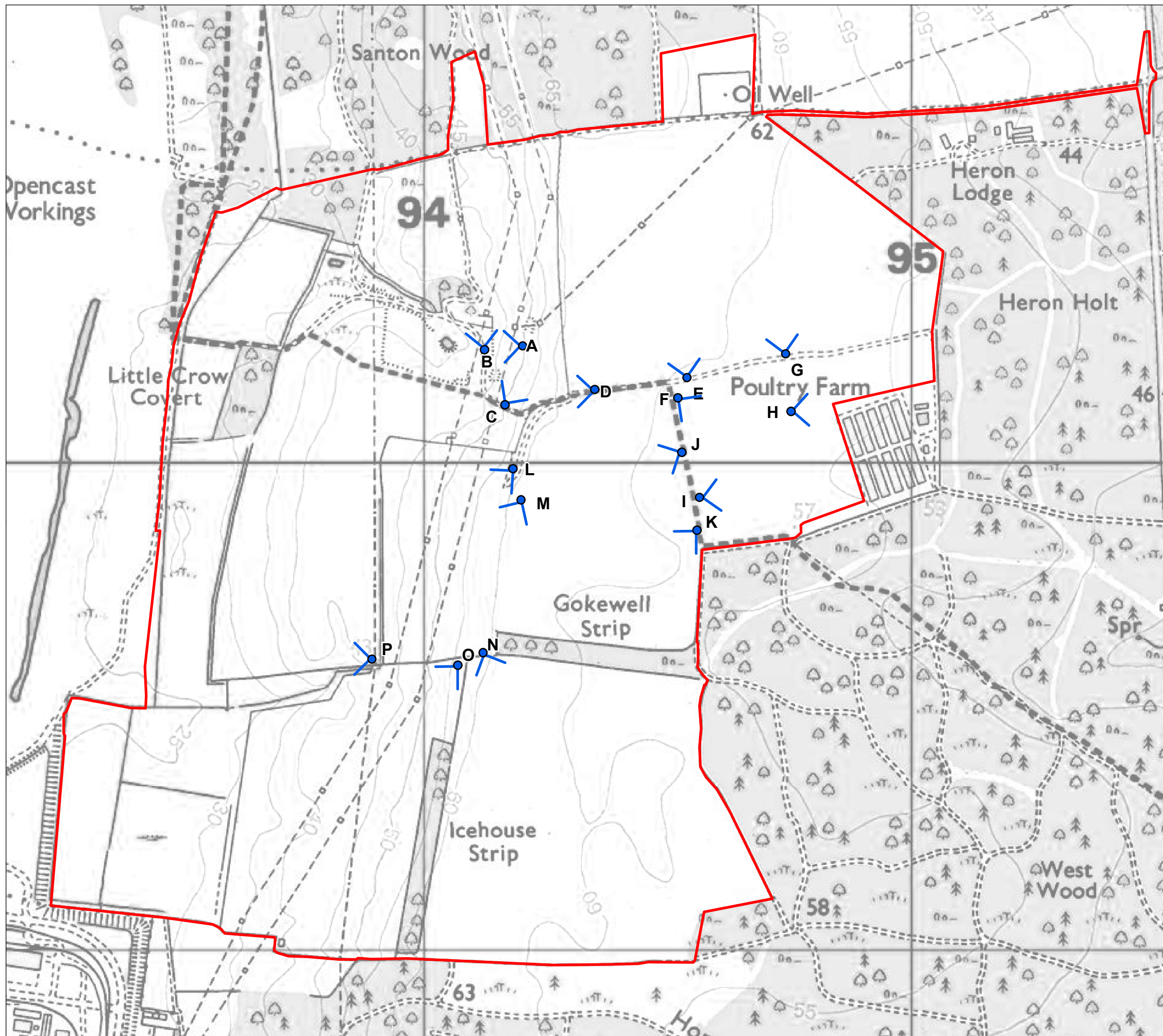
Figure 10: 1956 Ordnance Survey Map

Little Crow Solar Park, North Lincolnshire

Client: INRG Solar
DRWG No: **P17-0718.16** Sheet No: - REV: C
Drawn by: DL/RGO Approved by: GS
Date: 19/11/2018
Scale: 1:9,000 @ A3

Pegasus
Planning





Legend

- Site
- A ↖ Photograph location and direction, and reference in text

Revisions:
 First Issue- 06/04/2018 - DL
 Second Issue- 19/11/2018 - RGO

Figure 11: Photograph Locations

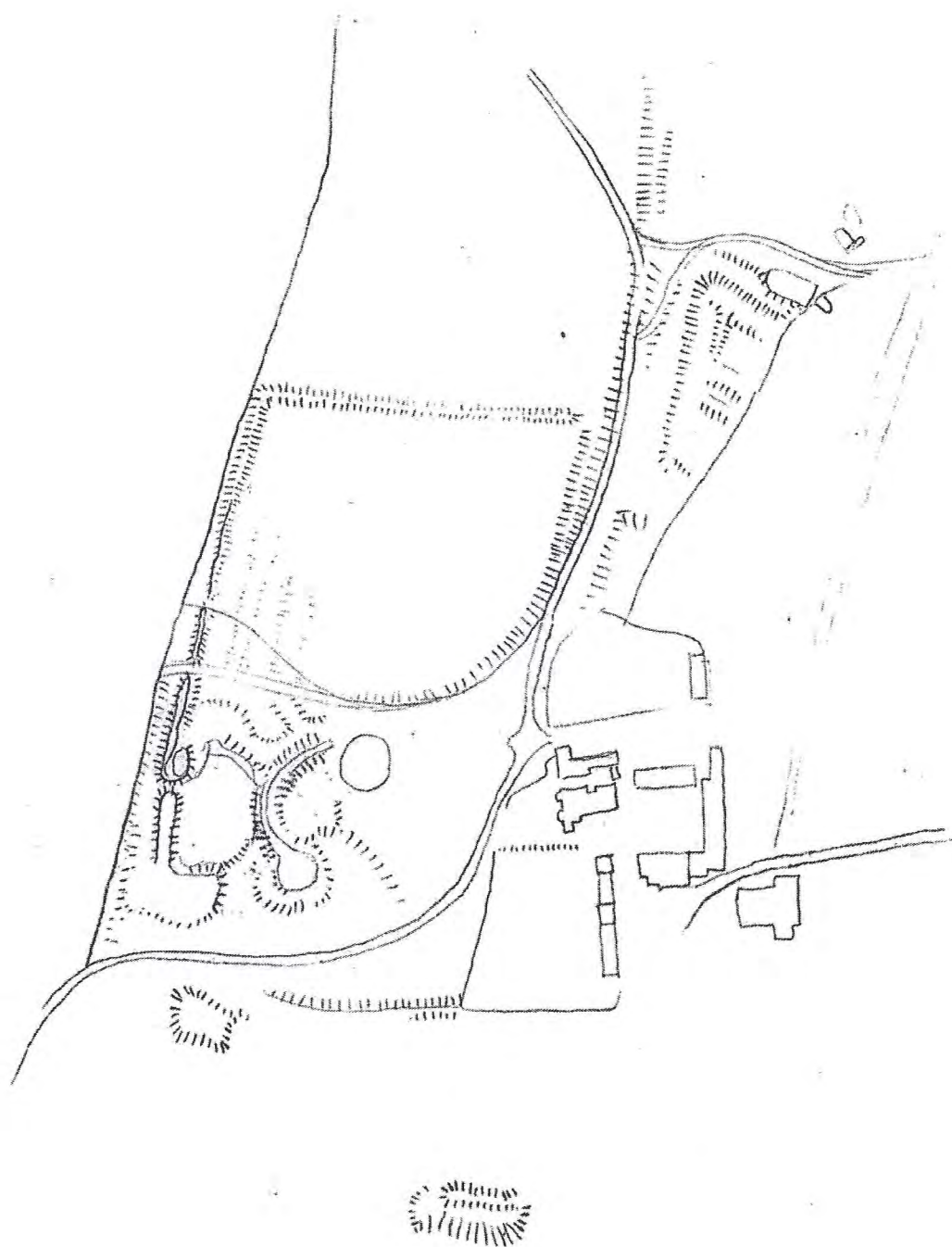
Little Crow Solar Park, North Lincolnshire

Client: INRG Solar
 DRWG No: **P17-0718.18** Sheet No: - REV:C
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Pegasus
Planning

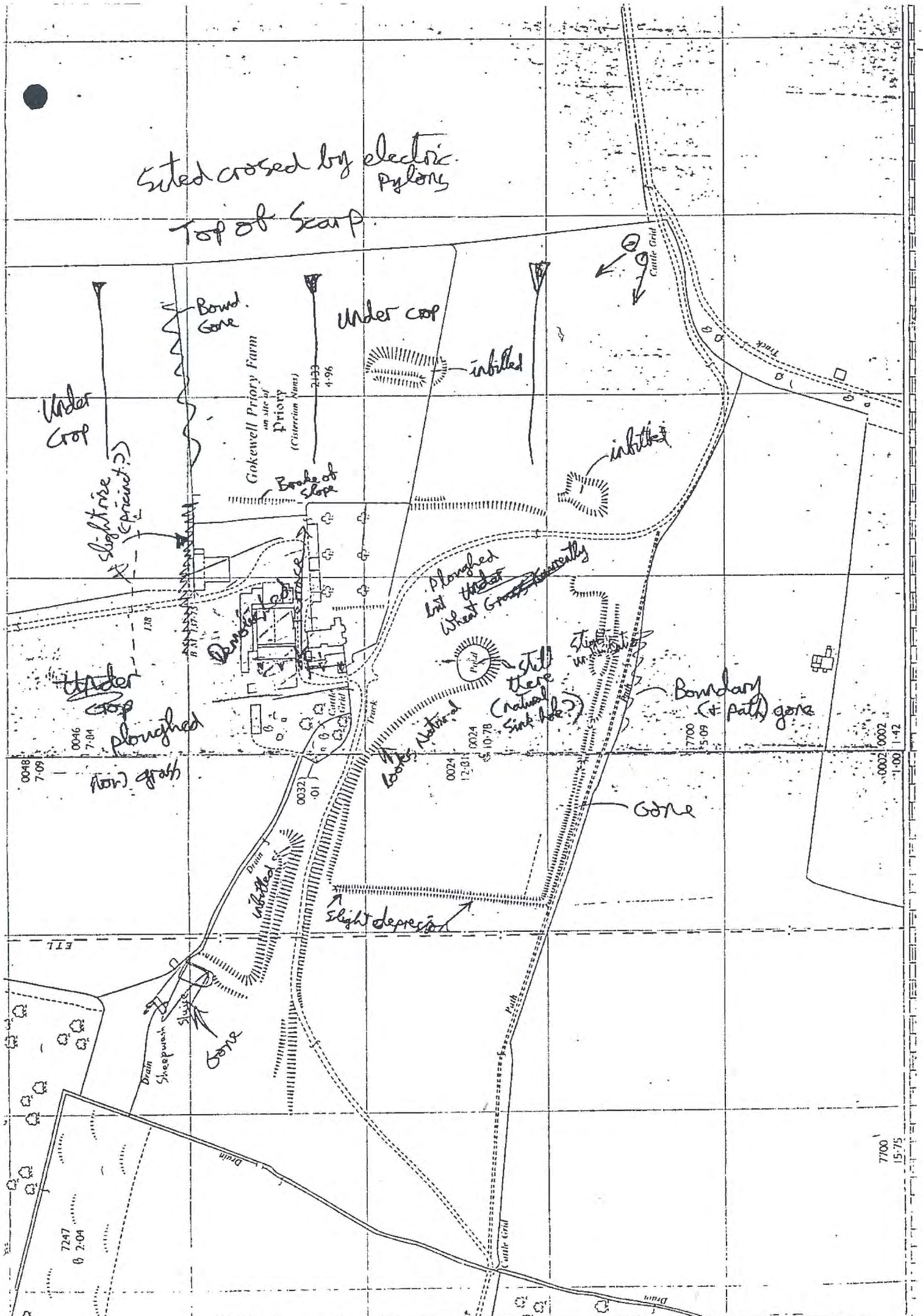


Appendix 3: Earthwork Survey



Sited crossed by electric pylons

Top of Scarp



Appendix 4: Non-Scheduling Report

1805.
ref. 10.

✓
general
review
14/3/98

NON-SCHEDULING REPORT

Site Gokewell Priory
Parish Broughton
District N Lincs
Grid Ref SE 9406 1032
SMR no. 1805
Evaluation Score 20

Visit Date ²⁴2/2/1998

Gokewell Priory was founded as a Cistercian nunnery by William de Alta Ripa in 1148 or 1185 and was dissolved in 1536. Pevsner notes some re-used 13th century stonework in the buildings of Gokewell Priory Farm. The SMR holds two good APs of standing earthworks surrounding the farm buildings together with a rough sketch plan of the site of unknown origin.

Unfortunately the farm buildings have now been demolished (although not cleared), and the surrounding fields turned over to arable, levelling the earthworks and filling in most of the depressions. The presumed precinct boundary is still traceable as a slight rise, depression or break of slope on all four sides, although not without several breaks. The site of the farm buildings, which is also thought to be the site of the convent buildings, is terraced into the rising ground to the east. As the western half of this area is built up ground, there may be very good archaeological survival underneath the later farm building remains.

It is proposed that a case for national importance cannot be made at this time given the lack of evidence of surviving remains. However, if it can be shown that remains of the convent buildings survive archaeologically, then the site should be reviewed and possibly scheduled.

Eric Instone MPPA
Date 4 March 1998

Appendix 5: Sources

Cartographic Sources

1824	Ordnance Survey map. County of Lincoln and parts adjacent
1842	Broughton Tithe Map. LA ref. I 291
1849	Broughton Enclosure Map. LA ref. LINDSEY AWARD/124
1887	25-inch Ordnance Survey map
1889-91	6-inch Ordnance Survey map
1907	25-inch Ordnance Survey map
1908	6-inch Ordnance Survey map
1948-50	6-inch Ordnance Survey map
1956	6-inch Ordnance Survey map
19565-67	25-inch Ordnance Survey map
1970	6-inch Ordnance Survey map
1972-79	1:10,000 Ordnance Survey map
1977	25-inch Ordnance Survey map
1978-95	1:10,000 Ordnance Survey map
1984	1:10,000 Ordnance Survey map

Documentary Sources

1852	Broughton Estate Sale Particulars
	Topographical Notes on Gokewell Priory. LA ref. AS/9/94
	Notebook O (relating to Gokewell Priory) LA ref. AS/9/13/11
	Broughton, Castlethorpe, Santon, Gokewell, Manby and Raventhorpe, General Survey and Valuation. LA ref. YARB/5/1/50 and YARB/5/1/33

For Bibliographic Sources, see footnotes in text

Aerial Photographic Sources

Oblique

Photo reference (NGR and Index number)	Film and frame number	Original number	Date	Film type		Map Reference (6 figure	What can you order?			
							Photocopy	Laser copy	Photographic copy	Digital copy
SE 9208 / 1	NMR 17389 / 19		02 NOV 1999	Colour slide	35 mm	SE 926085	Y	Y	Y	U
SE 9208 / 2	NMR 17389 / 20		02 NOV 1999	Colour slide	35 mm	SE 927087	Y	Y	Y	U
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Total 21 records

Vertical

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OS/96594	20833	V	23	N	SE 945 094	1	05 JUN 1996	A	7600	12	Black and White 9 x 9	NMR
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OS/01531	23617	V	26	N	SE 948 100	1	11 MAY 2001	A	7600	12	Black and White 9 x 9	NMR

Total Sorties 17

Total Frames 46

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APPENDIX 8.2

LITTLE CROW, SANTON, NORTH LINCOLNSHIRE – GEOPHYSICAL SURVEY REPORT (SUMO, SEPTEMBER 2018).



Little Crow

Solar Park

National significant infrastructure project in the Energy Sector

Little Crow Solar Park, Scunthorpe

GEOPHYSICAL SURVEY REPORT

GEOPHYSICAL SURVEY REPORT



**GEOPHYSICS FOR
ARCHAEOLOGY &
ENGINEERING**

**Little Crow Solar Park,
Scunthorpe,
North Lincolnshire**

Client
Cotswold Archaeology
For
INRG Solar (Little Crow) Ltd

Survey Report
13201

Date
September 2018

Revision Number 3 dated November 2018

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GEOPHYSICAL SURVEY REPORT

Project name:
**Little Crow Solar Park,
Scunthorpe,
North Lincolnshire**

SUMO Job reference:
13201

Client:
Cotswold Archaeology
For:
INRG Solar (Little Crow) Ltd

Survey date:
**23 July - 9 August &
13 August - 4 September 2018**

Report date:
27 September 2018

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1 SUMMARY OF RESULTS

A detailed magnetometer survey was conducted over approximately 214 ha of arable land near Scunthorpe, Lincolnshire. A ring ditch has been identified in the data, along with a few other ditch-like anomalies of possible archaeological origin. Several linear responses are of uncertain origin and could be archaeological, agricultural or natural. Evidence of fracturing within the limestone geology is visible, along with further areas of natural magnetic variation. Former field boundaries and ploughing effects have been mapped, as well as underground services and areas of magnetic disturbance.

2 INTRODUCTION

2.1 Background synopsis

SUMO Geophysics Ltd were commissioned to undertake a geophysical survey of an area outlined for solar farm development. This survey forms part of an archaeological investigation being undertaken by **Cotswold Archaeology** on behalf of **INRG Solar (Little Crow) Ltd**.

2.2 Site details

NGR / Postcode	SE 941 150 / DN20 0BQ
Location	The site is located c.5km to the east of Scunthorpe, Lincolnshire, to the north-west of the village of Broughton. Areas of woodland surround the site on all sides.
HER/SMR	Lincolnshire
District	North Lincolnshire
Parish	The site straddles two parish boundaries; Broughton CP and Appleby CP
Topography	Gently sloping down from east to west
Current Land Use	Arable
Geology	Solid: Charmouth Mudstone Formation - mudstone is predominantly recorded across the west of the site, with bands of Pecten Ironstone - ironstone, Marlstone Rock Formation - ferruginous limestone and ferruginous sandstone flanking either side. Bands of Whitby Mudstone Formation - mudstone, Northampton Sand Formation - sandstone, Grantham Formation - sandstone, siltstone and

mudstone and Lower Lincolnshire Limestone Member - limestone run down the centre of the site on a north-south alignment. The geology across the east of the site comprises Kirton Cementstone Beds - mudstone and limestone (interbedded) and Scawby Limestone - limestone and argillaceous rocks
Superficial: Sutton Sand Formation - sand is recorded across the west of the site and in small pockets across the western half (BGS 2018).

Soils

Newport 1 Association (551d) - deep well drained sandy and coarse loamy soils (SSEW 1983).

Archaeology

Three potential prehistoric records from the NLHER have been identified within the site. These include the site of a possible round barrow (MLS22718) located on aerial photographs. The data, function and archaeological provenance of this cropmark have not been proven through fieldwork. The NLHER also records the findspot of a number of flints (MLS6695) and the posited route of a prehistoric track (MLS20003), called the Jurassic Way, which runs from Winteringham to Lincoln. The line of the former Ermine Street Roman road (MLS100) follows the line of the B1027, a small portion of which is included in the site boundary at its eastern-most extent. It is possible that the site comprised part of an agricultural landscape during the Roman period. Within the northern part of the site is the location of the former Gokewell Priory, a small Cistercian nunnery founded in the 12th century (MLS1805, ELS800, ELS2566, ELS4211). The priory was a minor establishment with a small community of nuns. Potential below-ground remains relating to a former WWII Heavy Anti-Aircraft Battery (MLS21408) could survive within the eastern portion of the site (Pegasus 2018).

Survey Methods

Magnetometer survey (fluxgate gradiometer)

Study Area

c. 214 ha

2.3 Aims and Objectives

To locate and characterise any anomalies of possible archaeological interest within the study area.

3 METHODS, PROCESSING & PRESENTATION

3.1 Standards & Guidance

This report and all fieldwork have been conducted in accordance with the latest guidance documents issued by Historic England (EH 2008) (then English Heritage), the Chartered Institute for Archaeologists (CIfA 2014) and the European Archaeological Council (EAC 2016).

3.2 Survey methods

Detailed magnetic survey was chosen as an efficient and effective method of locating archaeological anomalies.

Technique	Instrument	Traverse Interval	Sample Interval
Magnetometer	Bartington Grad 601-2	1.0m	0.25m

More information regarding this technique is included in Appendices A, B and C.

3.3 Data Processing

The following basic processing steps have been carried out on the data used in this report:

De-stripe; de-stagger; interpolate

3.4 Presentation of results and interpretation

The presentation of the results includes a 'minimally processed data' and a 'processed data' greyscale plot. Magnetic anomalies are identified, interpreted and plotted onto the 'Interpretation' drawings.

When interpreting the results, several factors are taken into consideration, including the nature of archaeological features being investigated and the local conditions at the site (geology, pedology, topography etc.). Anomalies are categorised by their potential origin. Where responses can be related to other existing evidence,

the anomalies will be given specific categories, such as: *Abbey Wall* or *Roman Road*. Where the interpretation is based largely on the geophysical data, levels of confidence are implied, for example: *Probable*, or *Possible Archaeology*. The former is used for a confident interpretation, based on anomaly definition and/or other corroborative data such as cropmarks. Poor anomaly definition, a lack of clear patterns to the responses and an absence of other supporting data reduces confidence, hence the classification *Possible*.

4 RESULTS

The survey has been divided into twenty survey areas (Areas 1-20) and specific anomalies have been given numerical labels [1] [2] which appear in the text below, as well as on the Interpretation Figure(s).



Plan showing boundaries of individual survey areas 1-20.

4.1 *Probable Archaeology*

- 4.1.1 A small, circular anomaly [1] in Area 14 is the only response of 'probable' archaeological origin that has been identified in the data. The anomaly is indicative of a ring ditch which could be associated with a former barrow, though does not correspond with the location of the possible barrow (MLS22718) identified on aerial photographs.

4.2 *Possible Archaeology*

- 4.2.1 A long curvilinear anomaly [2] can be seen in Area 7 and has been assigned a 'possible' archaeological origin. The response is ditch-like in its characteristics, hence its classification as being possibly archaeological; however, there is no further evidence of archaeological activity within the area. It is possible that the response could relate to a former field boundary, but none are visible on historic mapping, hence the possible archaeological interpretation.
- 4.2.2 Similar ditch-type anomalies [3-4] have been identified in Areas 17 and 20. These are both of uncertain antiquity; the responses are very straight which suggests they may have a more recent origin and could relate to former field boundaries. However, no boundaries are visible in these locations on available historic maps.

4.3 *Uncertain*

- 4.3.1 A series of linear and rectilinear anomalies [5] can be seen throughout Area 20. Although they have the appearance of archaeological enclosures, the pattern is very similar to that typically produced by limestone fracturing and therefore their exact origin cannot be determined with confidence. The anomalies have therefore been assigned to the category *Uncertain Origin*.
- 4.3.2 A small rectilinear feature with closely spaced linear anomalies within [6] has been identified in the south-west of Areas 18 and 19. The anomaly is of uncertain origin, and an archaeological explanation is thought unlikely. The feature could instead be a result of more recent agricultural activity.

4.3.3 Several linear trends [7] and other ditch-like anomalies are present in the data and their interpretation is subjective. They could be the result of former ditches though their exact origin remains unclear; they may have archaeological, natural or agricultural origins.

4.4 *Former Field Boundary*

4.4.1 A number of linear anomalies [8-16] have been identified across the site and are associated with former field boundaries, visible on available historic OS mapping dating from 1889. Other linear anomalies in Areas 11-12 and 16 may be a result of former boundaries, though no such features are visible in these locations on historic mapping; hence the conjectural interpretation.

4.5 *Agricultural – Ploughing*

4.5.1 Closely spaced, parallel linear anomalies have been identified throughout the site. These are a result of agricultural activity.

4.6 *Natural / Geological / Pedological / Topographic*

4.6.1 A large number of amorphous, sinuous and curving responses have been identified in several areas. These are of natural origin and are a result of localised variations in the underlying geology.

4.7 *Ferrous / Magnetic Disturbance*

4.7.1 Magnetic disturbance is visible across Areas 3, 4, 5, 6 10, 11, 12 and 15, but have not been marked on the interpretation figures so as not to detract from other visible anomalies. This disturbance is a result of the spreading of modern 'green waste' fertilisers which contain large numbers of small ferrous items and metal contaminants and has the potential to mask weaker, more ephemeral responses. The ironstone geology underling the site is also likely to be contributing to the enhanced magnetic responses in these areas.

4.7.2 Strong bipolar linear anomalies running across Areas 6, 7, 13-14 and 20 are related to underground services, such as pipes or cables.

- 4.7.3 Ferrous responses close to boundaries are due to adjacent fences and gates. Smaller scale ferrous anomalies ("iron spikes") are present throughout the data and are characteristic of small pieces of ferrous debris (or brick / tile) in the topsoil; they are commonly assigned a modern origin. Only the most prominent of these are highlighted on the interpretation diagram.

5 DATA APPRAISAL & CONFIDENCE ASSESSMENT

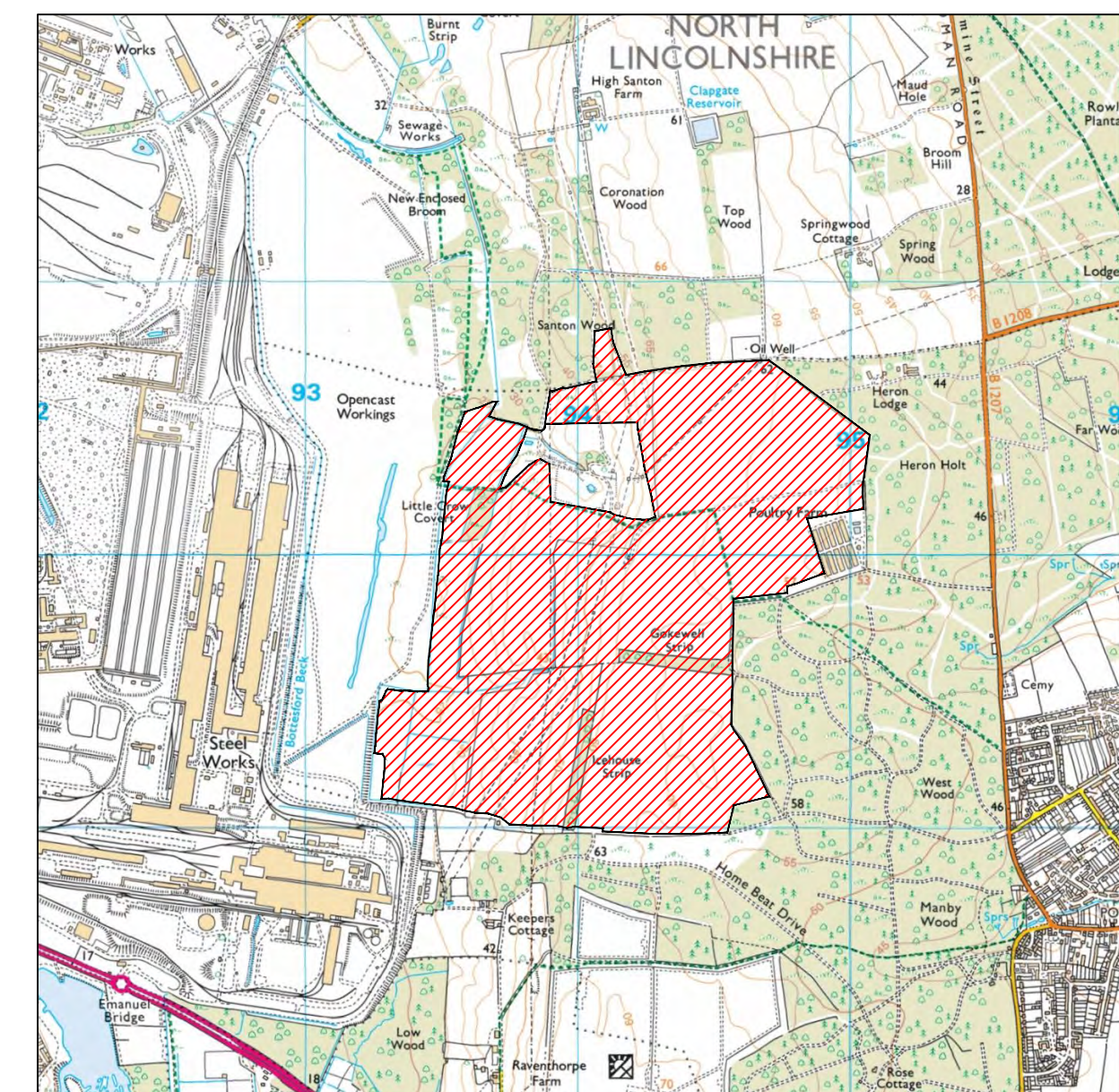
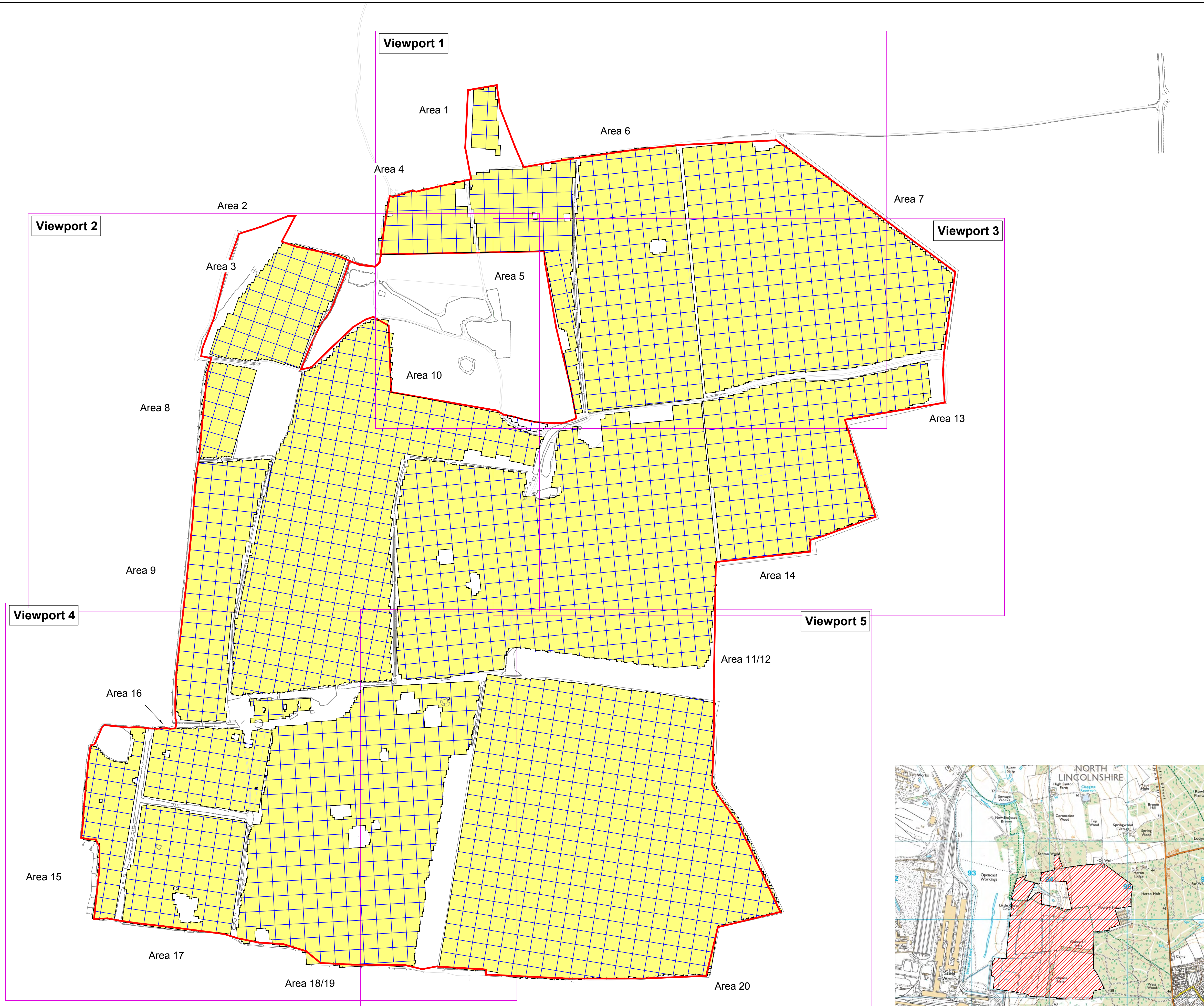
- 5.1 Historic England guidelines (EH 2008) Table 4 states that the average magnetic response on limestone, mudstone and sandstone can be variable. The results from this survey indicate the presence of a ring ditch, along with possible archaeological ditches and several linear trends of uncertain origin. However, the 'green waste' fertiliser and effects of ferruginous geology has the potential to mask weaker features, with only the strongest of features being visible. In areas where there is geological cracking, a medium level of confidence has been assigned.

6 CONCLUSION

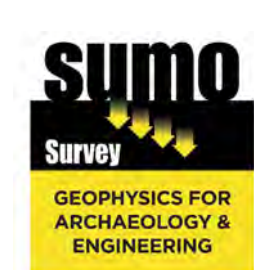
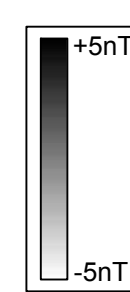
- 6.1 The survey at Little Crow has revealed evidence of a ring ditch along with linear anomalies which may be related to former ditches. Several linear trends are of uncertain origin, though an archaeological explanation cannot be ruled out entirely. Former field boundaries and evidence of ploughing can be seen in the data, along with natural fracturing in the limestone geology and other areas of localised magnetic variations. Green waste fertiliser appears to have been spread across several fields though uncertain linear features can still be seen. The remaining responses are modern and include underground services and disturbance from nearby ferrous objects such as fences and pylons.

7 REFERENCES

- BGS 2018 British Geological Survey, Geology of Britain viewer [Accessed 25/09/2018] *website:* (<http://mapapps.bgs.ac.uk/geologyofbritain/home.html?>)
- CIfA 2014 *Standard and Guidance for Archaeological Geophysical Survey. Amended 2016. CIfA Guidance note. Chartered Institute for Archaeologists, Reading*
http://www.archaeologists.net/sites/default/files/CIfAS%26GGeophysics_2.pdf
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- SSEW 1983 *Soils of England and Wales. Sheet 4, Eastern England. Soil Survey of England and Wales, Harpenden.*



	Site Location
	Survey Area - showing 30m grid
<small>Reproduced from Ordnance Survey's 1:25 000 map of 1998 with the permission of the controller of Her Majesty's Stationery Office. Crown Copyright reserved. Licence No. 100018665</small>	
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Client: Cotswold Archaeology	
Project: 13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire	
Scale: 0 200 metres 1:4000 @ A1	Fig No: 01



Title: Magnetometer Survey - Greyscale Plots - Overview		
Client: Cotswold Archaeology		
Project: 13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire		
Scale: 0 metres 200 1:4000 @ A1	Fig No: 02	

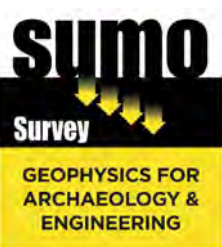
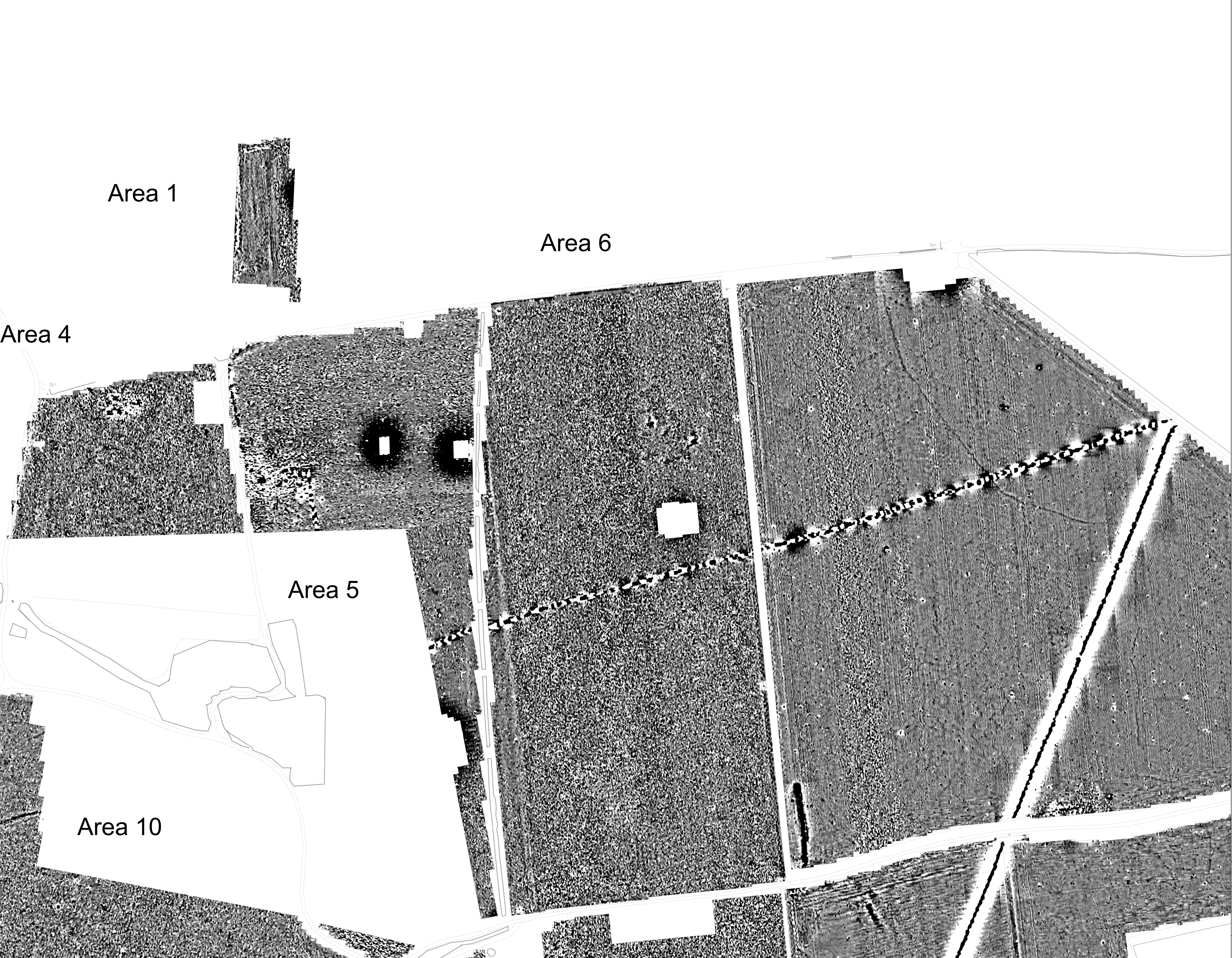


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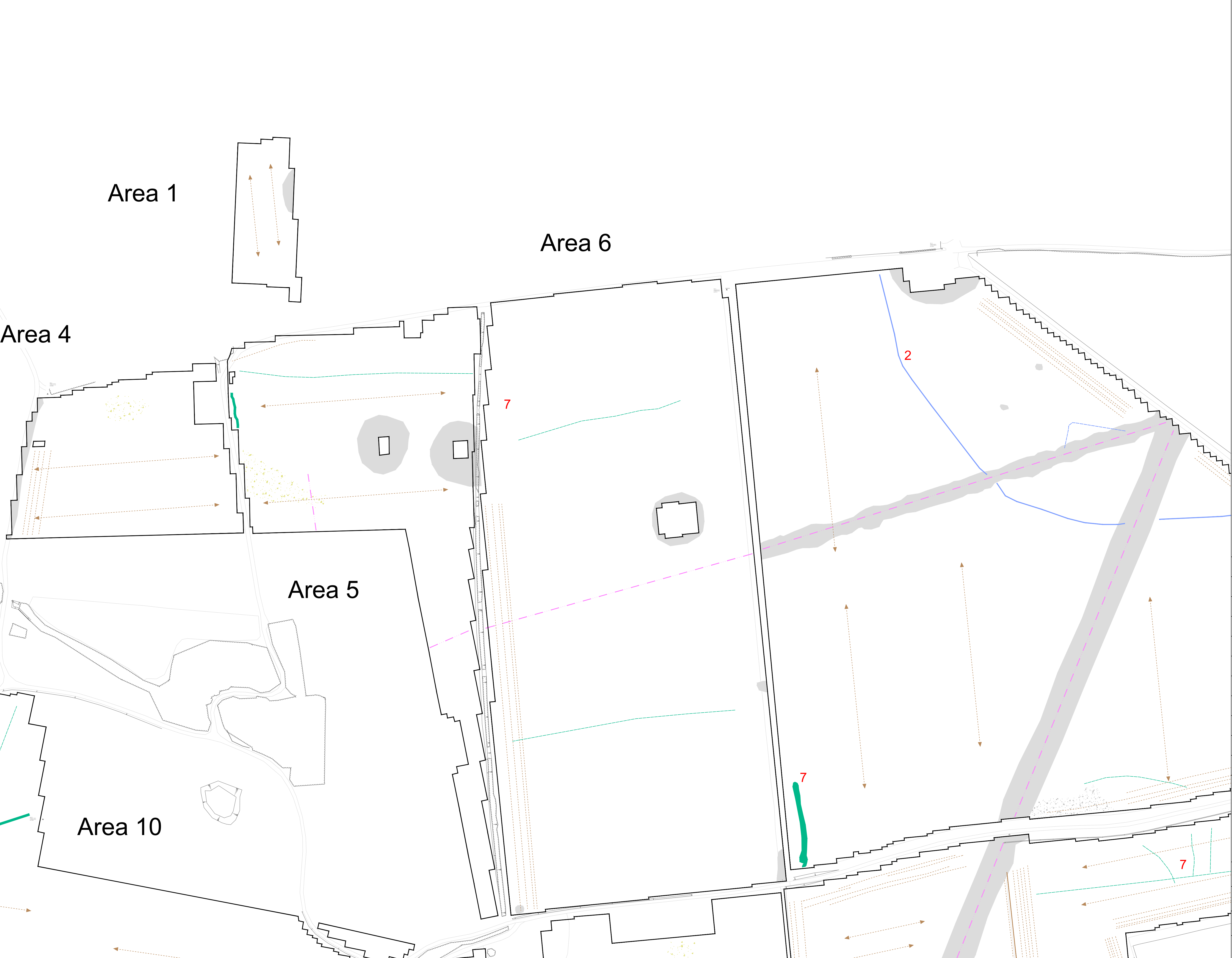
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	Possible archaeology (discrete anomaly / trend)
	Uncertain Origin (discrete anomaly / trend)
	Former field boundary (corroborated)
	Former field boundary (conjectural)
	Agriculture (plough)
	Natural (e.g. geological / pedological)
	Magnetic disturbance
	Service
	Ferrous



Title:	Magnetometer Survey - Interpretation - Overview
Client:	Cotswold Archaeology
Project:	13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire
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Fig No:	03

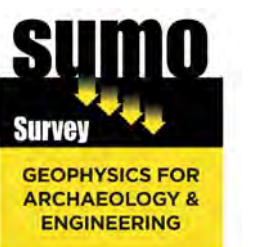


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Client: Cotswold Archaeology		
Project: 13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire		
Scale: 0 metres 75 1:1500 @ A1	Fig No: 04	

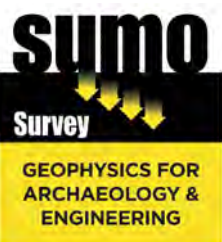
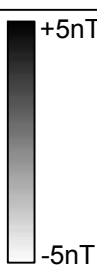
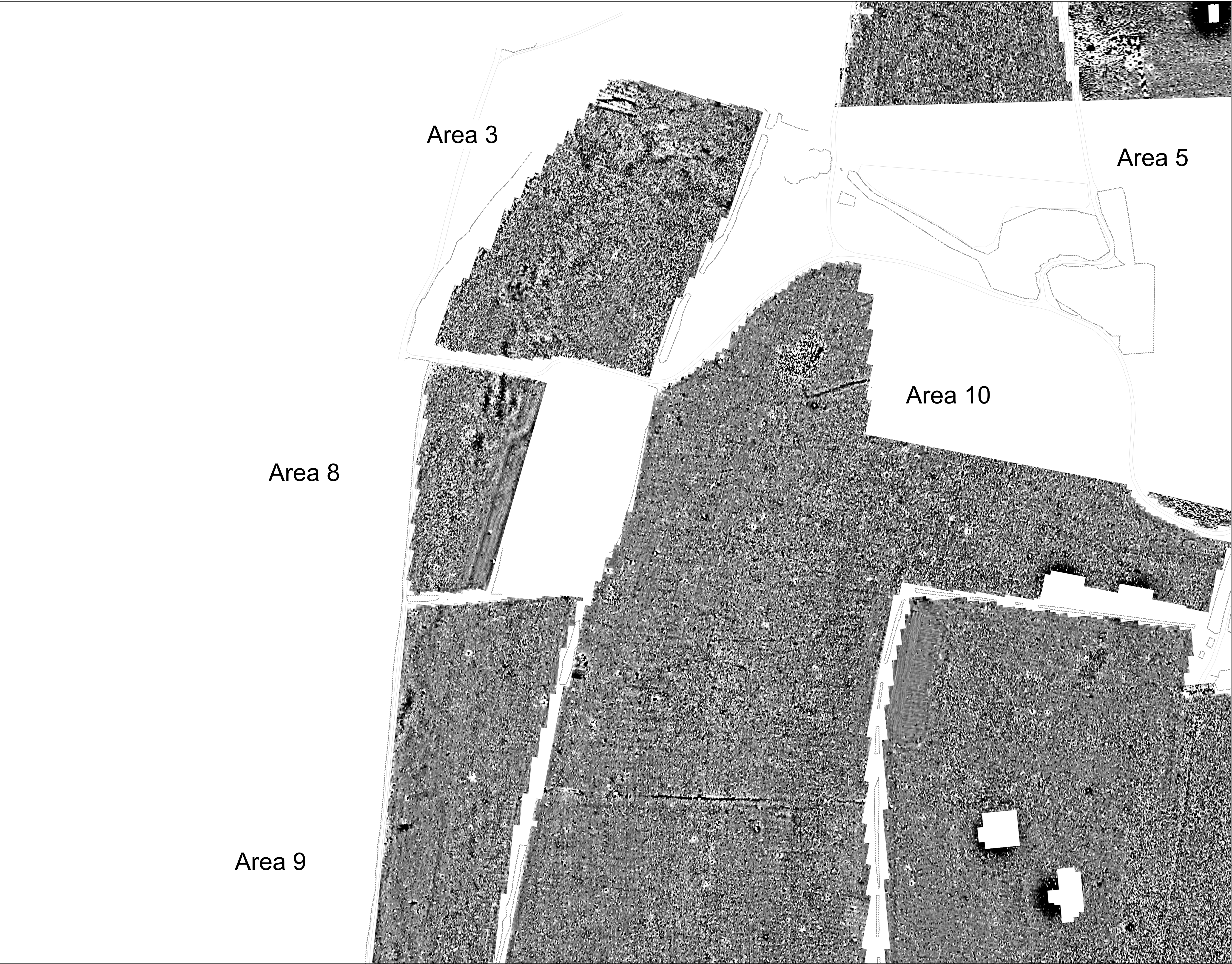


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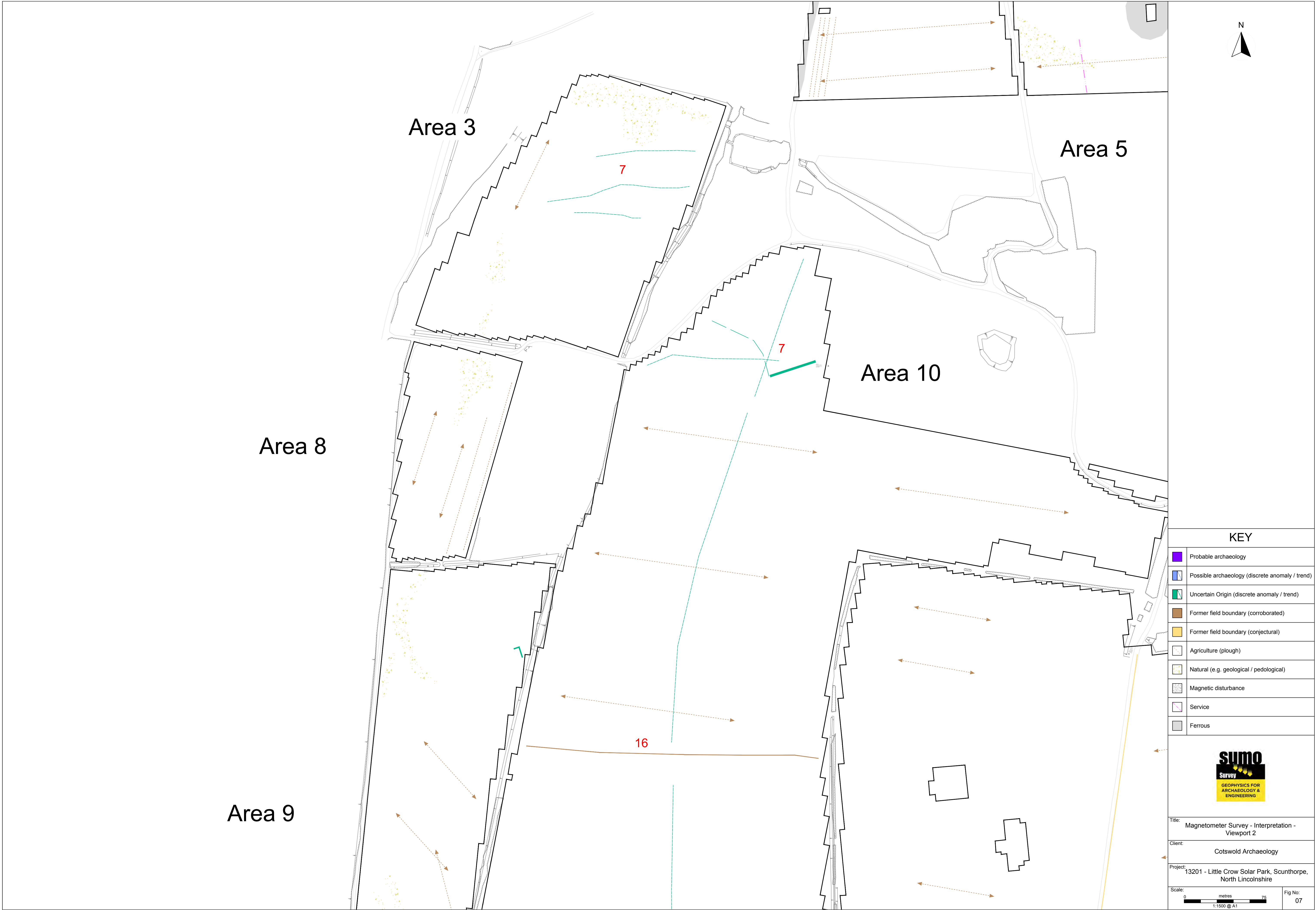
	Probable archaeology
	Possible archaeology (discrete anomaly / trend)
	Uncertain Origin (discrete anomaly / trend)
	Former field boundary (corroborated)
	Former field boundary (conjectural)
	Agriculture (plough)
	Natural (e.g. geological / pedological)
	Magnetic disturbance
	Service
	Ferrous

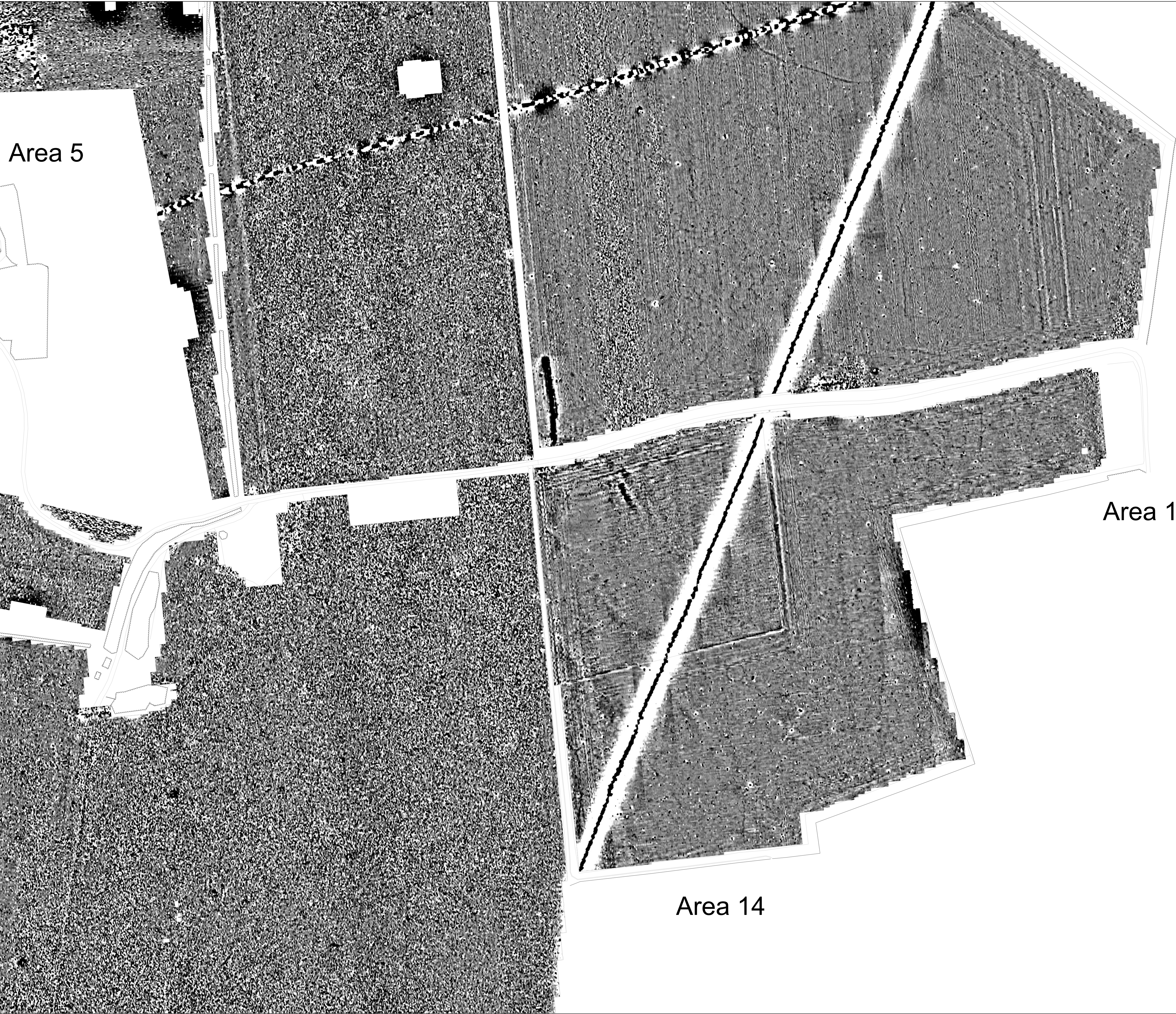


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Client:	Cotswold Archaeology
Project:	13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire
Scale:	0 metres 75 1:1500 @ A1
Fig No:	05



Title: Magnetometer Survey - Greyscale Plots - Viewport 2	
Client: Cotswold Archaeology	
Project: 13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire	
Scale: 0 metres 75 1:1500 @ A1	Fig No: 06

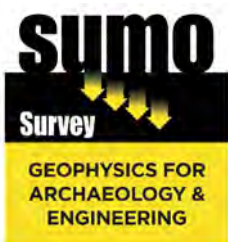
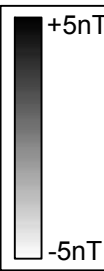




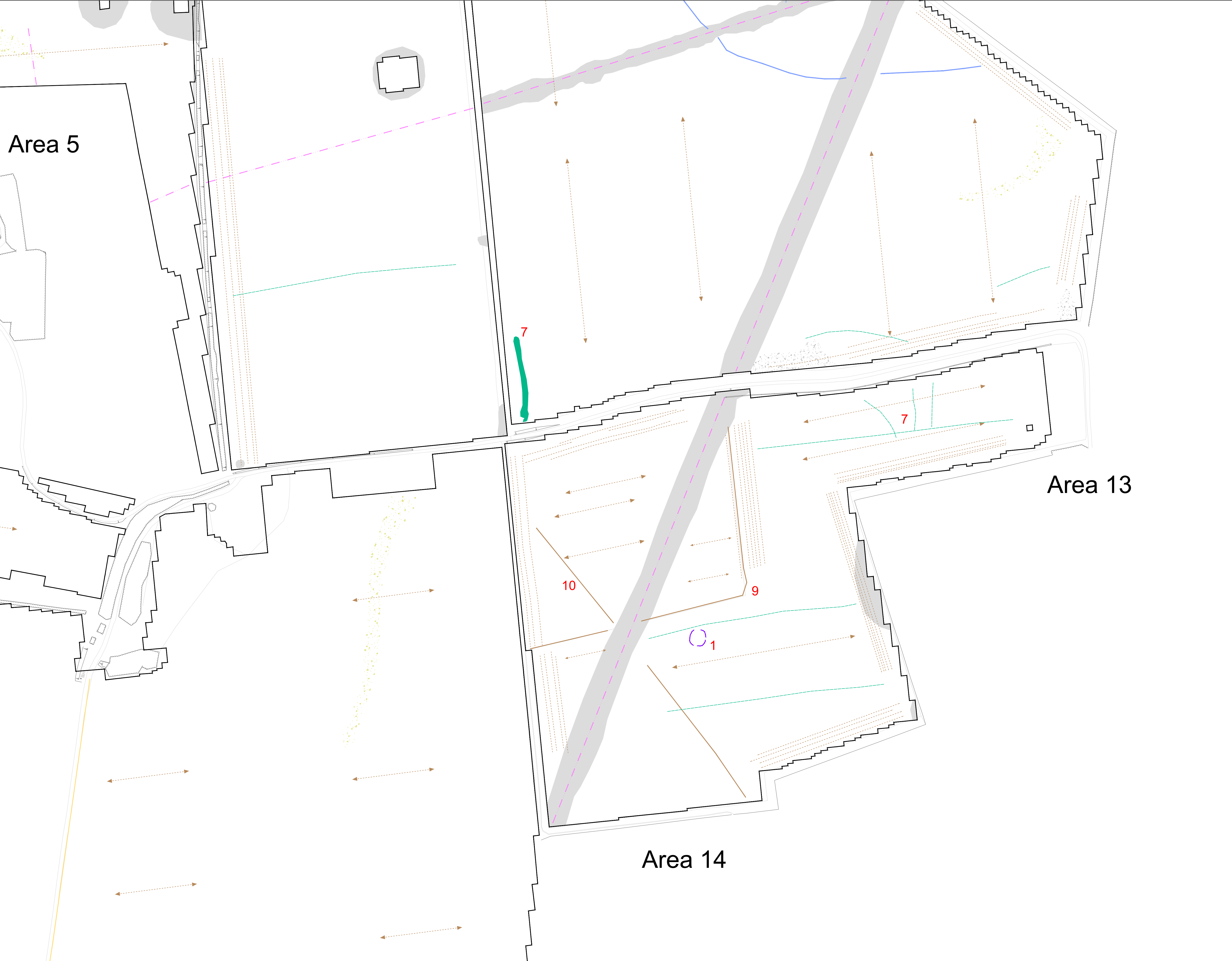
Area 5

Area 13











Area 14



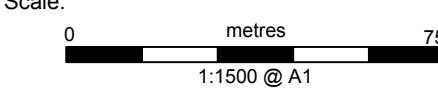
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Client: Cotswold Archaeology	
Project: 13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire	
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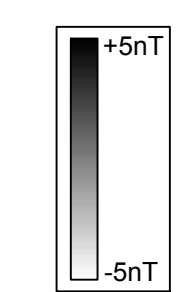
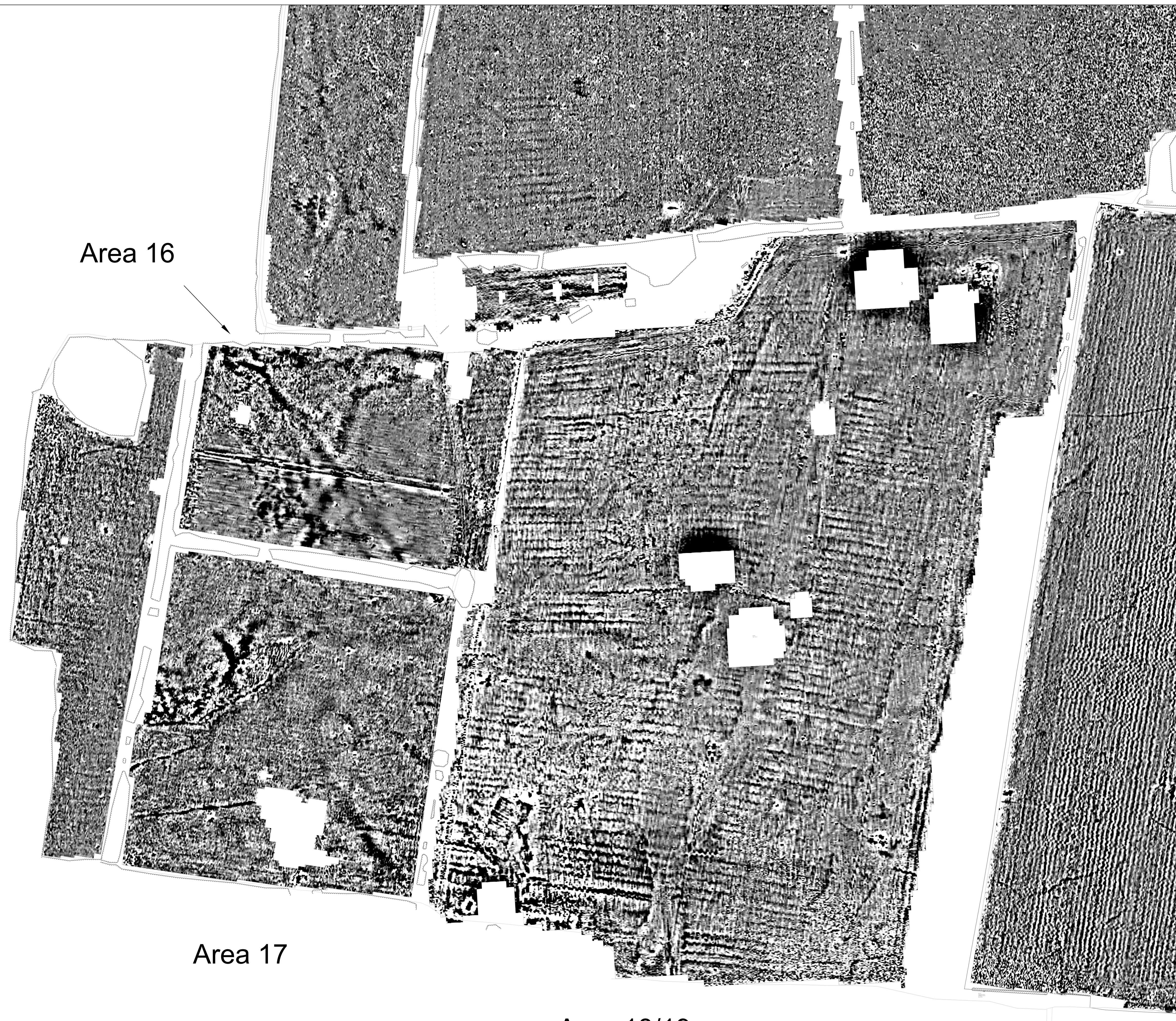


KEY

	Probable archaeology
	Possible archaeology (discrete anomaly / trend)
	Uncertain Origin (discrete anomaly / trend)
	Former field boundary (corroborated)
	Former field boundary (conjectural)
	Agriculture (plough)
	Natural (e.g. geological / pedological)
	Magnetic disturbance
	Service
	Ferrous



Title:	Magnetometer Survey - Interpretation - Viewport 3	
Client:	Cotswold Archaeology	
Project:	13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire	
Scale:	 0 metres 75 150 1:1500 @ A1	Fig No: 09



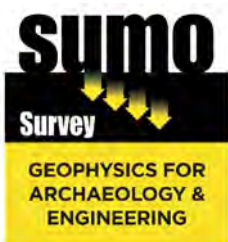
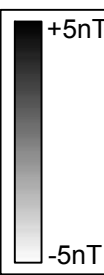
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Client: Cotswold Archaeology		
Project: 13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire		
Scale: 0 metres 75 1:1500 @ A1	Fig No: 10	

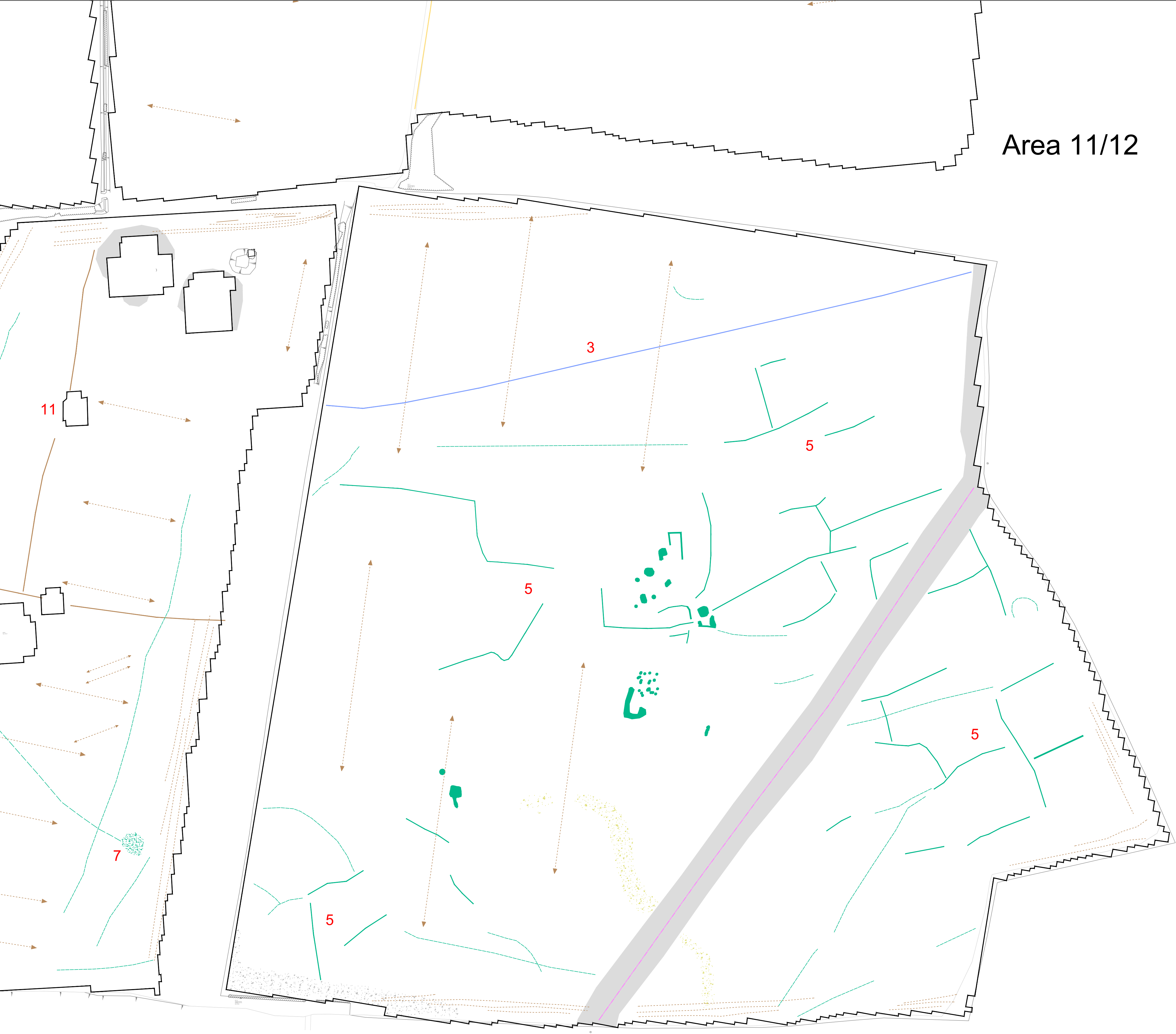




Area 11/12

Area 20





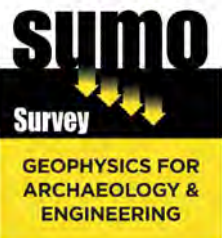
Area 11/12

Area 20



KEY

	Probable archaeology
	Possible archaeology (discrete anomaly / trend)
	Uncertain Origin (discrete anomaly / trend)
	Former field boundary (corroborated)
	Former field boundary (conjectural)
	Agriculture (plough)
	Natural (e.g. geological / pedological)
	Magnetic disturbance
	Service
	Ferrous



Title:	Magnetometer Survey - Interpretation - Viewport 5
Client:	Cotswold Archaeology
Project:	13201 - Little Crow Solar Park, Scunthorpe, North Lincolnshire
Scale:	0 metres 75 1:1500 @ A1
Fig No:	13

Appendix A - Technical Information: Magnetometer Survey Method

Grid Positioning

For hand held gradiometers the location of the survey grids has been plotted together with the referencing information. Grids were set out using a Trimble R8 Real Time Kinematic (RTK) VRS Now GNSS GPS system.

An RTK GPS (Real-time Kinematic Global Positioning System) can locate a point on the ground to a far greater accuracy than a standard GPS unit. A standard GPS suffers from errors created by satellite orbit errors, clock errors and atmospheric interference, resulting in an accuracy of 5m-10m. An RTK system uses a single base station receiver and a number of mobile units. The base station re-broadcasts the phase of the carrier it measured, and the mobile units compare their own phase measurements with those they received from the base station. This results in an accuracy of around 0.01m.

Technique	Instrument	Traverse Interval	Sample Interval
Magnetometer	Bartington Grad 601-2	1m	0.25m

Instrumentation: **Bartington Grad 601-2**

Bartington instruments operate in a gradiometer configuration which comprises fluxgate sensors mounted vertically, set 1.0m apart. The fluxgate gradiometer suppresses any diurnal or regional effects. The instruments are carried, or cart mounted, with the bottom sensor approximately 0.1-0.3m from the ground surface. At each survey station, the difference in the magnetic field between the two fluxgates is measured in nanoTesla (nT). The sensitivity of the instrument can be adjusted; for most archaeological surveys the most sensitive range (0.1nT) is used. Generally, features up to 1m deep may be detected by this method, though strongly magnetic objects may be visible at greater depths. The Bartington instrument can collect two lines of data per traverse with gradiometer units mounted laterally with a separation of 1.0m. The readings are logged consecutively into the data logger which in turn is daily down-loaded into a portable computer whilst on site. At the end of each site survey, data is transferred to the office for processing and presentation.

Data Processing

Zero Mean	This process sets the background mean of each traverse within each grid to zero.
Traverse	The operation removes striping effects and edge discontinuities over the whole of the data set.
Step Correction (De-stagger)	When gradiometer data are collected in 'zig-zag' fashion, stepping errors can sometimes arise. These occur because of a slight difference in the speed of walking on the forward and reverse traverses. The result is a staggered effect in the data, which is particularly noticeable on linear anomalies. This process corrects these errors.

Display

Greyscale/ Colourscale Plot	This format divides a given range of readings into a set number of classes. Each class is represented by a specific shade of grey, the intensity increasing with value. All values above the given range are allocated the same shade (maximum intensity); similarly, all values below the given range are represented by the minimum intensity shade. Similar plots can be produced in colour, either using a wide range of colours or by selecting two or three colours to represent positive and negative values. The assigned range (plotting levels) can be adjusted to emphasise different anomalies in the data-set.
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Interpretation Categories

In certain circumstances (usually when there is corroborative evidence from desk-based or excavation data) very specific interpretations can be assigned to magnetic anomalies (for example, *Roman Road, Wall, etc.*) and where appropriate, such interpretations will be applied. The list below outlines the generic categories commonly used in the interpretation of the results.

<i>Archaeology / Probable Archaeology</i>	This term is used when the form, nature and pattern of the responses are clearly or very probably archaeological and /or if corroborative evidence is available. These anomalies, whilst considered anthropogenic, could be of any age.
<i>Possible Archaeology</i>	These anomalies exhibit either weak signal strength and / or poor definition, or form incomplete archaeological patterns, thereby reducing the level of confidence in the interpretation. Although the archaeological interpretation is favoured, they may be the result of variable soil depth, plough damage or even aliasing as a result of data collection orientation.
<i>Industrial / Burnt-Fired</i>	Strong magnetic anomalies that, due to their shape and form or the context in which they are found, suggest the presence of kilns, ovens, corn dryers, metal-working areas or hearths. It should be noted that in many instances modern ferrous material can produce similar magnetic anomalies.
<i>Former Field Boundary (probable & possible)</i>	Anomalies that correspond to former boundaries indicated on historic mapping, or which are clearly a continuation of existing land divisions. Possible denotes less confidence where the anomaly may not be shown on historic mapping but nevertheless the anomaly displays all the characteristics of a field boundary.
<i>Ridge & Furrow</i>	Parallel linear anomalies whose broad spacing suggests ridge and furrow cultivation. In some cases, the response may be the result of more recent agricultural activity.
<i>Agriculture (ploughing)</i>	Parallel linear anomalies or trends with a narrower spacing, sometimes aligned with existing boundaries, indicating more recent cultivation regimes.
<i>Land Drain</i>	Weakly magnetic linear anomalies, quite often appearing in series forming parallel and herringbone patterns. Smaller drains may lead and empty into larger diameter pipes, which in turn usually lead to local streams and ponds. These are indicative of clay fired land drains.
<i>Natural</i>	These responses form clear patterns in geographical zones where natural variations are known to produce significant magnetic distortions.
<i>Magnetic Disturbance</i>	Broad zones of strong dipolar anomalies, commonly found in places where modern ferrous or fired materials (e.g. brick rubble) are present. They are presumed to be modern.
<i>Service</i>	Magnetically strong anomalies, usually forming linear features are indicative of ferrous pipes/cables. Sometimes other materials (e.g. pvc) or the fill of the trench can cause weaker magnetic responses which can be identified from their uniform linearity.
<i>Ferrous</i>	This type of response is associated with ferrous material and may result from small items in the topsoil, larger buried objects such as pipes, or above ground features such as fence lines or pylons. Ferrous responses are usually regarded as modern. Individual burnt stones, fired bricks or igneous rocks can produce responses similar to ferrous material.
<i>Uncertain Origin</i>	Anomalies which stand out from the background magnetic variation, yet whose form and lack of patterning gives little clue as to their origin. Often the characteristics and distribution of the responses straddle the categories of <i>Possible Archaeology / Natural</i> or (in the case of linear responses) <i>Possible Archaeology / Agriculture</i> ; occasionally they are simply of an unusual form.

Where appropriate some anomalies will be further classified according to their form (positive or negative) and relative strength and coherence (trend: weak and poorly defined).

Appendix B - Technical Information: Magnetic Theory

Detailed magnetic survey can be used to effectively define areas of past human activity by mapping spatial variation and contrast in the magnetic properties of soil, subsoil and bedrock. Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.1 nanoTeslas (nT) in an overall field strength of 48,000 (nT), can be accurately detected.

Weakly magnetic iron minerals are always present within the soil and areas of enhancement relate to increases in *magnetic susceptibility* and permanently magnetised *thermoremanent* material.

Magnetic susceptibility relates to the induced magnetism of a material when in the presence of a magnetic field. This magnetism can be considered as effectively permanent as it exists within the Earth's magnetic field. Magnetic susceptibility can become enhanced due to burning and complex biological or fermentation processes.

Thermoremanence is a permanent magnetism acquired by iron minerals that, after heating to a specific temperature known as the Curie Point, are effectively demagnetised followed by re-magnetisation by the Earth's magnetic field on cooling. Thermoremanent archaeological features can include hearths and kilns; material such as brick and tile may be magnetised through the same process.

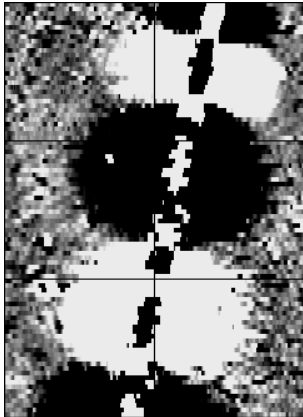
Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement allowing assessment and characterisation of subsurface features. Material such as subsoil and non-magnetic bedrock used to create former earthworks and walls may be mapped as areas of lower enhancement compared to surrounding soils.

Magnetic survey is carried out using a fluxgate gradiometer which is a passive instrument consisting of two sensors mounted vertically 1m apart. The instrument is carried about 30cm above the ground surface and the top sensor measures the Earth's magnetic field whilst the lower sensor measures the same field but is also more affected by any localised buried feature. The difference between the two sensors will relate to the strength of a magnetic field created by this feature, if no field is present the difference will be close to zero as the magnetic field measured by both sensors will be the same.

Factors affecting the magnetic survey may include soil type, local geology, previous human activity and disturbance from modern services.

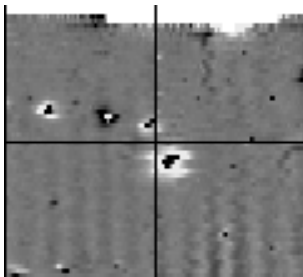
Appendix C - Glossary of Magnetic Anomalies

Bipolar



A bipolar anomaly is one that is composed of both a positive response and a negative response. It can be made up of any number of positive responses and negative responses. For example a pipeline consisting of alternating positive and negative anomalies is said to be bipolar. See also dipolar which has only one area of each polarity. The interpretation of the anomaly will depend on the magnitude of the magnetic field strength. A weak response may be caused by a clay field drain while a strong response will probably be caused by a metallic service.

Dipolar

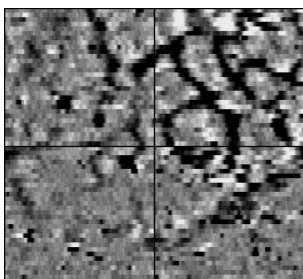


This consists of a single positive anomaly with an associated negative response. There should be no separation between the two polarities of response. These responses will be created by a single feature. The interpretation of the anomaly will depend on the magnitude of the magnetic measurements. A very strong anomaly is likely to be caused by a ferrous object.

Positive anomaly with associated negative response

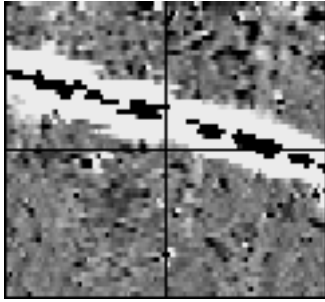
See bipolar and dipolar.

Positive linear



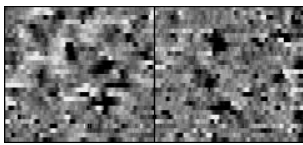
A linear response which is entirely positive in polarity. These are usually related to in-filled cut features where the fill material is magnetically enhanced compared to the surrounding matrix. They can be caused by ditches of an archaeological origin, but also former field boundaries, ploughing activity and some may even have a natural origin.

Positive linear anomaly with associated negative response



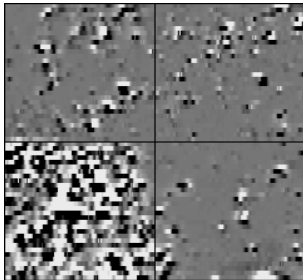
A positive linear anomaly which has a negative anomaly located adjacently. This will be caused by a single feature. In the example shown this is likely to be a single length of wire/cable probably relating to a modern service. Magnetically weaker responses may relate to earthwork style features and field boundaries.

Positive point/area



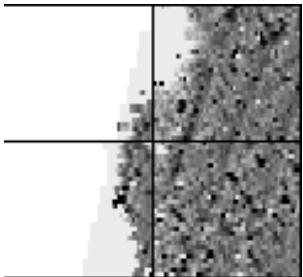
These are generally spatially small responses, perhaps covering just 3 or 4 reading nodes. They are entirely positive in polarity. Similar to positive linear anomalies they are generally caused by in-filled cut features. These include pits of an archaeological origin, possible tree bowls or other naturally occurring depressions in the ground.

Magnetic debris



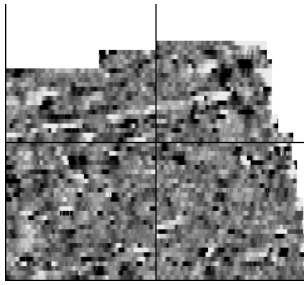
Magnetic debris consists of numerous dipolar responses spread over an area. If the amplitude of response is low ($\pm 3\text{nT}$) then the origin is likely to represent general ground disturbance with no clear cause, it may be related to something as simple as an area of dug or mixed earth. A stronger anomaly ($\pm 250\text{nT}$) is more indicative of a spread of ferrous debris. Moderately strong anomalies may be the result of a spread of thermoremanent material such as bricks or ash.

Magnetic disturbance



Magnetic disturbance is high amplitude and can be composed of either a bipolar anomaly, or a single polarity response. It is essentially associated with magnetic interference from modern ferrous structures such as fencing, vehicles or buildings, and as a result is commonly found around the perimeter of a site near to boundary fences.

Negative linear

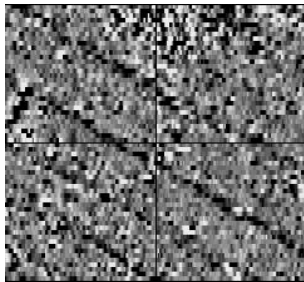


A linear response which is entirely negative in polarity. These are generally caused by earthen banks where material with a lower magnetic magnitude relative to the background top soil is built up. See also ploughing activity.

Negative point/area

Opposite to positive point anomalies these responses may be caused by raised areas or earthen banks. These could be of an archaeological origin or may have a natural origin.

Ploughing activity



Ploughing activity can often be visualised by a series of parallel linear anomalies. These can be of either positive polarity or negative polarity depending on site specifics. It can be difficult to distinguish between ancient ploughing and more modern ploughing. Clues such as the separation of each linear, straightness, strength of response and cross cutting relationships can be used to aid this, although none of these can be guaranteed to differentiate between different phases of activity.

Polarity

Term used to describe the measurement of the magnetic response. An anomaly can have a positive polarity (values above 0nT) and/or a negative polarity (values below 0nT).

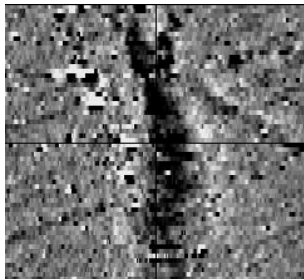
Strength of response

The amplitude of a magnetic response is an important factor in assigning an interpretation to a particular anomaly. For example a positive anomaly covering a 10m² area may have values up to around 3000nT, in which case it is likely to be caused by modern magnetic interference. However, the same size and shaped anomaly but with values up to only 4nT may have a natural origin. Colour plots are used to show the amplitude of response.

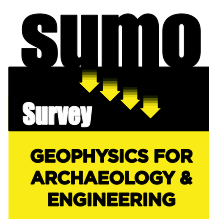
Thermoremanent response

A feature which has been subject to heat may result in it acquiring a magnetic field. This can be anything up to approximately ± 100 nT in value. These features include clay fired drains, brick, bonfires, kilns, hearths and even pottery. If the heat application has occurred in situ (e.g. a kiln) then the response is likely to be bipolar compared to if the heated objects have been disturbed and moved relative to each other, in which case they are more likely to take an irregular form and may display a debris style response (e.g. ash).

Weak background variations



Weakly magnetic wide scale variations within the data can sometimes be seen within sites. These usually have no specific structure but can often appear curvy and sinuous in form. They are likely to be the result of natural features, such as soil creep, dried up (or seasonal) streams. They can also be caused by changes in the underlying geology or soil type which may contain unpredictable distributions of magnetic minerals, and are usually apparent in several locations across a site.



- Archaeological
- Geophysical
- Laser Scanning
- Measured Building
- Topographic
- Utility Mapping

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