



GeoSurveys

LAND WEST OF STATION ROAD, LINGFIELD, SURREY

UAS LANDSCAPE SURVEY



Land West of Station Road, Lingfield, Surrey

UAS Landscape Survey

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ACKNOWLEDGEMENTS

SUMO GeoSurveys would like to thank Archaeology South-East for commissioning the work documented here.

EXECUTIVE SUMMARY

SUMO GeoSurveys undertook a UAS landscape survey on land to the west of Station Road, Lingfield, Surrey. The survey was commissioned by Archaeology South-East to investigate the archaeological potential at the site in preparation for development. The survey area comprises c. 6 ha of land. The data were processed in Agisoft Metashape and QGIS.

The UAS landscape survey conducted at Lingfield, Surrey, has successfully produced a detailed visual record of the pre-development landscape. A series of denuded ridge and furrow earthworks were recorded in the eastern and northern parts of the site. Modern mechanical ploughing was also noted within a no longer extant field parcel that was defined in the data as micro-topographical earthworks. Further relict field boundaries, that are depicted on historic mapping, were also noted.

1. INTRODUCTION

1.1 PROJECT BACKGROUND

SUMO GeoSurveys undertook a UAS landscape survey on land to the west of Station Road, Lingfield, Surrey. The survey was commissioned by Archaeology South-East to investigate the archaeological potential at the site in preparation for development. The survey area comprises c. 6 ha of land (Figure 2). The data were processed in Agisoft Metashape and QGIS.

1.2 SITE DETAILS

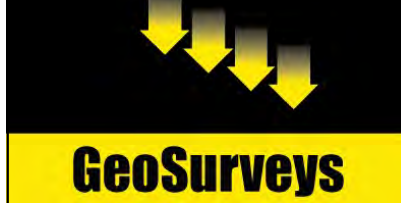
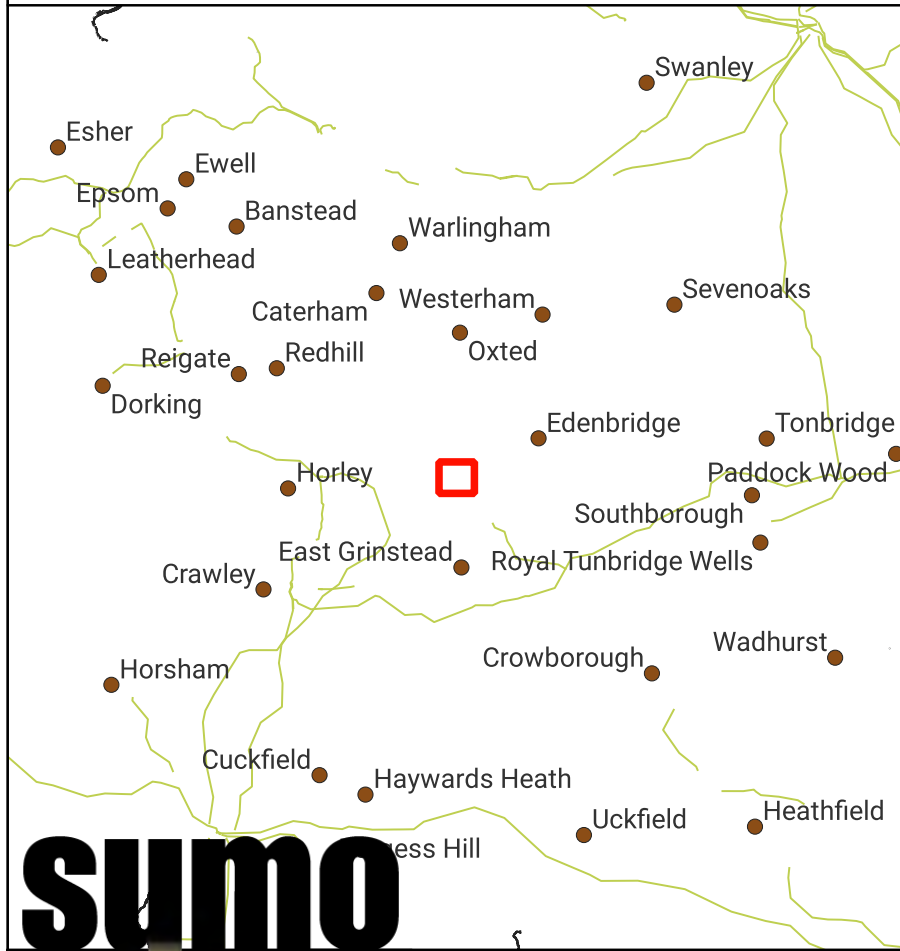
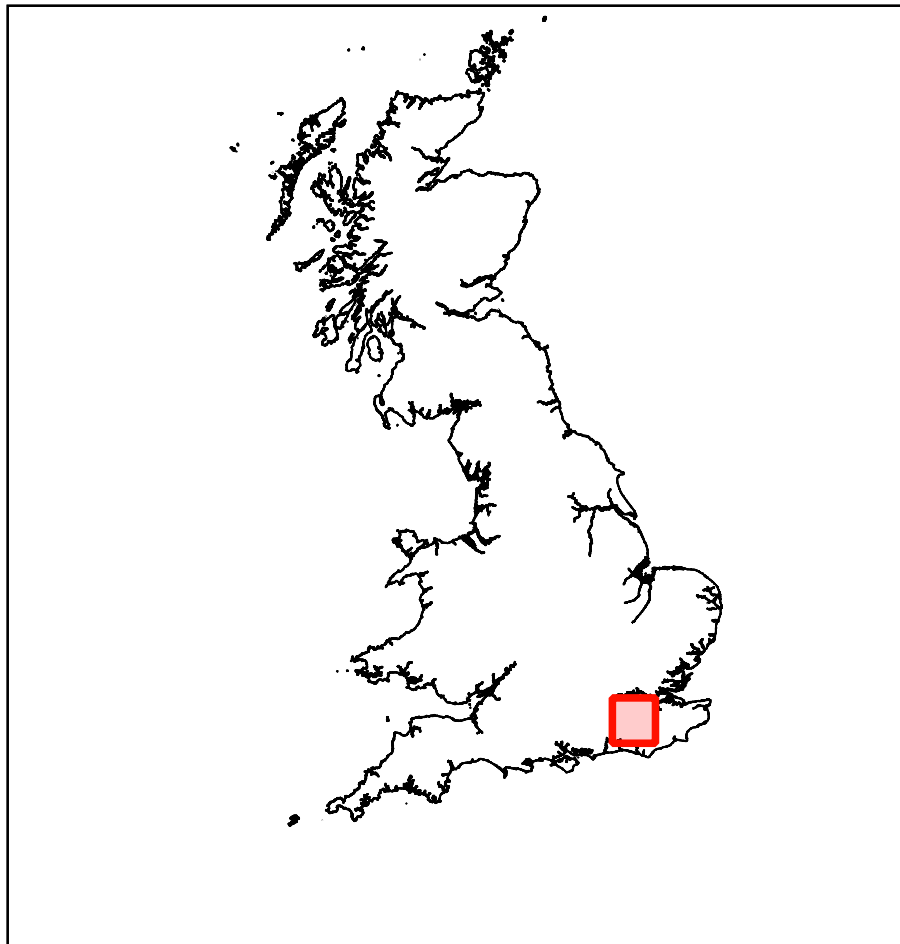
NGR / Postcode	TQ 39186 43621 / RH7 6AG
Location	The site is located to the west of the Station Road, and north of Tower Hill, in Lingfield, Surrey
HER	Surrey Historic Environment Record
District	Tandridge
Parish	Lingfield (civil)
Geology	Bedrock: Interbedded sandstone and siltstone of the Upper Tunbridge Wells Sand Superficial: None recorded (BGS 2023)
Archaeology	Probable ridge and furrow earthworks
Survey Methods	UAS RGB photogrammetry
Study Area	c. 6 ha
Topography	The site comprises land that is gently sloping down from the west towards the east from an elevation of c. 76 m to c. 50 m above Ordnance Datum (aOD)
Current Land Use	Agricultural

1.3 AIMS AND OBJECTIVES

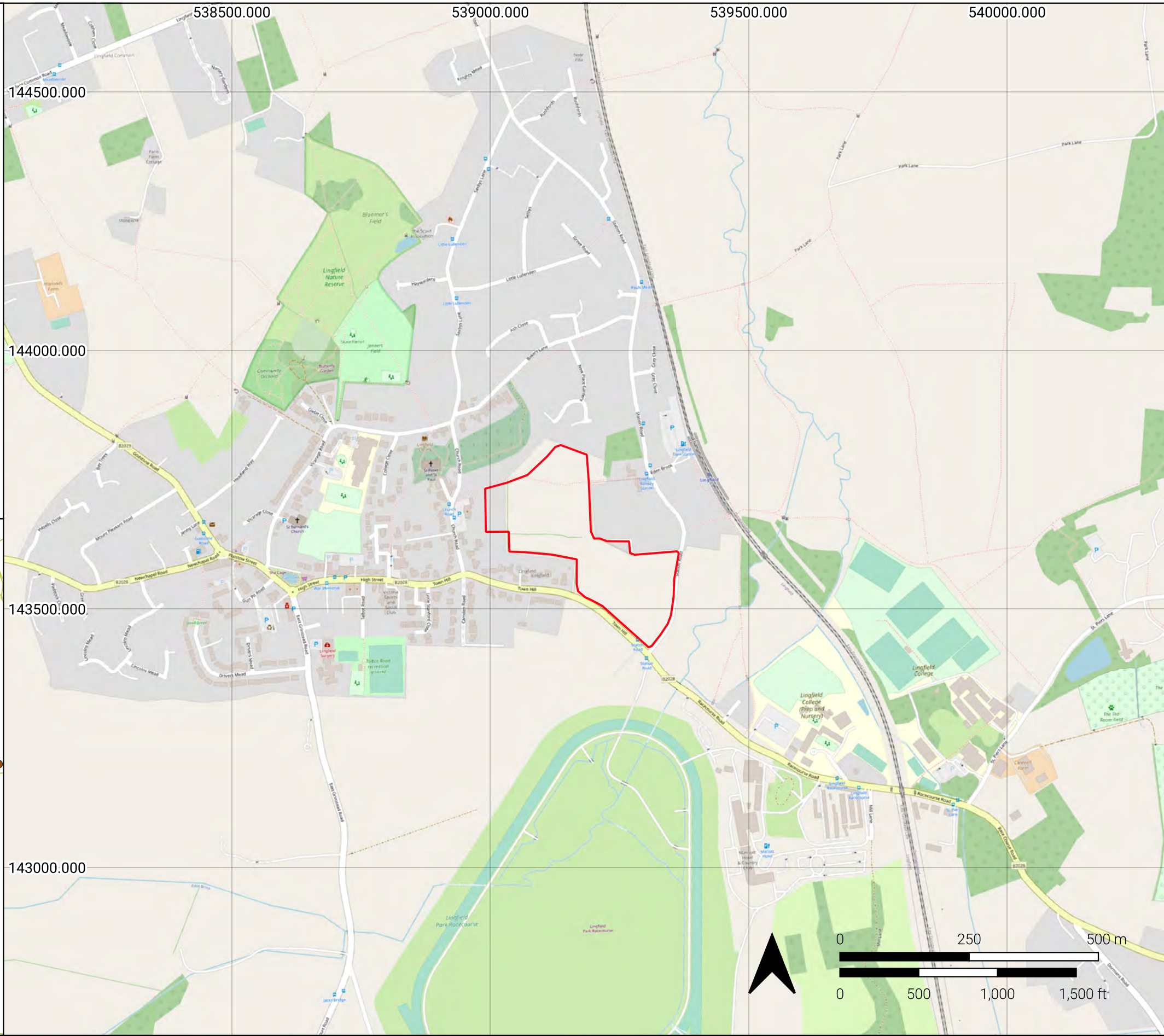
To conduct a detailed UAS (drone) geospatial landscape survey using RGB photogrammetry of the study area.

The objectives of the UAS geospatial survey were:

- Undertake a UAS geospatial survey using RGB photogrammetry for analysis
- Suggest a proposal for archaeological investigation, if required
- Document the survey result
- Ensure all work was carried out in accordance with the *Code of Conduct* of the Chartered Institute for Archaeologists (CIfA) (2022) and in line with current Historic England guidance for photogrammetry and landscape surveys (HE 2017a; 2017b)



Project	Lingfield
Client	Archaeology South-East
Date	17/04/23
Job No.	SUMO-12525



Location map

CRS: OSGB36 / British National Grid. EPSG:7405
 Contains public sector information licensed under the Open Government Licence v3.0
 © OpenStreetMap contributors. Data is available under the Open Database License Creative Commons Attribution-ShareAlike 2.0 license (CC BY-SA 2.0)

2. METHODOLOGY

2.1 SURVEY METHODOLOGY – TOPOGRAPHIC

2.1.1 PHOTOGRAPHY

An Unmanned Aircraft System (UAS) with a gimbal mounted camera was flown at an average elevation of 73 m (239 ft) above ground level.

2.1.2 PHOTOGRAMMETRY

Images were processed in Agisoft Metashape photogrammetric software to produce a 3D pointcloud with an average ground resolution of 1.61 cm spatial resolution. Data were exported as a raster Digital Elevation Model (DEM) with an average 13.6 cm spatial resolution and an orthophoto with an average 1.61 cm/pix .

2.1.3 REFERENCING

The photogrammetric models were referenced by seven ground control points (GCPs) that were distributed across the area. The seven points are visible in the aerial photographs and were also surveyed using high accuracy GPS to facilitate georeferencing to OS coordinates and provide an average error of 0.08 cm across the area (Table 1).

Point	Easting	Northing	Elevation
1	539351.98	143602.647	52.281
2	539309.538	143441.465	50.278
3	539178.172	143548.404	54.465
4	539063.994	143623.837	59.099
5	539164.733	143632.852	55.201
6	539177.462	143724.515	54.888
7	539053.341	143732.228	55.446

Table 1 Coordinate data for the GCPs

2.2 DATA PROCESSING AND VISUALISATION

2.2.1 DIRECTIONAL LIGHT SHADING (HILLSHADE)

Simulated illumination of the terrain surface from a chosen light source direction. This gives the viewer an intuitive sense of the 3D topography but can fail to reveal some features that are aligned with the light source.

2.2.2 AMBIENT LIGHT SHADING (OCCLUSION)

Simulated illumination of the terrain surface from a continuous encompassing light source. Illumination of a given point is determined by surrounding terrain and other objects which occlude incoming light and simulates diffuse, and scattered light that is reflected by various surfaces. It gives the viewer an intuitive sense of the 3D topography but can fail to reveal subtle features near much larger objects.

2.2.3 TERRAIN FLATTENING

Terrain flattening entails constructing a mathematical model that approximates broad-scale variation in the topography. This model surface is then subtracted from the original DEM to produce a new dataset that reflects only smaller scale features.

3. RESULTS

3.1 INTRODUCTION

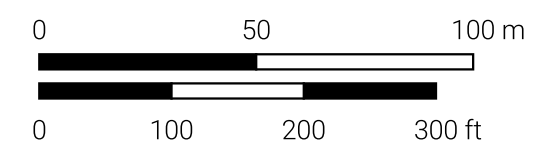
The results from the UAS RGB survey are presented below in a series of figures followed by a discussion.

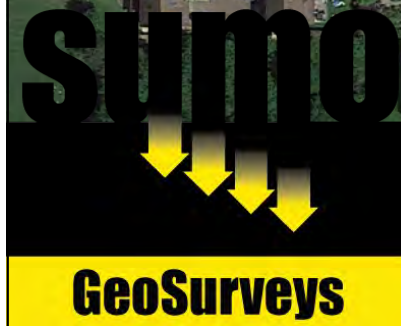


Project	Lingfield	Drawn	SW
Client	Archaeology South-East	Version	1.0
Date	17/04/23	Surveyed	SW
Job No.	SUMO-12525	Figure	2

Orthomosaic generated from UAS photogrammetry

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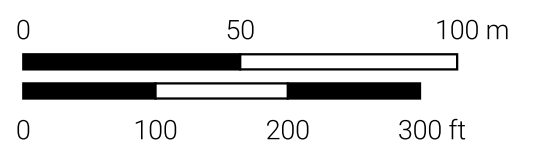


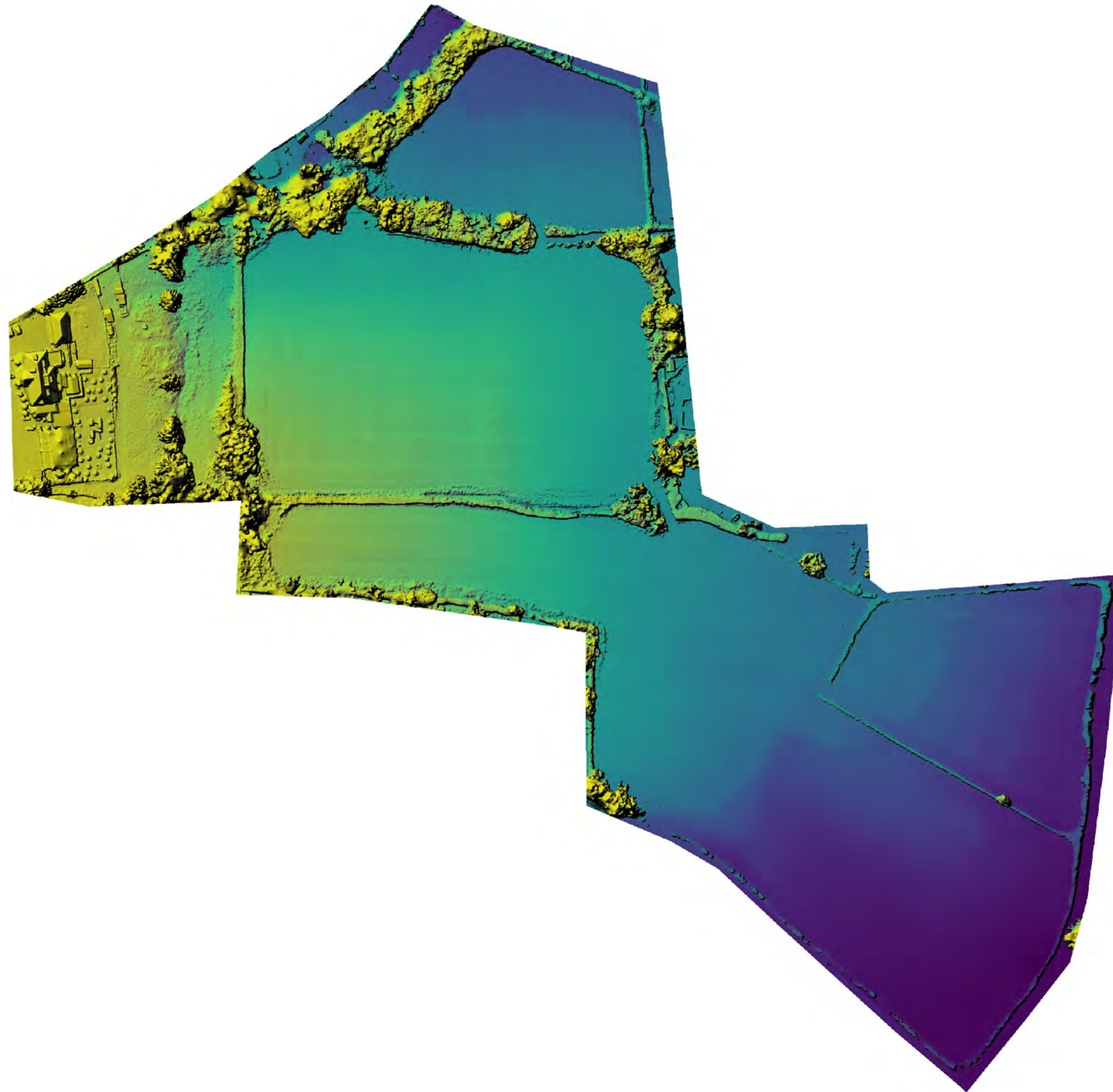
Project	Lingfield
Client	Archaeology South-East
Date	17/04/23
Job No.	SUMO-12525

Drawn	SW
Version	1.0
Surveyed	SW
Figure	3

Digital Elevation model with hillshade, overlaid onto satellite imagery. Map Data: Google

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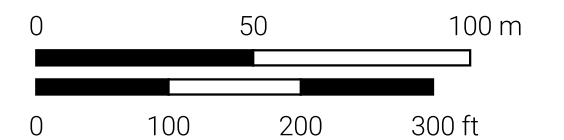


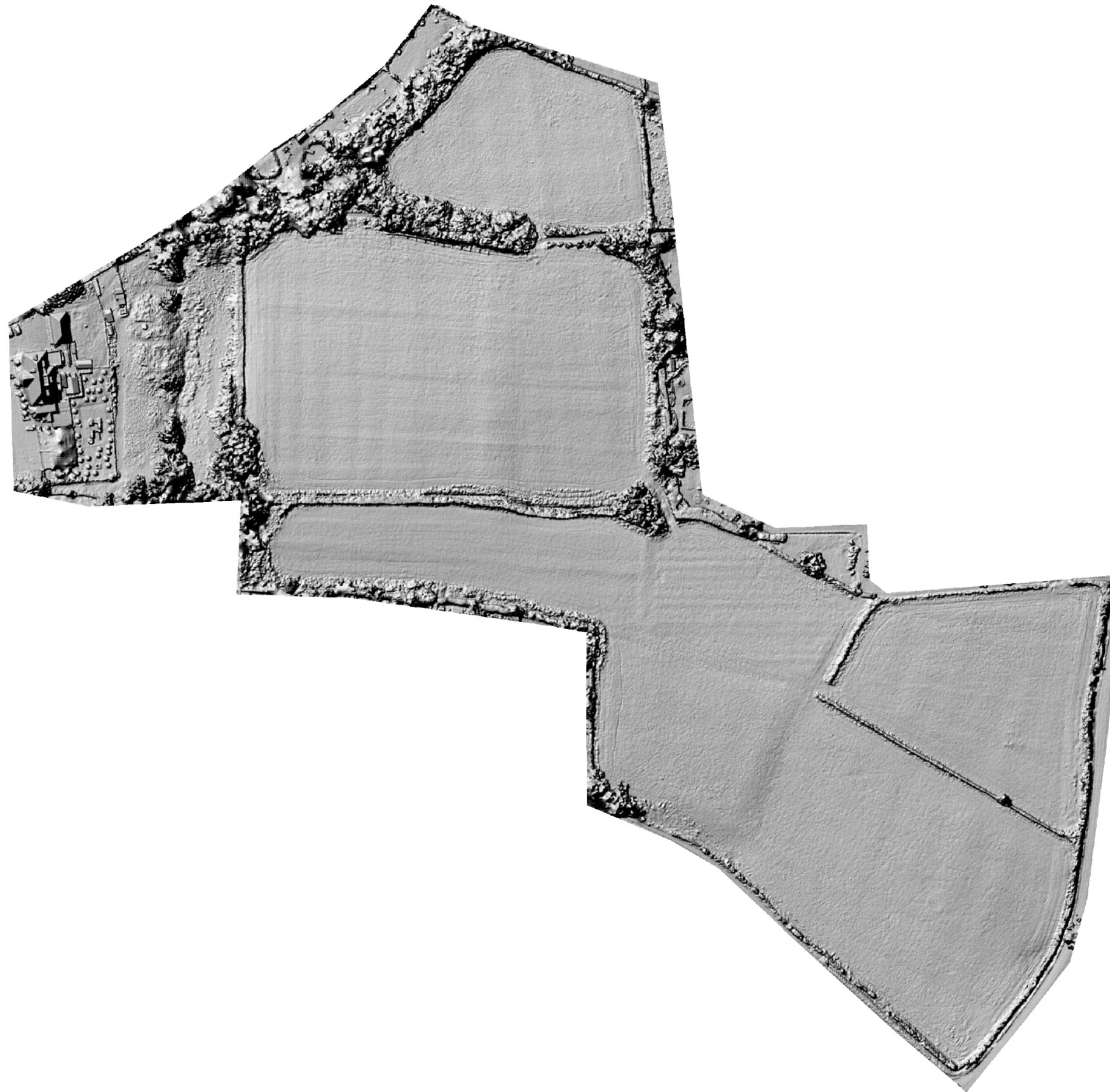


Project	Lingfield	Drawn	SW
Client	Archaeology South-East	Version	1.0
Date	17/04/23	Surveyed	SW
Job No.	SUMO-12525	Figure	4

DEM with elevation colour-scale expressed in metres above Ordnance Datum (aOD)

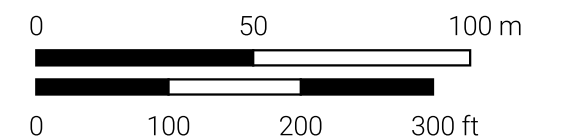
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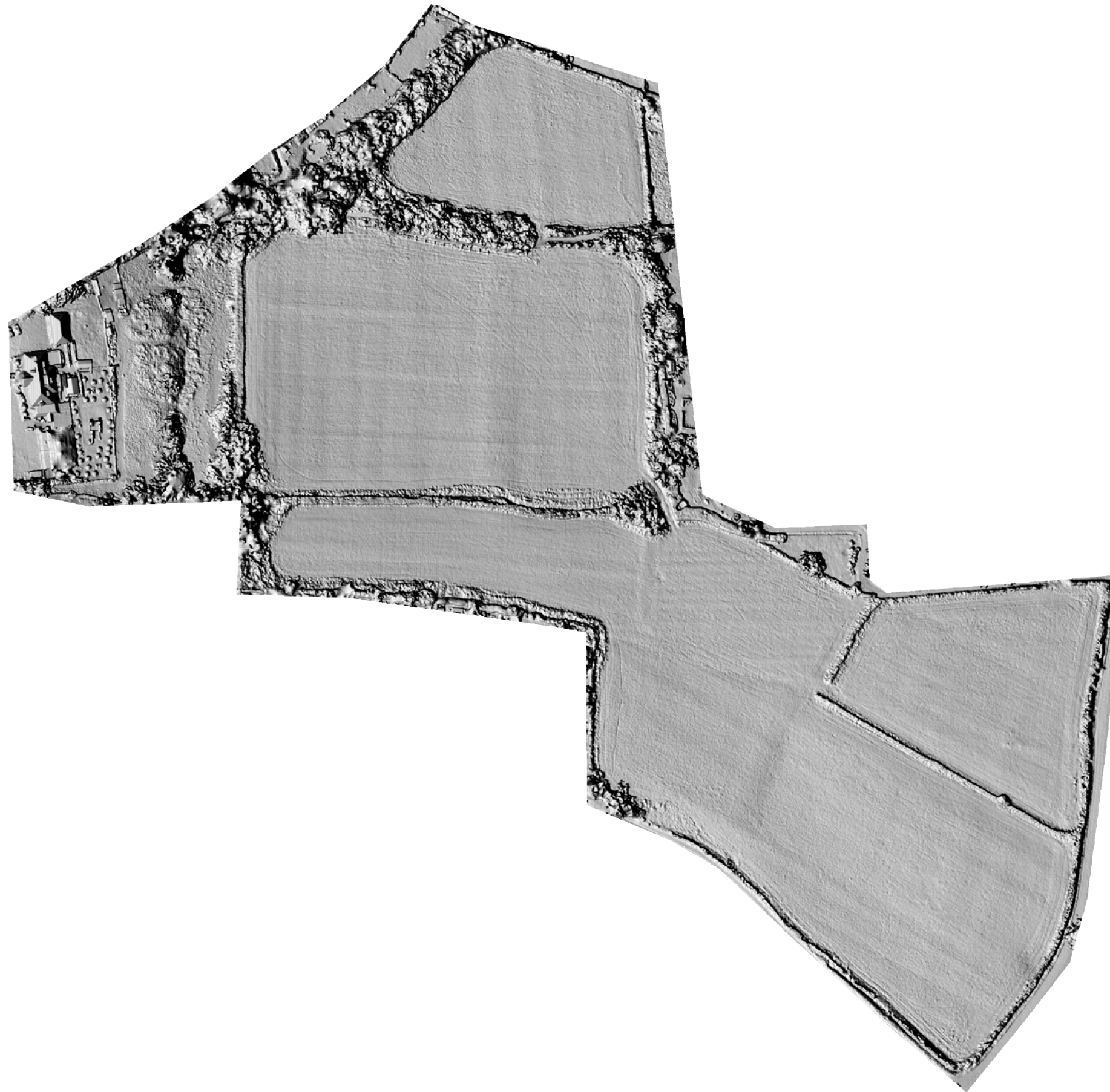


Project	Lingfield	Drawn	SW
Client	Archaeology South-East	Version	1.0
Date	17/04/23	Surveyed	SW
Job No.	SUMO-12525	Figure	5

Digital Elevation Model with hillshade. Azimuth 315 degrees / Altitude 45 degrees / Z factor 2



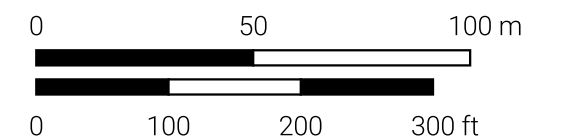
SUMO GeoSurveys is a trading name of SUMO Geophysics Ltd. whose parent company is SUMO Services Ltd

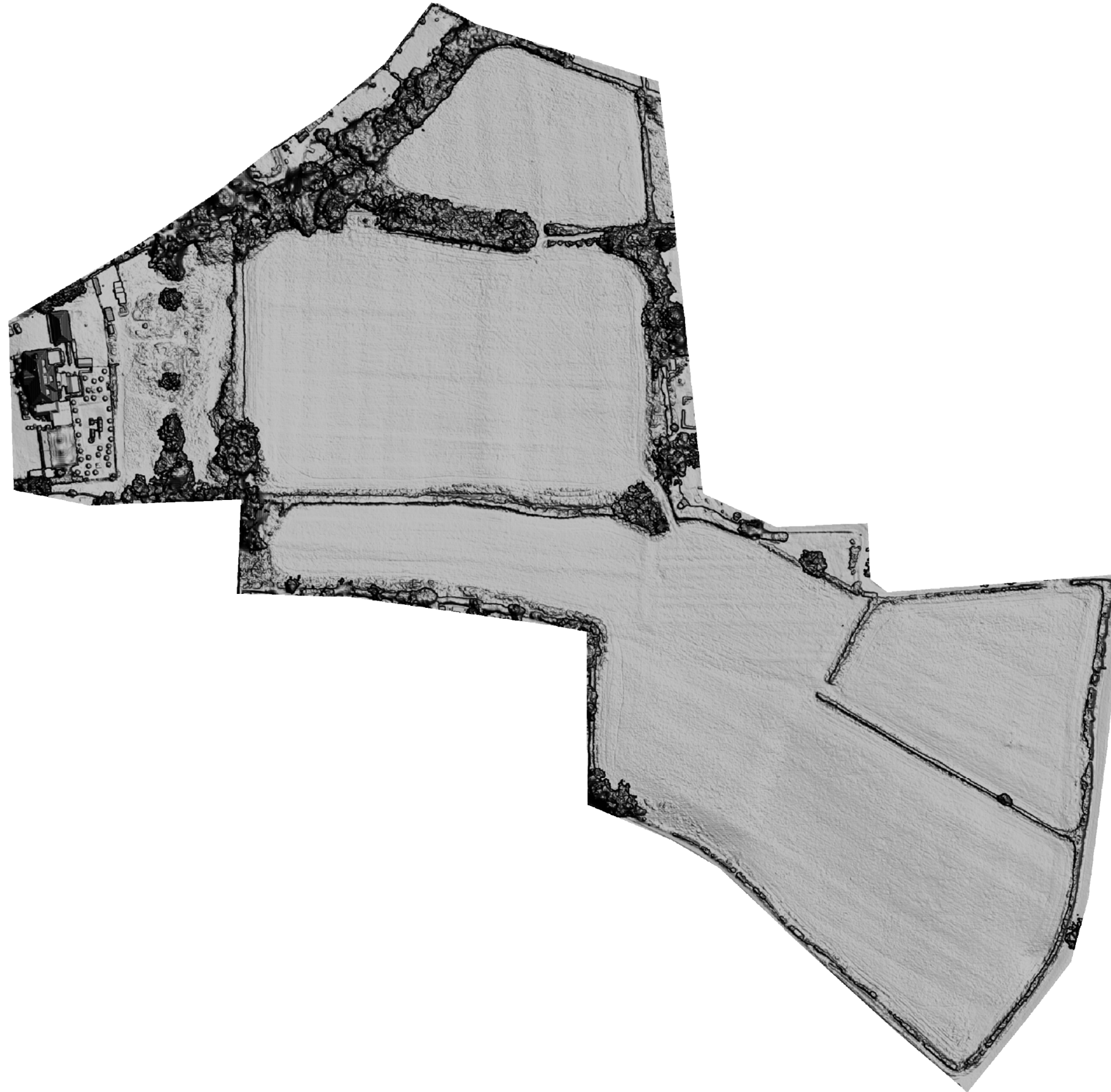


Project	Lingfield	Drawn	SW
Client	Archaeology South-East	Version	1.0
Date	17/04/23	Surveyed	SW
Job No.	SUMO-12525	Figure	6

Digital Elevation Model with hillshade. Azimuth 240 degrees / Altitude 45 degrees / Z factor 2

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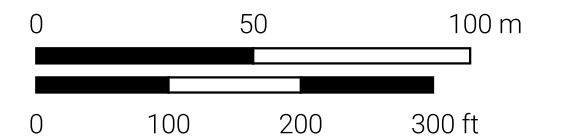


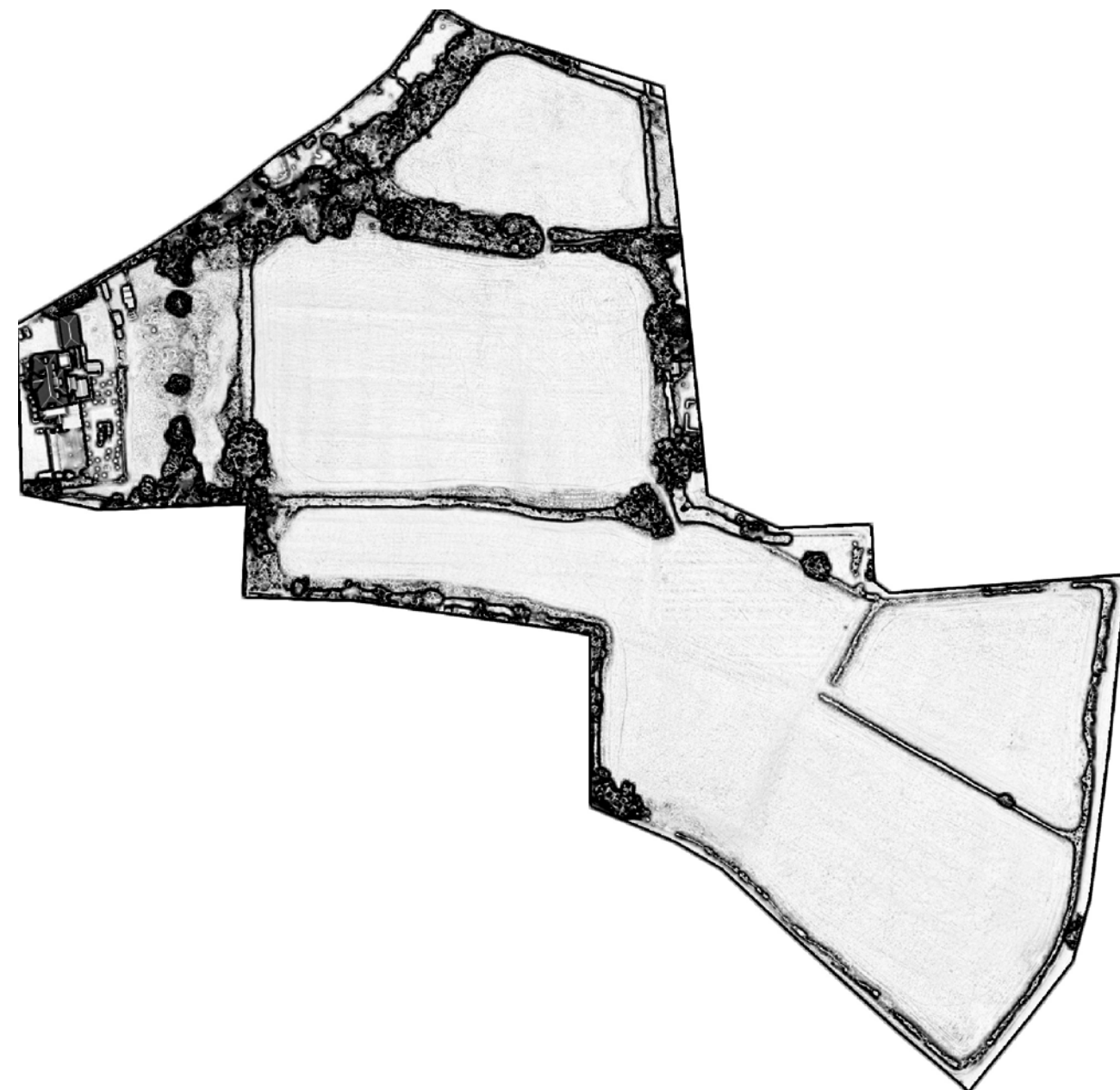
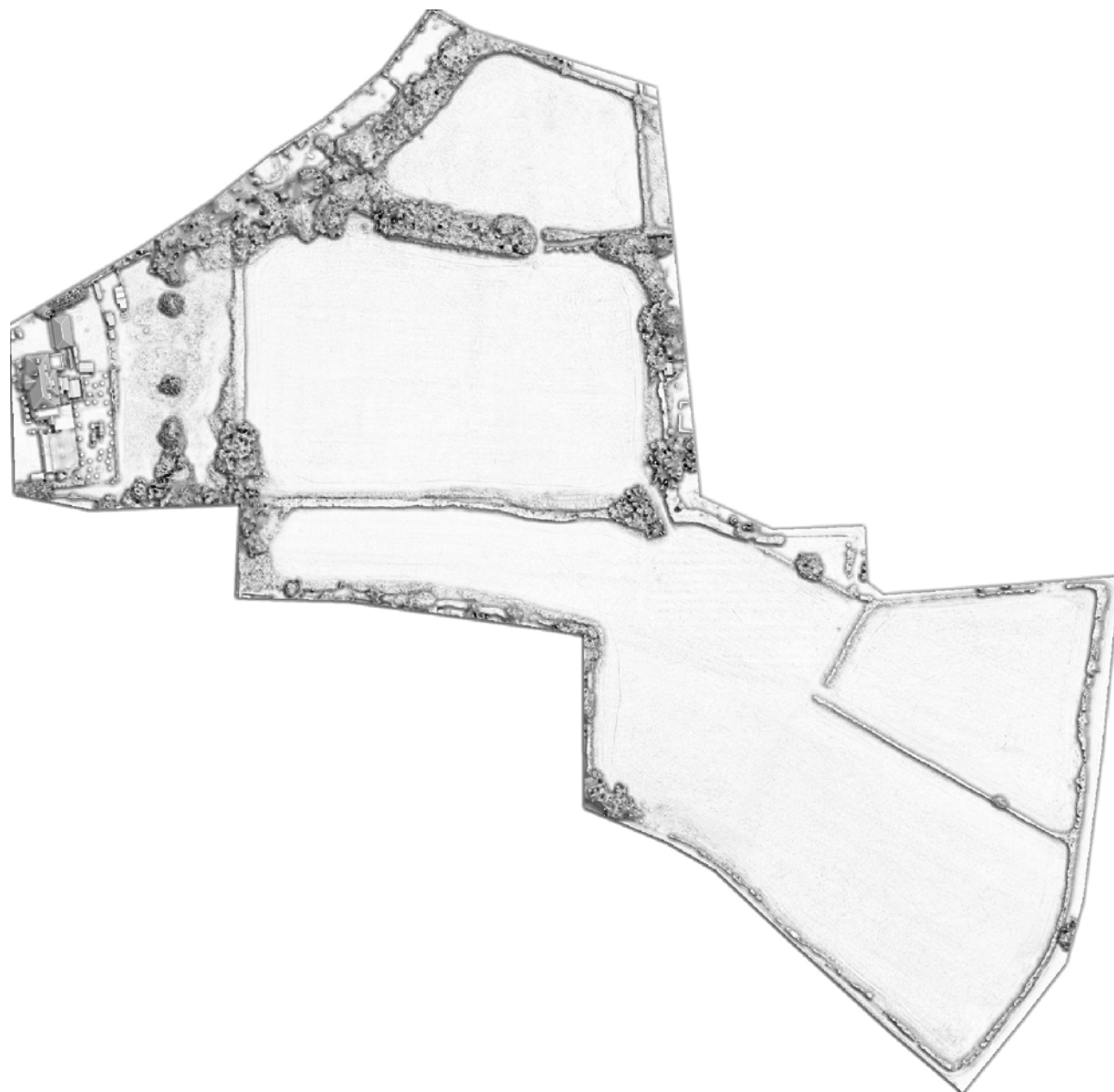


Project	Lingfield	Drawn	SW
Client	Archaeology South-East	Version	1.0
Date	17/04/23	Surveyed	SW
Job No.	SUMO-12525	Figure	7

Digital Elevation Model with hillshade using multidirectional light source

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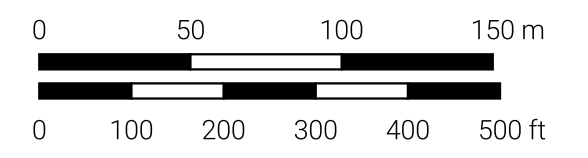


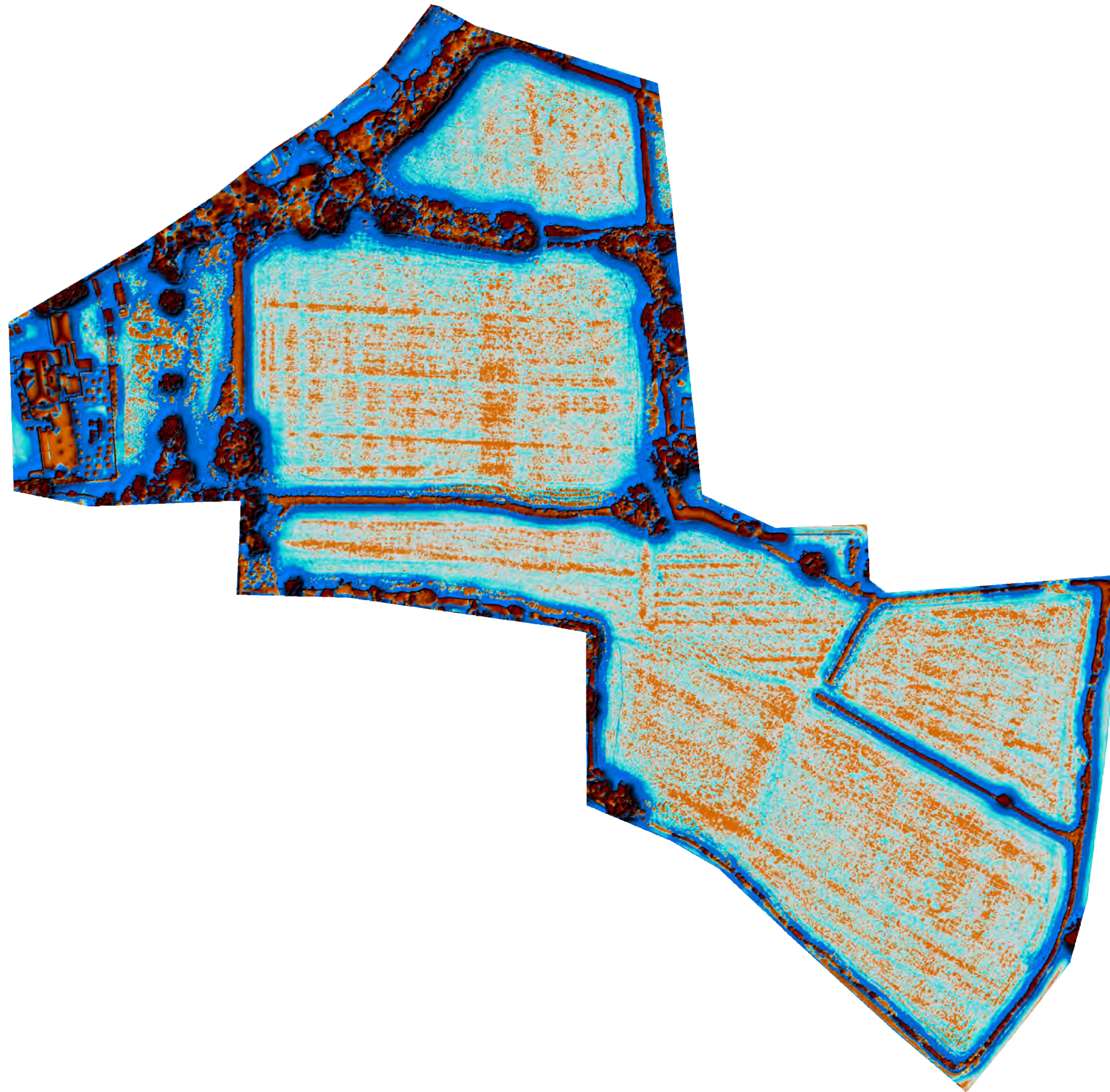


Project	Lingfield	Drawn	SW
Client	Archaeology South-East	Version	1.0
Date	17/04/23	Surveyed	SW
Job No.	SUMO-12525	Figure	8

RVT Anisotropic Sky-view analysis (left) and Terrain Shading Ambient Occlusion analysis (right)

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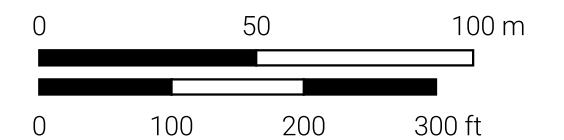


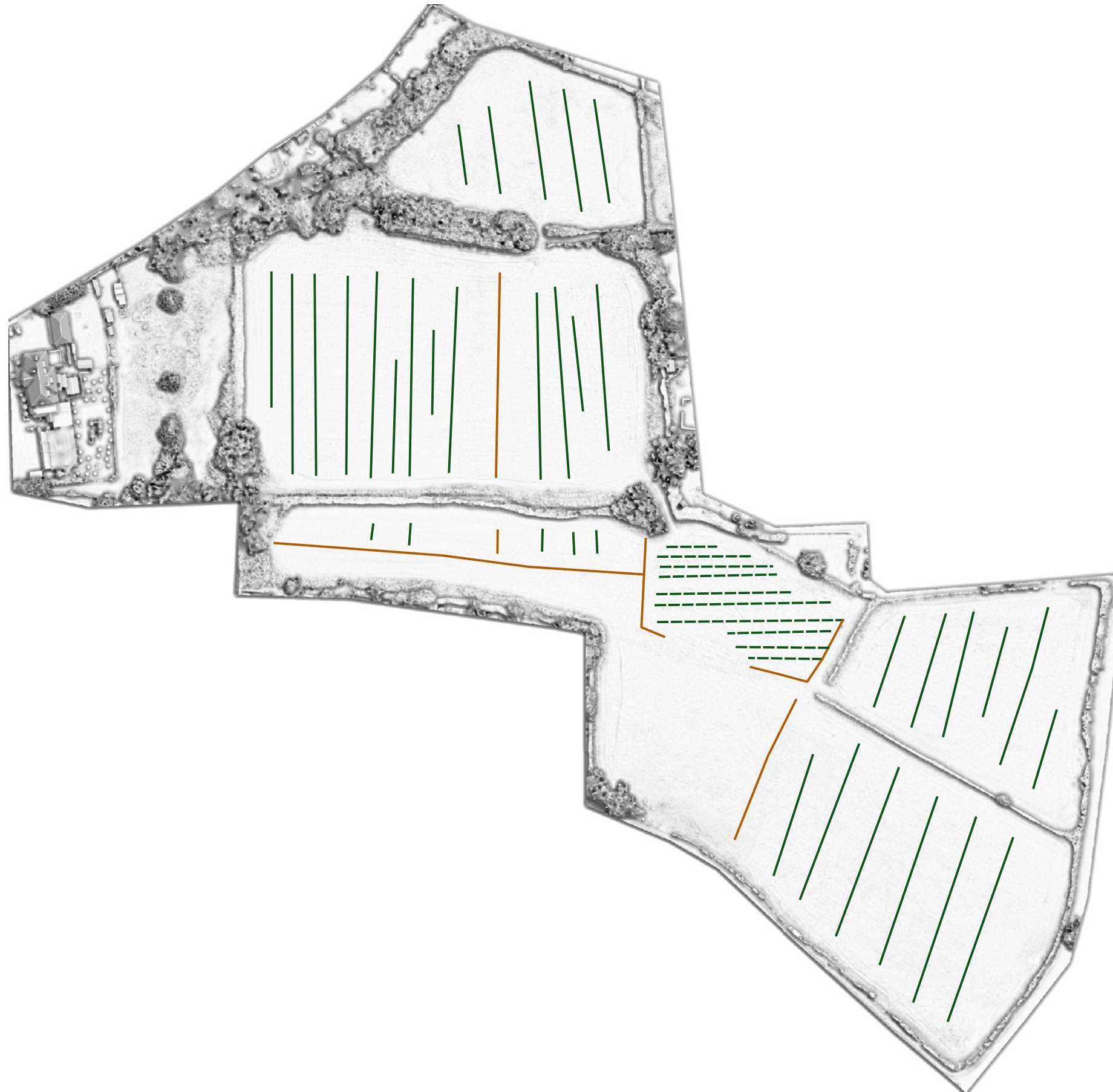


Project	Lingfield	Drawn	SW
Client	Archaeology South-East	Version	1.0
Date	17/04/23	Surveyed	SW
Job No.	SUMO-12525	Figure	9

Terrain flattened Digital Elevation Model

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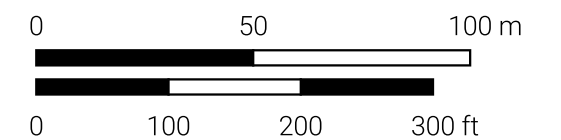
- Ridge and furrow
- - - Modern mechanical ploughing
- Relict field boundary



Project	Lingfield	Drawn	SW
Client	Archaeology South-East	Version	1.0
Date	17/04/23	Surveyed	SW
Job No.	SUMO-12525	Figure	10

Interpretation of features

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4. DISCUSSION

4.1 INTRODUCTION

The UAS photogrammetry survey has enabled the construction of an orthomosaic image (Figure 2), Digital Elevation Model (DEM), and 3D photogrammetric model of the landscape of the proposed development site to the west of Station Road in Lingfield, Surrey.

4.2 GROUND CONDITIONS

The agricultural fields of the proposed development site were under grass. The fields were divided by mature hedgerows and alignments of trees. The ground conditions were conducive to UAS survey methods.

4.3 DIGITAL ELEVATION MODEL

A DEM was produced for the proposed development site from the RGB photogrammetry. Elevation in metres above Ordnance Datum is depicted using a colour-scale overlay (Figure 4). The DEM provides a good indication of the topographic characteristics through hillshade manipulation in a Geographical Information System (GIS) (Figure 5 to Figure 7). This technique is also useful for the identification of micro-topographical archaeological features expressed at surface level.

4.4 GIS ANALYSIS

Hillshade analysis of the DEM using different light azimuths has illustrated several micro topographical features that are not clearly visible on the ground. More detailed analysis using RVT Anisotropic Sky-view did not produce any significant results beyond features already identified, and so this was cross-checked using Terrain Shading Ambient Occlusion analysis from which the results were similar (Figure 8). The DEM was flattened using Anomaly software to enhance the visibility of micro-topographic features (Figure 9).

4.5 ASSESSMENT

4.5.1 ARCHAEOLOGICAL FEATURES

The predominant archaeological features within the proposed development site are denuded ridge and furrow earthworks which are in the south-east and the north of the site. The medieval/post-medieval earthworks are aligned along a general north to south orientation, and respect the external field boundaries of the site, which appear to have remained unchanged for a considerable time (Cooper 2022). A small, enclosed parcel of modern mechanical ploughing is visible toward the centre of the site. This area is defined by relict field boundaries which are depicted on the 1965 and 1988–1993 Ordnance Survey editions (Cooper 2022, figures 15–16) and are depicted in the data as micro-topographical earthworks. Additional relict field boundaries, which are depicted on 18th–19th century mapping (Cooper 2022, figures 9–11) are also visible in the data as micro-topographic earthworks.

4.5.2 TOPOGRAPHY

The land is generally sloping from the west towards the east. A low-lying, generally level terrace of land is visible adjacent to the southern border of the site, to the west of the easternmost ridge and furrow. The area measures approximately 0.4 ha in size and is defined along its eastern side by a bank sloping down to the east. The area is notable for a lack of agricultural activity. However, no archaeological features were noted in the aerial survey results. It is possible that this terrace is a natural feature.

5. CONCLUSIONS

5.1 LIMITATIONS

The ground was boggy and saturated due to heavy rainfall. The weather on the day of the survey was generally overcast with some sunny spells, therefore, variations in cloud cover and light exposure are evident in the completed orthomosaic, however this has had no impact on the results.

5.2 CONCLUSION

The UAS landscape survey conducted at Lingfield, Surrey, has successfully produced a detailed visual record of the pre-development landscape. A series of denuded ridge and furrow earthworks were recorded in the eastern and northern parts of the site. Modern mechanical ploughing was also noted within a no longer extant field parcel that was defined in the data as micro-topographical earthworks. Further relict field boundaries, that are depicted on historic mapping, were also noted.

5.3 RECOMMENDATIONS

It is recommended that a targeted geophysical survey of the level terrace area would be desirable to determine the presence or absence of archaeological features at a subsurface level. This is advised due to the absence of agricultural activity at this location and the preservation that might be afforded were such features encountered.

6. SOURCES

6.1 BIBLIOGRAPHY

Chartered Institute for Archaeologists (CIfA). 2022. *Code of Conduct*. Reading, Chartered Institute for Archaeologists.

Cooper, E. 2022. *Land West of Station Road, Lingfield. Archaeological Desk Based Assessment*. HCUK Group unpublished report. Reference 07677A

Historic England (HE). 2017a. *Historic England Photogrammetric Applications for Cultural Heritage, Guidance for Good Practice*. Swindon: Historic England.

Historic England (HE). 2017b. *Understanding the Archaeology of Landscapes - A Guide to Good Recording Practice (Second Edition)*. Swindon: Historic England.

6.2 WEBSITES

BGS. 2023. *British Geological Survey - Geology of Britain Viewer*. Available from: <https://geologyviewer.bgs.ac.uk> (Accessed 17/04/2023)

APPENDIX 1 – RGB PROCESSING REPORT

Lingfield

Processing Report

06 April 2023



Survey Data

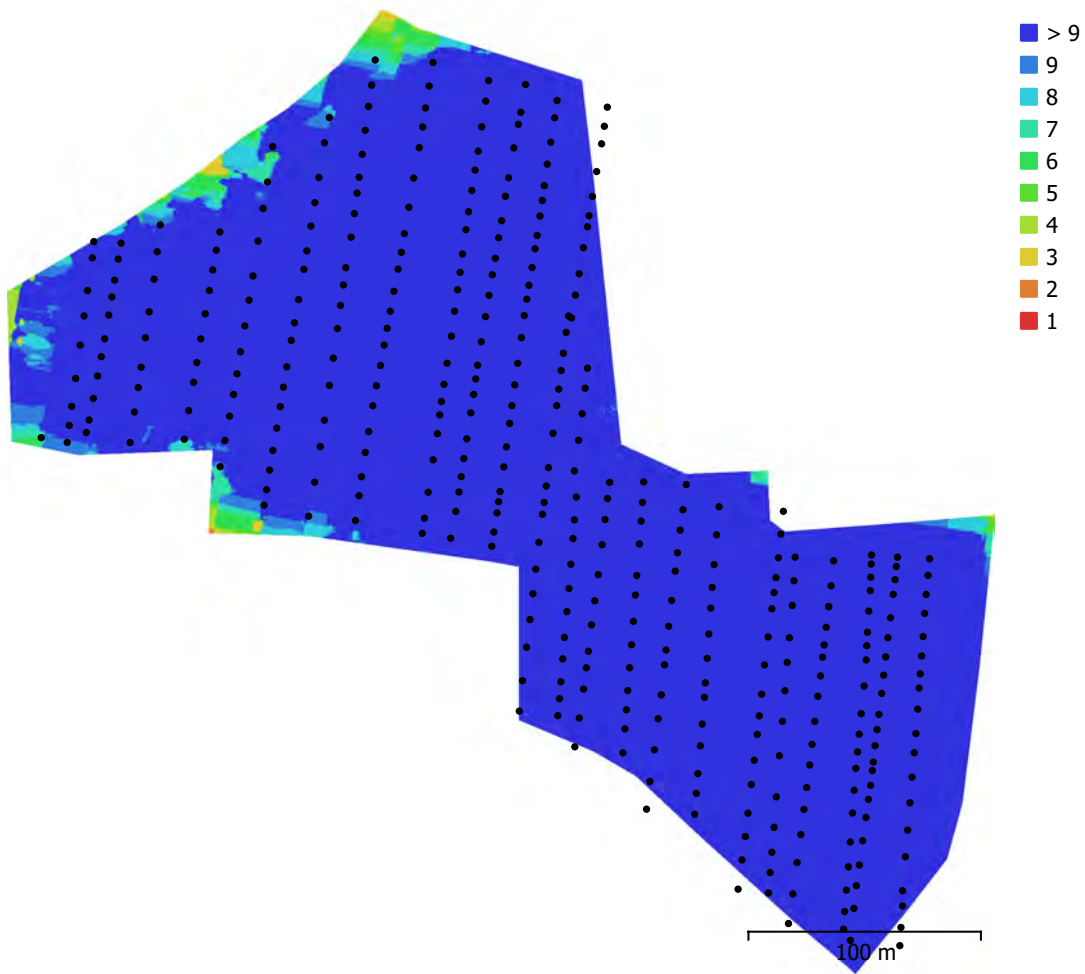


Fig. 1. Camera locations and image overlap.

Number of images:	389	Camera stations:	389
Flying altitude:	73.3 m	Tie points:	144,244
Ground resolution:	1.61 cm/pix	Projections:	1,356,590
Coverage area:	0.0716 km ²	Reprojection error:	1.11 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
L1D-20c, 28.0 mm f/2.8 ...	5464 x 3640	10.26 mm	2.41 x 2.41 μ m	No

Table 1. Cameras.

Camera Calibration

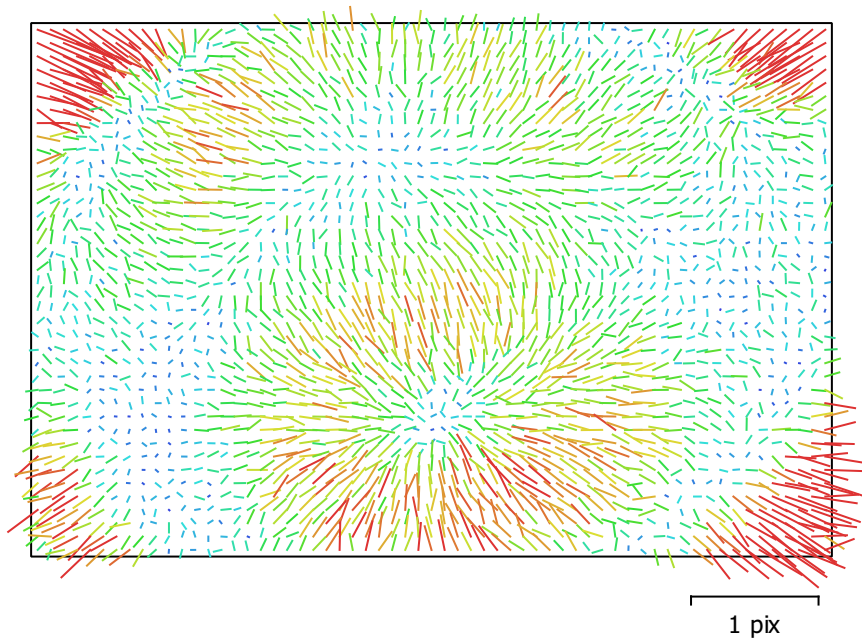


Fig. 2. Image residuals for L1D-20c, 28.0 mm f/2.8 (10.26mm).

L1D-20c, 28.0 mm f/2.8 (10.26mm)

389 images

Type	Resolution	Focal Length	Pixel Size
Frame	5464 x 3640	10.26 mm	2.41 x 2.41 μm

	Value	Error	F	Cx	Cy	B1	B2	K1	K2	K3	K4	P1	P2
F	4451.75	2.4	1.00	-0.14	-0.05	-0.04	-0.14	-0.47	0.15	-0.01	-0.21	0.25	-0.22
Cx	-30.9037	0.44		1.00	-0.01	0.45	0.04	0.10	-0.08	0.07	-0.04	-0.66	0.17
Cy	-55.4929	0.55			1.00	-0.12	0.55	0.07	-0.08	0.09	-0.09	0.16	-0.77
B1	-0.989725	0.028				1.00	-0.07	0.03	-0.03	0.03	-0.02	-0.19	0.25
B2	-0.0236747	0.032					1.00	0.08	-0.05	0.04	-0.02	0.08	-0.48
K1	-0.0303746	7.7e-05						1.00	-0.92	0.82	-0.66	-0.13	0.07
K2	0.0272519	0.00049							1.00	-0.98	0.89	0.06	0.01
K3	0.0083236	0.0013								1.00	-0.97	-0.02	-0.05
K4	-0.0696737	0.0013									1.00	-0.03	0.11
P1	0.00109966	3.4e-06										1.00	-0.24
P2	-0.00169223	3.3e-06											1.00

Table 2. Calibration coefficients and correlation matrix.

Ground Control Points



Fig. 3. GCP locations and error estimates.

Z error is represented by ellipse color. X,Y errors are represented by ellipse shape.

Estimated GCP locations are marked with a dot or crossing.

Count	X error (mm)	Y error (mm)	Z error (mm)	XY error (mm)	Total (mm)
7	3.85296	6.40105	2.99018	7.4712	8.04736

Table 3. Control points RMSE.

X - Easting, Y - Northing, Z - Altitude.

Label	X error (mm)	Y error (mm)	Z error (mm)	Total (mm)	Image (pix)
point 1	5.66486	3.10244	-3.68812	7.43761	0.623 (11)
point 2	-2.62955	4.42985	3.06315	5.99341	0.132 (19)
point 3	-3.26942	-12.7617	-3.29986	13.5809	0.153 (21)
point 4	5.48254	6.69661	-0.0744503	8.65496	0.124 (13)
point 5	0.939086	1.85531	1.60111	2.62443	0.102 (36)
point 6	-4.53246	-6.18328	4.61005	8.94587	0.124 (28)
point 7	-1.65506	2.8608	-2.21188	3.97691	0.137 (23)
Total	3.85296	6.40105	2.99018	8.04736	0.208

Table 4. Control points.
X - Easting, Y - Northing, Z - Altitude.

Digital Elevation Model

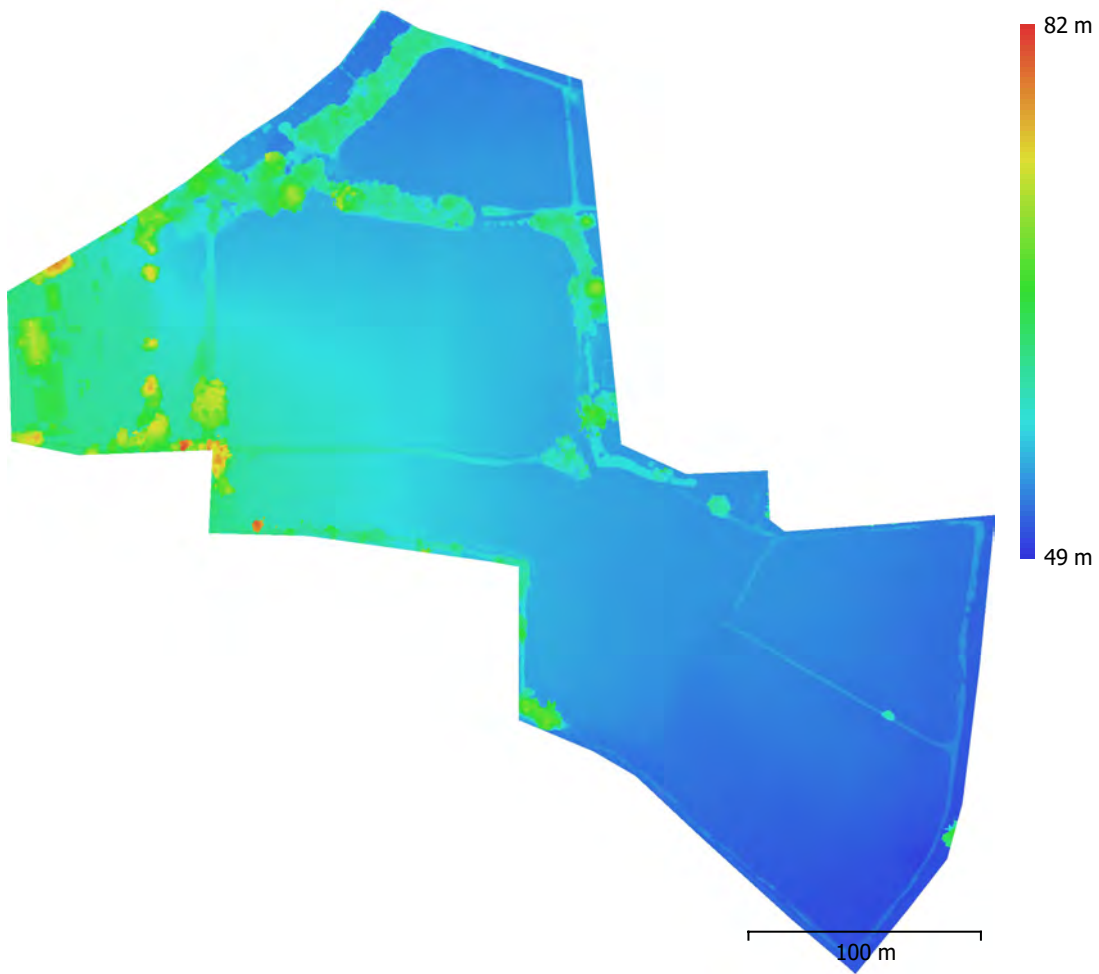


Fig. 4. Reconstructed digital elevation model.

Resolution: 13.6 cm/pix
Point density: 53.8 points/m²

Processing Parameters

General

Cameras	389
Aligned cameras	389
Markers	7

Shapes

Polygon	1
Coordinate system	OSGB36 / British National Grid + ODN height (EPSG::7405)
Rotation angles	Yaw, Pitch, Roll

Tie Points

Points	144,244 of 168,308
RMS reprojection error	0.163365 (1.10744 pix)
Max reprojection error	0.679184 (44.2613 pix)
Mean key point size	5.97161 pix
Point colors	3 bands, uint8
Key points	No
Average tie point multiplicity	10.2228

Alignment parameters

Accuracy	Medium
Generic preselection	Yes
Reference preselection	Source
Key point limit	1,000,000
Key point limit per Mpx	1,000,000
Tie point limit	4,000
Exclude stationary tie points	Yes
Guided image matching	No
Adaptive camera model fitting	No
Matching time	6 minutes 31 seconds
Matching memory usage	442.06 MB
Alignment time	7 minutes 15 seconds
Alignment memory usage	139.87 MB

Optimization parameters

Parameters	f, b1, b2, cx, cy, k1-k4, p1, p2
Adaptive camera model fitting	No
Optimization time	10 seconds
Date created	2023:04:05 15:19:01
Software version	2.0.1.15986
File size	43.16 MB

Depth Maps

Count	389
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Depth maps generation parameters

Quality	Medium
Filtering mode	Mild
Max neighbors	16
Processing time	16 minutes 5 seconds
Memory usage	1.20 GB
Date created	2023:04:06 07:41:31
Software version	2.0.1.15986
File size	694.08 MB

Point Cloud

Points	28,445,672
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Point attributes	
Position	
Color	3 bands, uint8
Normal	
Point classes	
Created (never classified)	28,445,672
Depth maps generation parameters	
Quality	Medium
Filtering mode	Mild
Max neighbors	16
Processing time	16 minutes 5 seconds
Memory usage	1.20 GB
Point cloud generation parameters	
Processing time	14 minutes 28 seconds
Memory usage	6.84 GB
Date created	2023:04:06 07:55:59
Software version	2.0.1.15986
File size	373.00 MB
Model	
Faces	4,068,975
Vertices	2,039,035
Vertex colors	3 bands, uint8
Depth maps generation parameters	
Quality	Medium
Filtering mode	Mild
Max neighbors	16
Processing time	16 minutes 5 seconds
Memory usage	1.20 GB
Reconstruction parameters	
Surface type	Arbitrary
Source data	Depth maps
Interpolation	Enabled
Strict volumetric masks	No
Processing time	4 minutes 29 seconds
Memory usage	5.30 GB
Date created	2023:04:06 08:20:21
Software version	2.0.1.15986
File size	170.85 MB
DEM	
Size	3,231 x 3,197
Coordinate system	OSGB36 / British National Grid + ODN height (EPSG::7405)
Reconstruction parameters	
Source data	Mesh
Interpolation	Enabled
Processing time	15 seconds
Memory usage	287.42 MB
Date created	2023:04:06 09:16:14
Software version	2.0.1.15986
File size	26.60 MB
Orthomosaic	
Size	12,924 x 12,788
Coordinate system	OSGB36 / British National Grid + ODN height (EPSG::7405)
Colors	3 bands, uint8
Reconstruction parameters	
Blending mode	Mosaic
Surface	DEM

Enable hole filling	Yes
Enable ghosting filter	No
Processing time	3 minutes 40 seconds
Memory usage	841.02 MB
Date created	2023:04:06 09:19:08
Software version	2.0.1.15986
File size	1.68 GB

System

Software name	Agisoft Metashape Professional
Software version	2.0.1 build 15986
OS	Windows 64 bit
RAM	255.68 GB
CPU	Intel(R) Xeon(R) W-2275 CPU @ 3.30GHz
GPU(s)	NVIDIA GeForce GTX 1660 Ti

