



Northfleet Embankment West

Further Laser Scan & Photogrammetry Surveys



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DATA LICENCES

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Contents

Summary.....	ii
Acknowledgements.....	ii
1 INTRODUCTION	3
1.1 Project and planning background	3
1.2 Scope of the report.....	3
1.3 Location, topography and geology	4
2 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND	4
2.1 Research sources	4
2.2 Mid- and late 19 th century development	4
3 AIMS AND METHODS	6
3.1 Project aims.....	6
3.2 Methods.....	6
4 RESULTS	8
5 CONCLUSIONS	8
6 ARCHIVE STORAGE AND CURATION	9
6.1 OASIS	9
6.2 Repository	9
7 COPYRIGHT	9
7.1 Archive and report copyright	9
7.2 Third party data copyright.....	9
REFERENCES	10

List of Figures

- Figure 1** Site location and surveyed areas
Figure 2 1885 OS mapping overlaid with survey data; 1869 estate map
Figure 3 Plan view of survey area, and associated structures exposed during excavation works
Figure 4 Plan view of kilns and tunnel; Oblique view of survey area
Figure 5 Section through tunnel looking ESE towards kilns; Section through tunnel looking WNW (laser scan data)
Figure 6 Elevations of tunnel entrances north of the kilns
Figure 7 Elevations of the kilns and southern tunnel entrance

List of Tables

- Table 1** Registration Results



Summary

Wessex Archaeology has been commissioned by RPS Consulting Services to undertake measured surveys of brick structural remains, exposed during the demolition phase of redevelopment works at the former Northfleet Cement Works, Gravesham.

A brick kiln structure and associated features (the 'northern kiln complex') was exposed centred on NGR 562040 174790 during the ongoing watching brief phase in Area E. Deemed too unstable for preservation, Wessex Archaeology carried out a laser scan and photogrammetry survey (Phase 1) of the area in October 2021 prior to demolition, which is described in a separate technical report (Wessex Archaeology 2021).

To the south-west, a row of kilns and a tunnel (the 'southern kiln complex') were identified during the mitigation phase on Areas A, B, C and D. Wessex Archaeology undertook a laser scan and photogrammetry survey of the kilns in February 2022, and another in March 2022 following further exposure of the tunnel and surrounding area. These Phase 2 and Phase 3 surveys are described together in this report.

In total the surveys cover an area of 1556.34 m², centred on centred on NGR 561978 174770. The surveys were carried out using both terrestrial laser scan and photogrammetry techniques, controlled by total station and geospatially located using a GNSS system. The purpose of the survey was to create an accurate record of the structural remains. The site is believed to form part of the former Bevans cement works.

Acknowledgements

Wessex Archaeology would like to thank Richard von Kalinowski-Meager, Archaeological Consultant and Director at RPS Consulting Services Ltd (London), for commissioning the survey. Wessex Archaeology is also grateful for the advice of Casper Johnson, Senior Archaeological Officer, who monitored the project for Kent County Council.

The metric surveys were completed by Roberta Marziani and Thomas Marshall.



Northfleet Embankment West

Further Laser Scan & Photogrammetry Surveys

1 INTRODUCTION

1.1 Project and planning background

- 1.1.1 Wessex Archaeology was commissioned RPS Consulting Services Ltd (London), to undertake metric surveys of 19th century kilns and associated structures located in the Land at Northfleet Embankment West, formerly Northfleet Cement Works, in Gravesham, Kent, DA11 6DD, centred on 561978 174770 (TQ 61978 74770) (Figure 1).
- 1.1.1 The development works comprises the construction of residential and commercial properties, an open playing field and a Heritage Park, along with associated ground works (*Land at Northfleet Embankment West WSI, WA 2020*).
- 1.1.2 The surveys were completed to fulfil condition 20 as defined in the outline planning permission for the development (EDC/16/0004).
- 1.1.3 During 2020-2022, other investigative work has been carried out for this development project: watching briefs, geoarchaeological survey, excavation and mitigation. The structures were uncovered during mitigation works.
- 1.1.4 The surveys, carried out in two separate visits (Phase 2 and 3), follow a previous laser scan and photogrammetry survey (Phase 1) of the 'northern kiln complex' which included a "bottle" shaped cement kiln, three bays, vaulted run-offs/ channels, a possible tunnel, and a vaulted structure centred on NGR 562040 174790.
- 1.1.5 The 'southern kiln complex' comprises 14 kilns and a directly associated 55m long kiln tunnel, along with a further three tunnels and a drying floor. The Phase 2 and Phase 3 laser scan and photogrammetry surveys focused on 6 largely intact kilns and the tunnel. The structures are most likely part of the Bevans site, operating from at least 1851 (HER TQ67SW459).
- 1.1.6 All exposed and accessible structures were surveyed and all work was undertaken in accordance with Historic England Guidance. These include *Photogrammetric Applications for Cultural Heritage* (2017) and *Metric Survey Specifications for Cultural Heritage* (2015) which detail the aims, methodologies and standards that were employed.
- 1.1.7 The survey work was undertaken on 22 February (Phase 2) and 24 March (Phase 3) 2022.

1.2 Scope of the report

- 1.2.1 The purpose of this report is to provide a detailed description of the methods of the metric surveys and to assess whether the aims of the survey have been met, and to discuss the survey results.
- 1.2.2 The presented results will provide further information on the archaeological resource that have been impacted by the ongoing development and facilitate an informed decision regarding the requirement for, and methods of, any further archaeological mitigation.



1.3 Location, topography and geology

- 1.3.1 The site is located within the former Northfleet Cement Works at Northfleet, Kent (Fig. 1). It is situated on the south bank of the Thames and on the eastern side of the Ebbsfleet Valley. The Site is surrounded by previously quarried land, and much of the Site itself was previously quarried (*Land at Northfleet Embankment West WSI, WA 2020*).
- 1.3.2 The survey area is in a parcel of land between the end of The Creek and west of The Shore which runs along River Thames. Most of the area to the east is occupied by Tarmac Cement and Lime's commercial structures and lorry car park now mainly used as site compound for the development works.
- 1.3.3 The Site currently consists of open grassed areas that are within and adjacent to former chalk quarry workings, and areas of concrete hard standing where the now demolished cement works buildings once stood.
- 1.3.1 The natural ground surface reaches c. 20-15 m above Ordnance Datum (aOD) at the southern boundary of the Site. Ground levels within the site have been substantially modified by excavation and removal of the buried structures and by prior quarrying and substantial backfilling, but generally the ground level slopes down northward to c. 5 m aOD.
- 1.3.2 According to the British Geological Survey mapping (BGS online viewer), the bedrock geology underling the Site consists of Upper Cretaceous deposits of the Seaford Chalk Formation (89.8-86.3 mya). At the highest, southernmost part of the Site, this is overlain by Thanet Sand (59.2-56 mya) (*Land at Northfleet Embankment West WSI, WA 2020*).

2 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

2.1 Research sources

- 2.1.1 A detailed archaeological and historical background to the Bevans site has been presented in the previous report describing the Phase 1 laser scan and photogrammetry survey, and in the Interim Statement for the excavation works (Wessex Archaeology 2021; 2022).

2.2 Mid- and late 19th century development

- 2.2.1 The southern kiln complex is depicted in an estate map dating to 1869 (Fig. 2), along with sales particulars for 'Portland Cement Works', sold at auction in October 1869 which provided a detailed insight into layout of the area during this period.
- 2.2.2 The 1869 estate map depicts a large rectangular area labelled *Drying Floor*. An unlabelled circular structure is depicted towards the centre of this feature. A bank of 8 kilns, labelled *Kilns* is depicted on its eastern flank while a single kiln is depicted and labelled to the north. To the south of the bank of kilns an area of chalk working is depicted, and a tunnel is labelled heading towards the kilns. To the north of the single kiln is a building labelled *Office*, located adjacent to a feature labelled as a *Road* and partially overlaying a series of unlabelled features.
- 2.2.3 The sales particulars pertain to the 'newly erected' Portland Cement Works covering 36 acres. The area of the southern kiln complex is covered by the following particulars;

A RANGE OF EIGHT SLURRY OR SETTLING BACKS, A NEWLY-ERECTED DRYING FLOOR, 156 feet by 73 feet 6, with iron plate flooring, iron column and tram rails, CIRCULAR CHIMNEY SHAFT about 80 feet, TWO SQUARE SHAFTS, each about 40 feet high, and Flues constructed for consuming gases



from EIGHT NEWLY-ERECTED KILNS, one other large kiln, an office with counting house and room over, facing the road.

- 2.2.4 The particulars go on to describe a second range of 8 kilns which likely refer to the those depicted on the estate map immediately to the north (of which nothing survives except the dock and wash mills), however the description could fit broadly with the remains identified to the northeast: the northern kiln complex (Phase 1 survey);

SECOND RANGE OF 8 KILNS, with an enclosed DRYING FLOOR attached in three compartments, 55 feet by 75 feet, 77 feet by 54 feet and 29 feet by 39 feet, and Flues for utilising the gases from the kilns; under the greater part of the Drying Floor are Large and Lofty Arches 75 feet by 17 feet, 74 feet by 16 feet 9, and 81 feet 4 by 16 feet 6, forming CEMENT STORES.

- 2.2.5 There was a major reorganisation of the Bevans works in the 1870s, centralising a previously dispersed layout. By 1900, there were 59 kilns in operation with a registered capacity of 1700 tons a week.
- 2.2.6 OS Mapping suggests that by 1895 the row of kilns in the southern kiln complex had been reduced in number and either converted or replaced by air shafts. The 1897 OS maps depict a row of only five circular structures to the east of a linear kiln tunnel and a sixth one positioned slightly to the south-west, which are labelled as Shafts and Air Shafts on the 1897 and 1943 Kent OS maps (revised 1939) respectively. The 1897 OS maps depict the now near-rectangular plan drying floor structure as open on all sides. A circle drawn at the approximate mid-point of the west side of the drying floor structure may represent an oven feature. The previously depicted single kiln to the north of the drying floor is not on the 1897 maps and may have been demolished. In the wider area, Hive House had been demolished and the slurry beds expanded by this point, with terraced housing and new residential streets built further south along the High Street.
- 2.2.7 The original rotary kilns were cleared in 1921 to be replaced by larger kilns in the 1920s. However, because of the plant's confined site, the redevelopment could only be accomplished by complete shutdown and demolition of the previous kilns, which took five years. The new kilns opened in 1926.
- 2.2.8 An anonymous article in *Cement and Cement Manufacture*, volume 1 (1928; transcribed on https://www.cementkilns.co.uk/cement_kiln_bevans.html) describes the Bevans plant immediately after its 1920s rebuild. Numerous aerial photographs dated 1927 and 1939 from the NMR Aerofilms collection (Britain from Above website, not reproduced) and the 1938-39 Kent OS map (not reproduced) show the cement works after its redevelopment. They illustrate that the 19th century northern kiln structure had been replaced. Similarly, the 1933 Kent OS map shows that the open-sided drying floor structure in the southern kiln complex had been removed, but the six air shafts are still shown. The 1943 OS map (revised 1939) shows the number of air shafts reduced to five, the northern one had been removed.
- 2.2.9 The Bevans plant remained one of APCM's base-load operations for forty years and was the primary exporting plant. In 1957, one of the kilns (B1) was modified for semi-wet process, but this was relatively unsuccessful, and shut down in 1967. The rest of the plant shut down in 1970. However, much of the cement handling and wharfage remained in use and was incorporated into the adjacent Northfleet plant to the west.



3 AIMS AND METHODS

3.1 Project aims

With due regard to the Historic England guidance the general aims of the survey, as agreed with the County Archaeologist, were:

- To create a metrically accurate record of the surviving structures.
- To aid ongoing interpretation of the structures within their historical context.
- To aid decision making in regard of mitigating the loss of historic fabric and help to understand the potential, the significance, and the options available for the next stage of investigation.

3.2 Methods

Introduction

3.2.1 All works were undertaken in accordance with the methodology agreed and in compliance with the standards outlined in the Historic England guidance. The methods employed are summarised below.

3.2.2 The Phase 2 survey focused on capturing the kilns, and Phase 3 on the tunnel and other surrounding features. The survey covered all areas of the structures, however data in the tunnel was limited to that which could be captured from a safe distance.

Fieldwork methods – Phase 2 Survey

3.2.3 The metric survey was carried out using Leica GNSS GS07 Captivate, a Leica TS16 P 5" R500 Total Station and a FARO S70 laser scanner.

3.2.4 The photogrammetric survey was carried out using a Pentax K1 mounting lens HD Pentax-D FA 15-30mm DSLR and a telescopic camera pole.

3.2.5 The higher parts of the surviving structures were photographed using a telescopic pole. The aperture was maintained around the values of f7 and f8, with ISO constantly set up at 400. Seventeen targets for photogrammetry were placed around the structures and recorded with the total station. A total of 769 photographs were taken.

3.2.6 A closed loop traverse was carried out using a total station against a local grid. The adjusted traverse produced a final error of 0.002 m horizontal distance and 0.011 m in residual height.

3.2.7 Sixteen laser scans were recorded at a resolution of 7.7 mm @ 10 metres, primarily controlled using FARO sphere targets. Four checkerboard target positions were also recorded using the total station, to provide a secondary check and transform the data to the survey grid.

3.2.8 Two control points were recorded with the GNSS instrument, averaging 300 measurements taken using an RTK correction service. This was used to georeference the final dataset to OS grid and datum.

Fieldwork methods – Phase 3 Survey

3.2.9 The metric survey was carried out using Leica GNSS GS07 Captivate, a Leica TS16 P 5" R500 Total Station and a FARO S70 laser scanner.



- 3.2.10 The photogrammetric survey was carried out using a Pentax K50 DSLR with a Pentax SMC DA 18-55 mm f/3.5-5.6 AL WR lens, and a telescopic camera pole.
- 3.2.11 The higher parts of the surviving structures were photographed using a telescopic pole. The aperture was maintained around the values of f9 and f8, with ISO between 100 and 1600 to accommodate different light conditions. Eleven targets for photogrammetry were placed around the structures and recorded with the total station in a single setup. A total of 1135 photographs were taken.
- 3.2.12 Twenty-four laser scans were recorded at a resolution of 7.7 mm @ 10 metres, primarily controlled using FARO sphere targets. Eight checkerboard targets were also used, and were recorded using the total station to provide a secondary check and transform the data to the survey grid.
- 3.2.13 Two control points were recorded with the GNSS instrument, averaging 300 measurements taken using an RTK correction service. This was used to georeference the final dataset to OS grid and datum.

3.3 Data Processing

Phase 2 Survey

- 3.3.1 A total of 16 scans were processed in FARO Scene (version 2021.5.1.9021) and registered with a maximum distance error of 10.2 mm and a mean distance error of 2.3 mm.
- 3.3.2 The photogrammetry and the laser scan data were then processed using Metashape Pro (version 1.8.1)
- 3.3.3 Registration results are shown in Table 1.
- 3.3.4 The laser scan produced a point cloud of 73,192,998 points. The laser scan point cloud was later used to produce a mesh while the photogrammetric data set was used to colourise the mesh and produce the final texture.

Phase 3 Survey

- 3.3.5 A total of 24 scans were processed in FARO Scene (version 2021.5.1.9021) and registered with a maximum distance error of 8.5 mm and a mean distance error of 2.10 mm.
- 3.3.6 The photogrammetry and the laser scan data were then processed using Metashape Pro (version 1.8.1)
- 3.3.7 Registration results are shown in Table 1.
- 3.3.8 The laser scan produced a point cloud of 100,706,793 points. The laser scan point cloud was later used to produce a mesh while the photogrammetric data set was used to colourise the mesh and produce the final texture.

Table 1 Registration Results

Registrations	Phase 2 Mean Point Error	Phase 3 Mean Point Error
FARO Scene	2.10 mm	2.30 mm
Photogrammetry	13.1 mm	6 mm



3.4 Outputs

- 3.4.1 The laser scan point cloud was used to produce the mesh while the photogrammetric data set was used to colourise and texturize the mesh. The textured mesh was used to create the orthographic views.
- 3.4.2 A total of seven orthographic images were created: an orthographic plan view of the kilns and tunnel (Fig. 3 & Fig. 4), two site sections (Fig. 5) elevations of the three tunnel entrances (Fig. 6 and Fig. 7) and an elevation of the bank of kilns (Fig. 7)
- 3.4.3 A perspective view of the survey area is shown in Figure 4.

4 RESULTS

- 4.1.1 Laser scan and photogrammetric data was capture as far as reasonable and safe access allowed.
- 4.1.2 The surveyed structures are described in detail in the Interim Statement (Wessex Archaeology 2022), which will be superseded by an assessment report (forthcoming). A very brief summary of main features is provided here.
- 4.1.3 At the centre of the survey area is a row of six largely intact brick kilns and connected loading chambers, originally part of a bank of 11. The kilns measure 4 m in diameter at the widest point and have a 'beehive' profile. The kiln bodies measure 8 m high, and would originally have had a chimney.
- 4.1.4 The loading chambers connect to a 4.6 m wide, 8 m high brick arched tunnel running NNE-SSW parallel to the kiln bank, which runs along its ESE flank. This main tunnel section is 55 m long and has a 15 m long 'open' section to the north, where the northern extent of the metric survey has captured the entrance to a further section of covered tunnel.
- 4.1.5 A number of bricked-up archways are visible within the tunnel, as well as two open branches of additional tunnels connected to the main structure (Tunnel 22A and 22B)
- 4.1.6 At the southern end of the survey area the upstanding structural remains of one of the kiln tunnel roof openings, and a further partly demolished kiln with a partially intact chimney, which survives to a height of approximately 1 m above the rest.

5 CONCLUSIONS

- 5.1.1 The structures surveyed in Phases 1, 2 and 3 are believed to be part of the west side of the Bevan cement works, set up by Thomas Sturge in 1851 to the east of Robins and Co. The site was a well-known "Portland Cement" making centre from the second half of 1800s.
- 5.1.2 The surviving structures have been surveyed to produce an accurate metric record, which might be used for 3D digital reconstruction of the site. The data will be made available to help inform post-excavation assessment and interpretation, and for further analysis and reporting.



6 ARCHIVE STORAGE AND CURATION

6.1 OASIS

6.1.1 An OASIS online record (<http://oasis.ac.uk/pages/wiki/Main>) has been initiated, and key fields completed on Details, Location and Creators Forms. All appropriate parts of the OASIS online form will be completed for submission, and will include an uploaded .pdf version of the final report. Subject to any contractual requirements on confidentiality, copies of the OASIS record will be integrated into the relevant local and national records and published through the Archaeology Data Service ArchSearch catalogue.

6.2 Repository

6.2.1 The archive resulting from the survey is currently held at the offices of Wessex Archaeology in Salisbury.

6.2.2 The site falls within the collecting area of Dartford Museum. The museum is not currently accepting archaeological archives. As there is no physical archive associated with this project, digital data deposition with the Archaeology Data Service (ADS) is recommended.

7 COPYRIGHT

7.1 Archive and report copyright

7.1.1 The full copyright of the written/illustrative/digital archive relating to the project will be retained by Wessex Archaeology under the Copyright, Designs and Patents Act 1988 with all rights reserved. The client will be licenced to use each report for the purposes that it was produced in relation to the project as described in the specification. The museum, however, will be granted an exclusive licence for the use of the archive for educational purposes, including academic research, providing that such use shall be non-profitmaking, and conforms to the Copyright and Related Rights Regulations 2003. In some instances, certain regional museums may require absolute transfer of copyright, rather than a licence.

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About cement <https://www.cementkilns.co.uk/cement.html>

About "Roman" cement <https://www.cementkilns.co.uk/roman.html>

Robins https://www.cementkilns.co.uk/cement_kiln_robins.html

Bevans https://www.cementkilns.co.uk/cement_kiln_bevans.html



About Aspdin Kiln, on Kent County Council “Exploring Kent’s Past”

<https://webapps.kent.gov.uk/KCC.ExploringKentsPast.Web.Sites.Public/>

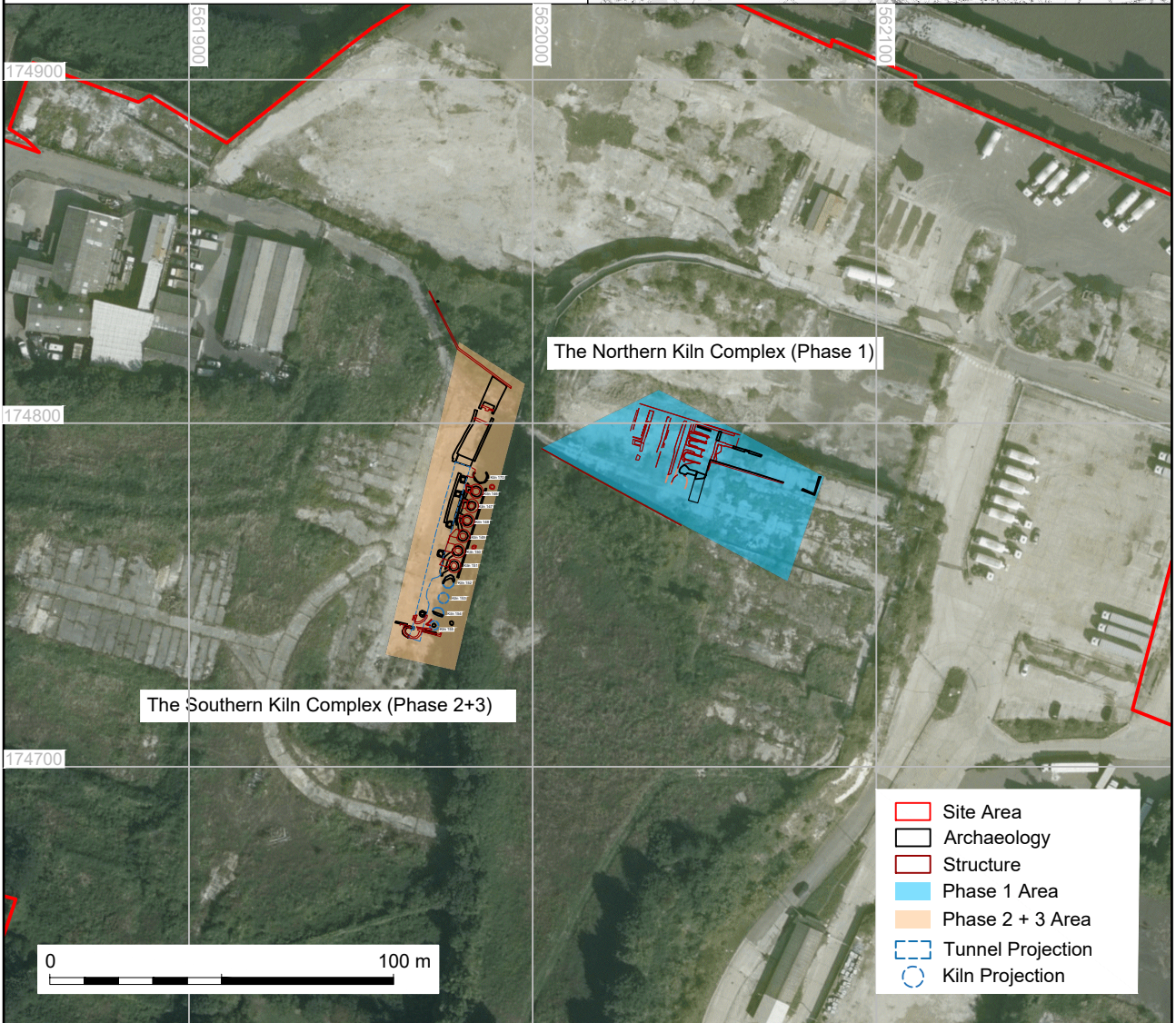
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Ordnance Survey mapping viewed on:

National Library of Scotland map finder <https://maps.nls.uk/> (accessed 24 March 2022)

Old-maps <https://www.old-maps.co.uk/#/> (accessed 20 November 2021)



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Site Location and surveyed areas

Figure 1



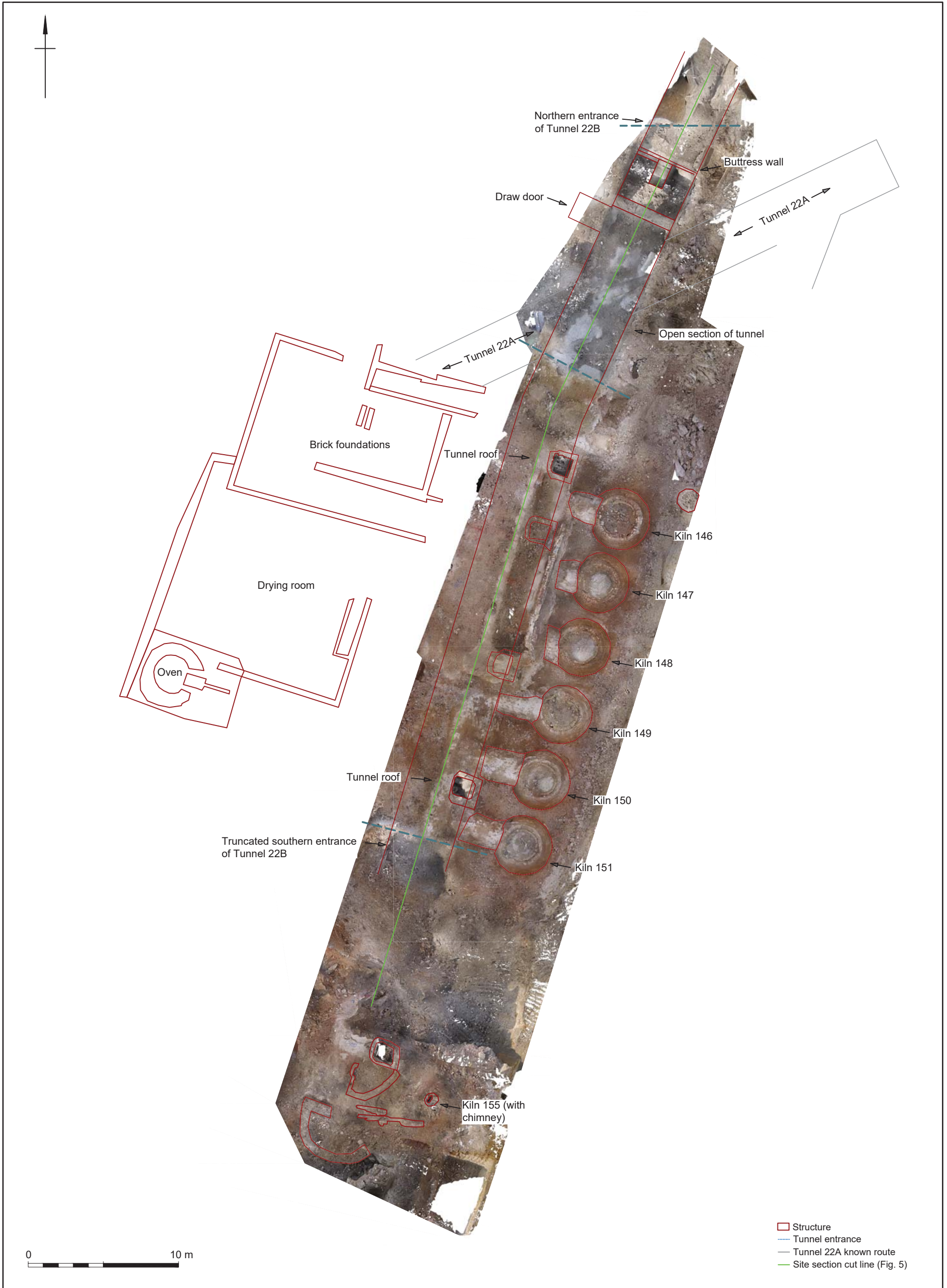
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1885 OS Mapping overlaid with survey data; 1869 estate map

Figure 2



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Plan view of survey area, and associated structures exposed during excavation works

Figure 3



Key:
 Tunnel area covered
 Tunnel area open
 --- Tunnel entrance

0 10 m

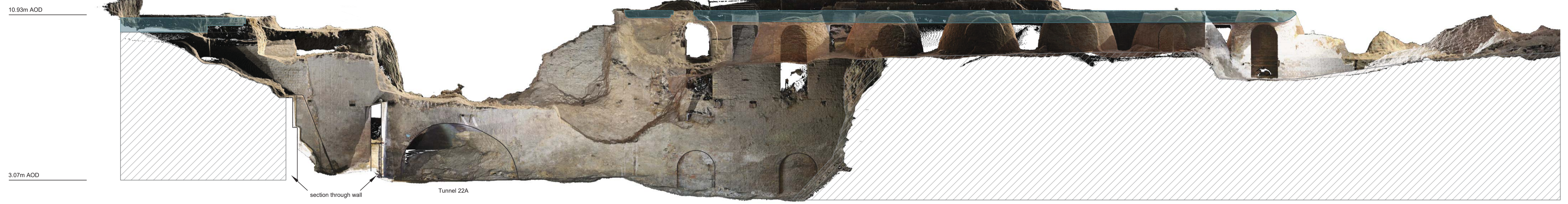


Plan view of kilns & tunnel; Oblique view of survey area

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Figure 4



WNW facing



ESE facing



Key:
 Section through tunnel arch
 Unexcavated tunnel infill

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Figures_Phase_2_3\232993_Figure_5.dwg	

Section through tunnel looking ESE toward kilns (laser scan data); Section through tunnel looking WNW (laser scan data)



Tunnel entrance facing NNE



Tunnel entrance facing SSW

Key:
▼ Level



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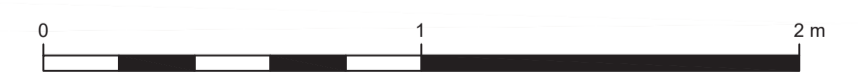
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Elevation of the kilns facing ESE



Southern tunnel entrance facing SSW



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			Scale:	1:50 & 1:20 at A1
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Elevation of the kilns and southern tunnel entrance			I:\Figures_Phase_2_3\232993_Figure_7.dwg	



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