Embankment at Lydney Harbour, Lydney, Gloucestershire

Photogrammetric and Laser Scan Survey Report

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Document Information

Document title	Embankment at Lydney Harbour, Lydney, Gloucestershire
Document subtitle	Photogrammetric and Laser Scan Survey Report
Document reference	270193.3
Commissioned by	Jackson Civil Engineering Group LTD
Address	30 White House Road Ipswich Suffolk IP1 5LT
On behalf of	The Environment Agency
Address	Aqua House 20 Lionel Street Birmingham B3 1AQ
Site location	Lydney Harbour Harbour Road Lydney Forest of Dean
County	Gloucestershire
National grid reference (NGR)	NGR 364830, 201315 (SO 64830 01315)
Statutory designations	Scheduled Monument - Lydney Harbour no. 1002079
Scheduled Monument Consent	S00243013
Planning authority	Gloucestershire County Council
WA project name	Lydney Harbour UAV/PHOT
WA project code	270193
Dates of fieldwork	18 – 20 July 2023
Fieldwork directed by	Anthony Russell
Assisted by	Rebecca Havard, Sally Jones
Project management by	Tori Wilkinson
Document compiled by	Rebecca Havard
Contributions from	Roberta Marziani Anthony Russell
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Quality Assurance

Issue	Date	Author	Approved by
1	15/09/2023	RJH	 TW

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Summary

Wessex Archaeology was commissioned by Jackson Civil Engineering Group LTD on behalf of The Environment Agency, to undertake a photogrammetric survey of the embankment and coal tips along the southern bank of the Lydney Canal. The embankment covers an area of approximately 1,500 m² centred on NGR 364830, 201315.

The survey comprised an Unmanned Aerial Vehicle (UAV) photogrammetric survey, supported by terrestrial photogrammetry. Due to an unfavourable weather forecast for UAV flights, in an agreed change to the Written Scheme of Investigation methodology a laser scan survey was also undertaken, targeting the embankment.

Weather conditions improved and a site-wide UAV photogrammetric survey was also able to proceed, which is not the subject of this report, covering a total area of approximately 6.3 ha and incorporating the embankment. The laser scan and UAV photogrammetric survey was supported by terrestrial photogrammetry around the coal tips, where access and visibility was restricted.

The datasets were combined to produce a 3D model, from which photogrammetric orthomosaics were generated, to provide a lasting visual record of the retaining wall and coal tips following a programme of ground clearance.

Acknowledgements

Wessex Archaeology would like to thank Jackson Civil Engineering Group LTD for commissioning the photogrammetric survey, and Sarah Howard for managing the project on behalf of the Environment Agency. Wessex Archaeology is also grateful to Melanie Barge for monitoring the work on behalf of Historic England, and to Jackson Civil Engineering Group LTD and David Frodin (Harbour Master) for their cooperation and help on site.

The photogrammetric survey was completed by Anthony Russell with the assistance of Rebecca Havard and Sally Jones. The project was managed on behalf of Wessex Archaeology by Tori Wilkinson.

Embankment at Lydney Harbour
Lydney, Gloucestershire

Photogrammetric and Laser Scan Survey Report

1 INTRODUCTION

1.1 Project background

1.1.1 Wessex Archaeology was commissioned by Jackson Civil Engineering Group Ltd, on behalf of the Environment Agency, to undertake an archaeological photogrammetric survey of the harbour embankment wall and coal tips along the Southern bank of the Lydney Canal, ahead of a programme of works within the harbour. The embankment comprises an area of approximately 1,500 m² centred on NGR 364830, 201315 (Fig. 1).

1.1.2 Lydney Docks and Harbour is scheduled by Historic England (NHLE 1002079), and the Swing Bridge within the scheduled area at the west end of the inner dock is also separately listed as Grade II. A Scheduled Monument Consent (S00243013) has been granted by the Department for Digital, Culture, Media & Sport (DCMS) advised by Historic England.

1.1.3 All works were undertaken in accordance with a Written Scheme of Investigation (WSI) which detailed the aims, methodologies and standards to be employed in order to undertake the survey (Wessex Archaeology 2023a). Melanie Barge, Inspector of Ancient Monuments, approved the WSI on behalf of Historic England, prior to the fieldwork.

1.1.4 The survey comprised an Unmanned Aerial Vehicle (UAV) photogrammetric survey, supported by terrestrial photogrammetry. Due to an unfavourable weather forecast for UAV flights, in an agreed change to the WSI methodology a laser scan survey was undertaken, targeting the embankment.

1.1.5 Weather conditions improved and a site-wide UAV photogrammetric survey was also able to proceed, which is not the subject of this report, covering an area of approximately 6.3 ha (Fig. 1) and incorporating the embankment. The laser scan and UAV photogrammetric survey was supported by terrestrial photogrammetry around the coal tips, where access and visibility was restricted.

1.1.6 The survey was undertaken between 18-20 July 2023, following a programme of soil and vegetation clearance which was monitored by watching brief (Wessex Archaeology 2023b).

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 survey, to interpret the results and assess whether the aims of the survey have been met.

1.2.2 The presented results provide a record of the harbour embankment wall, following a programme of scrub clearance.

1.3 Location, topography and geology

1.3.1 The survey area is located at Lydney Harbour. The site lies to the south-east of Lydney, on the northern bank of the River Severn, is bounded to the east by Lydney Yacht Club and to the north by agricultural fields.

1.3.2 The site is within a relatively flat area of land adjacent to the River Severn, at approximately 9 m above Ordnance Datum (aOD).

1.3.3 The underlying bedrock geology is mapped as St Maughan's Formation comprising interbedded sedimentary argillaceous rocks and sandstone formed approximately 393 to 419 million years ago in the Devonian Period. Superficial deposits are mapped as Tidal Flat Deposits - Clay and Silt, deposits formed up to 2 million years ago in the Quaternary Period (British Geological Survey 2022).

2 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

2.1.1 The present Lydney Harbour dates to the early 19th century, constructed when the earlier harbour site was adversely affected by changes in the course of the River Severn (Gloucestershire HER no. 434).

2.1.2 In 1813 the Severn & Wye Railway and Canal company constructed a horse drawn tramway to transport coal to the new harbour created to link an 18th-century canal from Lydney directly to the Severn. A new outer harbour and lock were added in 1821. Subsequently, the tram road was extended the full length of the harbour, which enabled the direct loading of boats via coal chutes along the harbour side (LCCT 2017, 2-3).

2.1.3 In the 1860s the tramway was replaced by new railway lines running on the south side of the harbour and further facilities were added in the 1870s, after which little further expansion took place (*ibid*.).

2.1.4 In the later 19th century, at the height of its industrial use, around 300,000 tons of coal were exported annually in over 2000 ships. The docks included a boat building yard, now the site of the yacht club, a row of late 19th-century workers cottages converted from earlier industrial buildings (demolished in the 1980s), a customs house, a house for the harbour master, as well as the railway sidings, coal loading chutes, and dock side cranes serving the harbour and associated industrial buildings including the surviving lime kiln (*ibid*.).

2.1.5 From after the Second World War until *c*.1970, the industrial estate established adjacent to the original upper docks at the head of the canal and railway junction imported timber and other raw materials and ships brought timber for the plywood factory at Pine End. The decision of the Pine End factory to transport the timber by road meant an end to the commercial viability of the docks and in 1976 the British Transport Docks Board decided to close the port by walling in the tidal basin (*ibid*.).

2.1.6 In 1985 the eastern part of the harbour from the swing bridge downstream was designated as a Scheduled Monument (NHLE ref: 1002079) in recognition of its national importance as a substantially unaltered early 19th century harbour that provided an important transport link for the Forest of Dean coal and iron industries to the Severn (*ibid*.).

2.2 Previous investigations

Watching Brief (2023)

2.2.1 Wessex Archaeology was commissioned to monitor the scraping back of soil on the embankment and intrusive works associated with excavation of previously undisturbed archaeological ground surfaces within the site (Wessex Archaeology 2023b).

3 AIMS AND OBJECTIVES

3.1 Project aims

3.1.1 The general aims (or purpose) of the photogrammetric survey, as stated in the WSI (Wessex Archaeology 2023a) were:

- To assist in providing a better understanding of the structure (where possible within the confines of the works),
- To compile a lasting record, to analyse the findings/record and then disseminate the results.

3.2 Project objectives

3.2.1 In order to achieve the above aims, the general objectives of the metric survey were:

- To make a photogrammetric record of the site, in compliance with the methods outlined in *Metric Survey Specifications for Cultural Heritage* (Historic England 2015). The recorded data from the survey will be made publicly available via the resulting report (and if warranted publication) and the project archive.

4 METHODS

4.1 Introduction

4.1.1 All works were undertaken in accordance with the detailed methodology set out within the WSI (Wessex Archaeology 2023a) and in general compliance with the standards outlined in CIfA (CIfA 2014) and Historic England (2015, 2017 and 2018) guidance. The methods employed are summarised below.

4.2 Fieldwork methods

4.2.1 A variation to the methodology outlined in the WSI was agreed in writing with the client prior to being implemented. Poor flight conditions were forecast for the agreed survey dates, and suggesting the proposed methodology of UAV data capture might not be possible.

4.2.2 A laser scan survey was carried out targeting the retaining wall and coal tips along the southern bank of the Lydney Canal, covering an area of approximately 1,500 m² (Fig. 1), to create a 3D point cloud. Weather conditions improved and a site-wide UAV photogrammetric survey was also able to proceed, incorporating the embankment.

4.2.3 The laser scan and UAV photogrammetric survey was supported by terrestrial photogrammetry around the coal tips, where access and visibility was restricted. Due to site constraints, this had to be captured in an unsystematic way, therefore it was necessary to implement a methodology to ensure the production of a complete 3D point cloud of the structure, so that the photographs could be accurately positioned during processing.

4.2.4 A Leica RTC360 laser scanner was used to capture medium density scans at approximately 10 m intervals. The Leica RTC360 has a maximum range of 130 m, a ranging error of ±2 mm and a ranging noise of 0.4 mm at a range of 10 m and 0.5mm at 20m. It uses an eye safe class 1 laser.

4.2.5 The Leica RTC360 has an inbuilt camera which produces HDR colour images of up to 36 megapixels, when the scanner's full field of view is scanned. The scanner was set to record colour information, allowing better visualisation of the point cloud for dissemination and interpretation.

4.2.6 Survey control was established on site using FARO reference spheres to aid in the registration of the data and scans were initially aligned and referenced on site using Leica Cyclone Field 360. The laser scan survey was conducted in a local coordinate system established on site and georeferenced using targets that were located on the British National Grid during processing.

4.2.7 Aerial photography was captured using an unmanned aerial vehicle (UAV) for the purpose of producing a photogrammetric model. The survey was undertaken using a DJI Inspire 2 UAV equipped with a Zenmuse X5S 3-axis gimbal stabilised 20.8-megapixel camera, achieving an average Ground Sampling Distance (GSD) of 1.32 cm per pixel.

4.2.8 Ground control points (GCPs) were established to control the aerial photogrammetric survey. The location of the GCPs was recorded using a Real Time Kinematic (RTK) Global Navigational Satellite System (GNSS) which provides an accuracy of +/-30mm in accordance with metric survey specifications laid down by Historic England (2015).

4.2.9 The interior of Coal Tip 7 was recorded by means of terrestrial photography, using a digital single-lens reflex (DSLR) camera, as it could not be captured in sufficient detail by the laser scanner or UAV survey. The terrestrial photographs were taken with a Sony Alpha7R II camera with a Sony FE 16-35mm F4 ZA OSS lens. The Sony Alpha7R II is a 42 megapixel full frame mirrorless camera with a 35 mm BSI CMOS sensor.

4.3 Data processing

4.3.1 The laser scan data was processed in Cyclone Register 360 into an ordered 3D point cloud (.e57 format).

4.3.2 The photogrammetric data was processed using the latest version of Agisoft Metashape Professional into a 3D point cloud (.las format).

4.3.3 The laser scan point cloud and panoramic photographs were imported in to Agisoft Metashape and combined with the point cloud derived from the photogrammetric surveys to produce a combined dense cloud, 3D textured mesh model, and 2D orthomosaics (geotiff format).

4.4 Outputs

4.4.1 A 2D orthographic plan view image (Fig. 2) and a perspective overview (Fig. 4) of the embankment and wider context was produced from the UAV survey data.

4.4.2 A 2D orthographic elevation view of the embankment was produced from the combined laser scan and UAV dataset (Fig. 3)

4.4.3 A 3D textured mesh model, produced to an accuracy of 0.01m, was uploaded as a private model on Sketchfab.

5 RESULTS

5.1.1 To create a lasting record of the retaining wall and coal tips along the southern bank of the Lydney Canal, a composite dense point cloud was derived from three data capture methods; laser scanning, terrestrial photogrammetry and aerial photogrammetric survey. A 3D texture mesh model and 2D orthographic images were generated from the point cloud.

5.1.2 This methodology has ensured the resulting outputs are metrically accurate with a photorealistic textural clarity, to aid visual inspection of the structures remotely. The production of a contemporary, lasting, visualisation of the retaining wall and coal tips ensures that the assets have been preserved by record prior to further works at the site, and as such the objectives of the survey have been met.

6 ARCHIVE STORAGE AND CURATION

6.1 Preparation and deposition of the archive

6.1.1 The digital archive generated by the project will be deposited with a Trusted Digital Repository, in this instance the Archaeology Data Service (ADS), to ensure its long-term curation. Digital data will be prepared following ADS guidelines (ADS 2013 and online guidance) and accompanied by metadata.

6.2 OASIS

6.2.1 An OASIS (online access to the index of archaeological investigations) online record (http://oasis.ac.uk) 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.

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.

7.2 Third party data copyright

7.2.1 This document, the report and the project archive may contain material that is non-Wessex Archaeology copyright (e.g., Ordnance Survey, British Geological Survey, Crown Copyright), or the intellectual property of third parties, which Wessex Archaeology are able to provide for limited reproduction under the terms of our own copyright licences, but for which copyright itself is non-transferable by Wessex Archaeology. Users remain bound by the conditions of the *Copyright, Designs and Patents Act 1988* with regard to multiple copying and electronic dissemination of such material.

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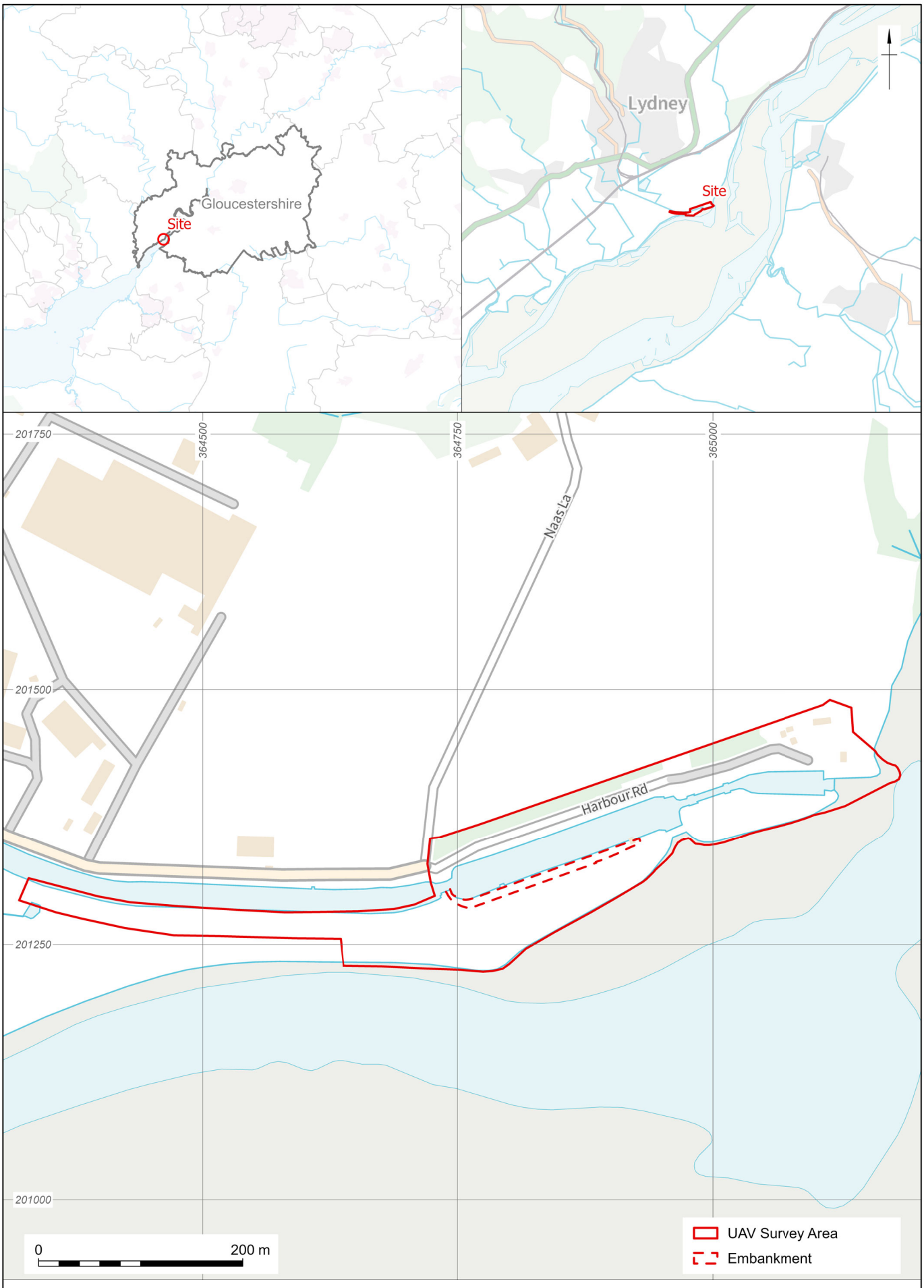

Coordinate system: OSGB 1936 British National Grid

Date: 15/09/2023	Created by: SJ	Revision: 0	Scale: 1:5,000 at A4

Figure 1: Site location plan

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364750

364800

364850

364900

201350

201300

0 20 m

Coordinate system: OSGB 1936 British National Grid

Date: 15/09/2023	Created by: SJ	Revision: 0	Scale: 1:500 at A3

Figure 2: Orthographic plan view of embankment

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North West Facing Elevation

0 5 m

Date: 19/09/2023	Created by: RM	Revision: 0	Scale: 1:100 at A3

Figure 3 : Orthographic elevation of embankment- 1 of 3

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North West Facing Elevation

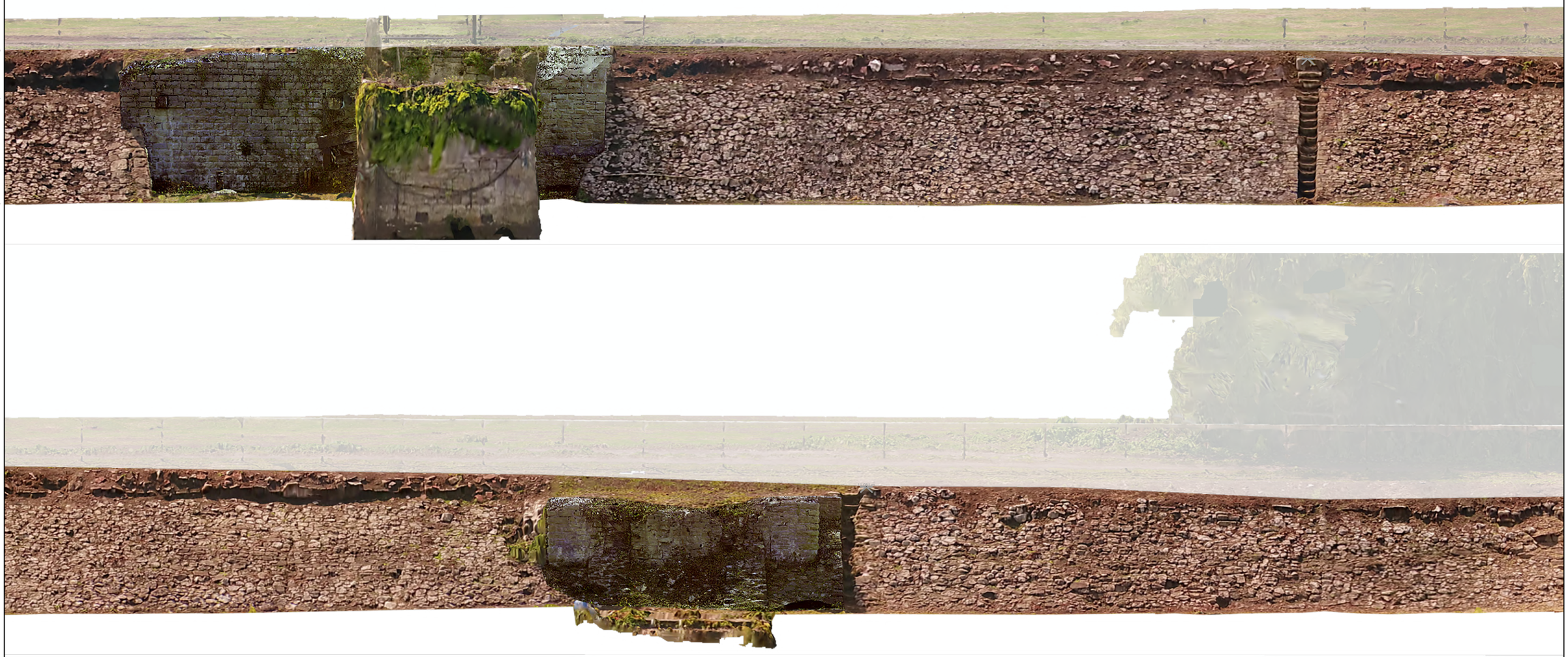

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Figure 3 : Orthographic elevation of embankment- 2 of 3

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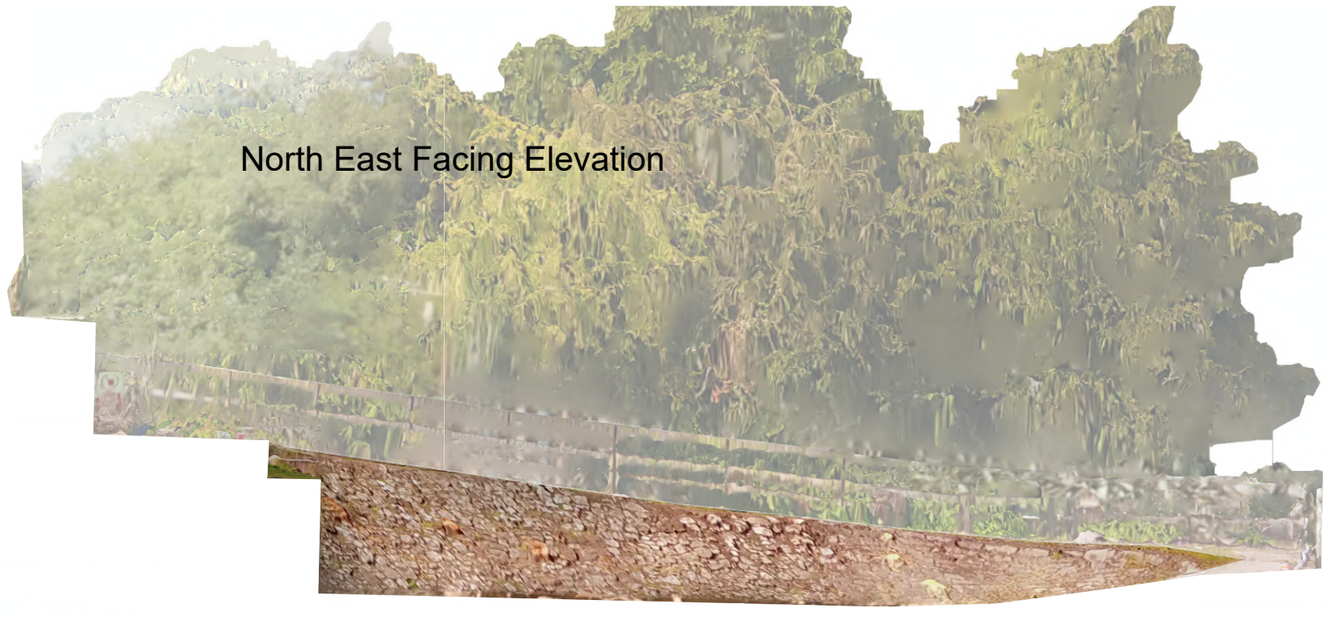

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Date: 19/09/2023	Created by: RM	Revision: 0	Scale: 1:100 at A3

Figure 3 : Orthographic elevation of embankment - 3 of 3

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Date: 19/09/2023	Created by: RM	Revision: 0	Scale: Not to Scale at A3

Figure 4 : Perspective view of embankment

APPENDICES

Appendix 1 OASIS summary

OASIS Summary for wessexar1-518760

OASIS ID (UID)	wessexar1-518760
Project Name	Embankment at Lydney Harbour, Lydney, Gloucestershire: Photogrammetric and Laser Scan Survey
Sitename	Lydney Harbour
Sitecode	270193
Project Identifier(s)	270193
Activity type	Laser Scanning Survey, Photogrammetric Survey
Planning Id	
Reason For Investigation	Heritage management
Organisation Responsible for work	Wessex Archaeology
Project Dates	18-Jul-2023 - 20-Jul-2023
Location	Lydney Harbour NGR : SO 64846 01341 LL : 51.7096976216692, -2.510168068517634 12 Fig : 364846,201341
Administrative Areas	Country : England County : Gloucestershire District : Forest of Dean Parish : Lydney
Project Methodology	Wessex Archaeology was commissioned to undertake a photogrammetric survey of the embankment and coal tips along the southern bank of the Lydney Canal, following a programme of ground clearance. The survey comprised a UAV survey, supported by terrestrial photogrammetry. Due to an unfavourable weather forecast for UAV flights, in an agreed change to the Written Scheme of Investigation methodology a laser scan survey was also undertaken. A 3D model and photogrammetric orthomosaics were generated from the data.
Project Results	The survey was undertaken in accordance with an approved WSI, and the project aims and objectives were achieved. A lasting photogrammetric record of the embankment was made, preserving the structure by record to inform future works
Keywords	Embankment - POST MEDIEVAL - FISH Thesaurus of Monument Types
Funder	Private or public corporation Jackson Civil Engineering Group Ltd,Environment Agency
HER	Historic England review - unRev - STANDARD Gloucestershire HER - noRev - LITE
Person Responsible for work	Rebecca Havard, Sally Jones, Anthony Russell, Tori Wilkinson
HER Identifiers	
Archives	

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