Geophysical Survey

of

Waterloo Carpark, Cirencester GPR Survey

Gloucestershire

For

The Environment Partnership (TEP) Ltd

On Behalf of

Cotswold District Council

Magnitude Surveys Ref: MSSP465

Scheduled Monument: No. 361: Corinium Roman Town

May 2019

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Draft 1.0	Internal Initial Draft	Amedeo Viccari BSc MSc PCIfA Freddie Salmon BSc FGS	Julia Cantarano Ingénieur PCIfA	Julia Cantarano Ingénieur PCIfA	15 May 2019
Draft 1.1	Internal Corrections	Julia Cantarano Ingénieur PCIfA	Julia Cantarano Ingénieur PCIfA	Finnegan Pope-Carter BSc (Hons) MSc FGS	15 May 2019
Final 2.0	Minor correction from Client	Julia Cantarano Ingénieur PCIfA	N/A	Julia Cantarano Ingénieur PCIfA	21 May 2019

Abstract

A ground penetrating radar survey has been successfully carried out across the site. Highlighting areas of both possible and probable archaeological activity correlating to results produced from previous archaeological excavations within site. Large, high amplitude anomalies relating to historic construction building material dominate the survey area with further anomalies situated within, possibly corresponding with structural remains related to the Roman period largely identified in previous study of the site. Widespread modern activity has been detected within the surface layers, representing the tarmacadum layer and various drainage related features within the hardcore basecourse. An earlier phase of drainage system was also detected underlying the current phase. This earlier drainage impinges on the Roman layers identified in the borehole survey but most likely dates to after the roman period.

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1. Introduction

1.1. Magnitude Surveys Ltd (MS) was commissioned by The Environment Partnership on behalf of Cotswold District Council to undertake a ground penetrating radar (GPR) survey on a c. 0.56ha area of land at Waterloo Carpark, Cirencester, Gloucestershire (SP 0264 0206).

1.2. The geophysical survey was undertaken using the GPR method, which is well suited to locating and characterising the remains of stone- and brick-built buildings, graves and cut-and-filled features such as pits and ditches (where they have a strong contrast with their matrix). GPR is further capable of assessing the subsurface in three dimensions, allowing phasing of stratified sites.

1.3. The survey was conducted in line with the current best practice guidelines produced by Historic England (David et al., 2008), the Chartered Institute for Archaeologists (2014) and the European Archaeological Council (Schmidt et al., 2015).

1.4. The ground penetrating radar survey was conducted in accordance with a WSI produced by MS in March 2019 (Salmon, 2019).

1.5. The survey commenced on 23/04/2019 and took two days to complete.

2. Quality Assurance

2.1. Magnitude Surveys is a Registered Organisation of the Chartered Institute for Archaeologists (CIfA), the chartered UK body for archaeologists, and a corporate member of ISAP (International Society of Archaeological Prospection).

2.2. Director Dr. Chrys Harris is a Member of CIfA, has a PhD in archaeological geophysics from the University of Bradford and is the Vice-Chair of ISAP. Director Finnegan Pope-Carter is a Fellow of the London Geological Society, the chartered UK body for geophysicists and geologists, as well as a member of GeoSIG, the CIfA Geophysics Special Interest Group. Reporting Analyst Dr. Kayt Armstrong has a PhD in archaeological geophysics from Bournemouth University, is the Vice Conference Secretary and Editor of ISAP News for ISAP, and is the UK Management Committee representative for the COST Action SAGA.

2.3. All MS managers have relevant degree qualifications to archaeology or geophysics. All MS field and office staff have relevant archaeology or geophysics degrees and/or field experience.

3. Objective

3.1. The objective of this geophysical survey was to assess the subsurface archaeological potential of the survey area.

4. Geographic Background

4.1. The site is located in Cirencester, Gloucestershire, c.150m east of the town centre (Figure 1). Survey was undertaken over one carpark bounded by road called The Waterloo to the northwest and southwest, the River Churn to the northeast, and housing off The Waterloo to the southeast (Figure 2).

4.2. Survey considerations:

Survey Area	Ground Conditions	Further Notes
1	Paved carpark; flat.	The survrey area was bounded by brick walls on all sides. There were lampposts, trees and parked cars throughout the survey area.

4.3. The underlying geology comprises of mudstone of the Forest Marble Formation. A thin layer of tarmacadum overlays a shallow gravel basecourse. Variations in mudstone composition occur below this, concurrent with made ground, starting with a silty clay matrix containing abundant, coarse limestone rubble. Below this; sediments become finer containing less limestone and more of a brick hardcore interface. Water strike occurs c. 1.5m and standing water is noted at c.1.9m from the surface. Below this, stratified river terrace deposits categorised fine to course contain a clastic sandy gravel layer from c.2m depth to c.6m depth (BGS SP00SW/190) (British Geological Survey, 2019).

4.4. Soils consist of loamy shallow lime-rich soils over chalk or limestone (Soilscapes, 2019).

5. Archaeological Background

5.1. The following section provides a brief overview of the archaeological background of the site derived from an archaeological evaluation, a Written Scheme of Investigation for archaeological works and a geoarchaeological report respectively produced by Cotswold Archaeological Trust, Cotswold Archaeology and ARCA Geoarchaeology. For a more detailed discussion of this background, see Coleman (1998), Cotswold Archaeology (2019) and Watson (2019).

5.2. Two series of archaeological and geoarchaeological interventions have already occurred on the study area; six test pits in 1998 and of three trenches with a drilled borehole each in 2019. Test pits were dug at the west (TP1, TP2) and southeast corner (TP5), northeast (TP6) and north corner (TP4) and also towards the middle of the site (TP3); trenches and relative boreholes were excavated towards the west corner (BH1), at the southeast corner (BH2) and in the middle of the area (BH3). The site revealed a very rich archaeological potential especially regarding the Roman period but medieval and post-medieval occupation levels were documented as well.

5.3. Evidence for a pre-Roman watercourse running along the southern part of the survey area has been found. During the Roman period, the site lay within the town of Corinium (Scheduled Monument No. 361, HE ref. 1003426) and a roman road running on a roughly north to south orientation was observed in 1974-5 c.90m to the south of the study area. No traces of this road were identified within TP1, which suggested that it might be positioned beyond the survey area itself, further to the southwest.

5.4. Besides that, the plan of at least one roman building presumably orientated at a right angle to the aforementioned street (west-southwest to east-southeast) was found within the study site. The remains of a series of walls and/or wall foundations belonging to this building and comprising limestone blocks together with demolition rubble were identified. Specifically, remains of a wall come from TP1, TP2, TP3 and TP4 which lie in the western half of the site; TP5, located at the southeast corner, gave evidence of roman demolition rubble while a late roman stone floor made of limestone blocks was found in TP6, towards the northeaster end of the area.

5.5. In the Medieval period, the study site lay immediately outside of the main settlement areas of the Anglo-Saxon town. No structures of this date have been recorded so far but known medieval features including robber trenches probably targeting Roman walls and a floor surface, both identified in TP1, pits, postholes and "dark earth" layers were detected throughout the area.

5.6. The town map of 1795 by Richard Hall & Son shows the study area as an open field, while, as both maps and excavations reveal, the area was in agricultural use throughout the 19th and 20th centuries. 18th and 19th centuries building rubble along with post-medieval layers related to a small building were found as well; this building is visible on OS map 1st (1875) and 2nd edition (1903) and was located towards the southeaster end of the site (identified within TP5). The current car park was built in the 1960s.

6. Methodology

6.1. Data Collection

6.1.1. Geophysical survey will comprise the GPR method as described in the following table.

6.1.2. Table of survey strategies:

Method	Instrument	Traverse Interval	Sample Interval
Ground Penetrating Radar	Mala GX with a 450 Mhz Antenna carried on a skid	0.5m	0.02m

6.1.3. GPR data was collected along lines, using the system's odometer wheel to position sampling points. The lines were located and guided by means of tapes laid out in a grid covering the survey area, which were positioned and controlled using RTK GPS with sub-centimetre accuracy.

6.2. Data Processing

6.2.1. GPR data will be processed in the standard commercial software package ReflexW 3D. GPR Processing steps will be limited to:

<u>DC Shift</u> – The waveform response for each traverse will be centred to correct for striping effects caused by small variations in sensor electronics and orientation.

<u>Bandpass Filter</u> – Frequencies outside the normal range of the measuring antennae will be filtered out to remove errors from external sources.

<u>Background Removal</u> – Background 'noise' will be filtered out of the data to improve clarity and aid in the detection of weak anomalies.

<u>Gain Adjust</u> – A gain curve will be manually calculated to account for signal attenuation with depth. The gain adjust will allow features at depth with a weaker signal to be resolved at the same plotting scale as near surface features.

6.3.Data Visualisation and Interpretation

6.3.1. The individual GPR radargrams will be stacked to form a three-dimensional cube of measurements. Greyscales will be created by horizontally slicing the cube to produce plan-view time-slices. These "timeslices" will initially considered in an animated GIF form to analyse the three-dimensional extent of anomalies. For print purposes, three gross soil volumes will be considered: shallow, middle, and deep. The mean of the timeslices within each gross soil volume will be taken and used as a representative time slice for the interpretation figures. Timeslices will be interpreted in a layered environment, overlaid against open street mapping, satellite imagery, historic mapping, LiDAR data, and soil and geology mapping. The timeslices will also interpreted in consideration with the radargrams, which visualise the form of the geophysical response, aiding in anomaly interpretation.

6.3.2. Geodetic position of results - All vector and raster data will be projected into OSGB36 (ESPG27700) and provided upon request in ESRI Shapefile (.SHP) and Geotiff (.TIF) respectively.

7. Results

7.1.Qualification

7.1.1. Geophysical results are not a map of the ground and are instead a direct measurement of subsurface properties. Detecting and mapping features requires that said features have properties that can be measured by the chosen technique(s) and that these properties have sufficient contrast with the background to be identifiable. The interpretation of any identified anomalies is inherently subjective. While the scrutiny of the results is undertaken by qualified, experienced individuals and rigorously checked for quality and consistency, it is often not possible to classify all anomaly sources. Where possible an anomaly source will be identified along with the certainty of the interpretation. The only way to improve the interpretation of results is through a process of comparing excavated results with the geophysical reports. MS actively seek feedback on their reports as well as reports of further work in order to constantly improve our knowledge and service.

7.2.Discussion

7.2.1. The GPR survey was successfully completed, allowing for the identification of modern and archaeological features within the top 1.5m of the site. Further information has been gathered from deeper timeslices; the high groundwater level and surface moisture within the car parks tarmacadum layer has made some possible deeper anomalies to appear discrete and ephemeral. However, broad bands likely to be related to an Alluvial clay layer could be detected. Bands of better signal penetration were detected across the survey area. The zones of greater signal penetration and corresponding anomaly amplitudes correlate with the parking bays rather than the 'roads' of the car park. This phenomenon has been observed on other car park sites but at present there is no satisfactory explanation: it could be something to do with different construction, compaction, erosion or drainage between the two, or some combination of all of these (Figure 3). Anomalies could still be detected in the 'blank' zones but with a weaker amplitude which resulted in classifying the anomalies as possible archaeology instead of probable archaeology.

7.2.2. Previous studies within the site (see section 5), including test pit excavation and borehole analysis identified areas of both probable and possible archaeological activity of mostly Roman origin. Cross-sectional analysis of this data indicates a large clastic spread of sub-angular limestone fragments below the basecourse set for the tarmac surface. Differing from the local superficial geology it is possible this fragmented limestone layer results from an anthropogenic influence. The previous study within the site took into account various cross sections through the site and identified a "Roman horizon". Within the GPR survey large amorphous bands of high amplitude material has been identified correlating to the location of both, Roman wall features and a build-up of contemporary basecourse on the surface from the construction of the carpark. Analysis of both the trenching cross-section and the radar profile has allowed for the differentiation between these layers and interpretation of multiple areas of probable archaeological activity. Due to the significant modern activity over the years and the bands of weaker responses it was difficult to identify clear shapes within the timeslices, however, rubble and structural responses were clearly detected in the radargrams (Radargrams: 3428, 3490, 3508 & 3782).

7.2.3. Two phases of drains/pipes were identified on site. One is matching the current layout of the car park, associated with clear hyperbolas in the radargrams (Figures 4 and 5). Another set of drain/pipe response is recorded around 1.2m. They have clear drain/pipes responses in the timeslices (Figure 7) but are much weaker and do not always show clear hyperbolas in the radargrams (Radargram 3490). They are located at the same depths as the archaeological layer, and at another orientation than the modern drains. These indicate an earlier origin than the current phase. Some of the drains are located near the Roman wall identified in the trenching TP3 (see section 3), however, it is difficult to confidently say that they are of Roman origin as they could be the result of a later system cutting through Roman features.

7.2.4. Within the deepest timeslices large amorphous bands of low amplitude natural material have been identified. At depths greater than 1.4m signal attenuation is high due to the ground water level within site. Around 2m deep a weak reflecting layer can be seen within the radargrams, corresponding with a geological interface. Borehole data from previous site investigations identifies a band of 'Alluvial Clay' present around this depth. When saturated an alluvial matrix will further increase signal loss.

7.3. Interpretation

7.3.1. General Statements

7.3.1.1. Geophysical anomalies will be discussed broadly as classification types across the survey area. Only anomalies that are distinctive or unusual will be discussed individually.

7.3.1.2. **Undetermined** – Anomalies are classified as Undetermined when the anomaly origin is ambiguous through the geophysical results and there is no supporting or correlative evidence to warrant a more certain classification. These anomalies are likely to be the result of geological, pedological or agricultural processes--although an archaeological origin cannot be entirely ruled out.

7.3.2. Specific Anomalies

7.3.2.1. **Archaeology (Probable) –** Within the surface layers, numerous discrete, high amplitude anomalies correlate to data collected during a trenching survey of the site. Evidence of structural remains **[1a]** (also visible on Radargram 3490) and further Construction Building Material (CBM) **[1b]** (Radargram 3782) was noted during this study. More concentrated areas of probable archaeology are identified under the current location of the parking spaces and are visible through the timeslices (Figure 3, 4, 5 & 6). They are identified as 'Zone of Better Signal Penetration' in the timeslices and appear to have enhanced CBM and rubble. See for example on Radargram 3490; between 0m and 22m the signal is weaker and from 22 m the signal is stronger and show rubble, and structural anomalies. Additional rubble and structural anomalies are likely to also be present under the non-enhanced areas (see archaeology (Possible)).

7.3.2.2. **Archaeology (Probable) –** Visible at approximately 1.10m deep both in timeslice and radargrams (Figure 5, Radargram 3490) a small area of attenuation **[1c]** may show the presence of 'Dark Earth'. The attenuation area is recorded 23m north-east of the 'Dark Earth' identified in the trenching BH1 (Figure 2). An additional weaker potential 'Dark Earth' was detected in Radargram 3428.

7.3.2.3. **Archaeology (Possible) –** Throughout the non-parking zones of the car park the signal received was more attenuated which made the discrimination of anomalies more difficult. However, though the depth profile of the survey numerous discrete linear anomalies are noted within close proximity to areas of probable archaeology. Two possible curvi-linear enclosure type features **[1d]** are noted within the uppermost layers of the survey. Appearing as very weak, low amplitude anomalies they both measure c.5mx3m and are located within close proximity to areas of better signal penetration. A single discrete, low amplitude linear anomaly **[1e]** is noted within the central portion of the site only within the uppermost timeslices. With depth, the feature disappears; however, it shares a similar alignment to the known wall-feature **[1a]**.

7.3.2.4. **Drain/Pipe Current Phase** – Identifying numerous modern drainage features, near surface results predominantly reflect a modern influence and construction related activity. Close to the surface layers, several broad anomalies aligning with each other follow the lines of gulleys linking drainage grates on the surface layer. The alternating bands of high and low amplitude data indicate differences in sub-surface material, be it drainage detritus or an undulating build-up of hardcore to aid with surface run-off flow into gulleys. With an increase in depth, these broad, high amplitude features change. Consulting the radargrams for these specific areas identifies a change in material, starting at a depth too deep to be of contemporary origin. Within the middle depth timeslices diagonal anomalies crossing the survey area indicate drainage lines exiting the site to the north, emanating from the drainage grates present on the surface at the time of survey. These drainage trends are identified as more of a point source anomaly within the radargram; a more discrete, isolated sub-surface feature.

7.3.2.5. **Drain/Pipe Earlier Phase** – Below and at a different angle than the first phase of drains (see above) 5 linear anomalies were detected **[1i]** (Figure 5). They are located around 1.2m deep within layers showing anomalies identified as archaeological possible and probable (see Radargrams 3490 & 3508). Their type of response would suggest an early drain system possibly of the same period as the archaeology detected around. However, it is more likely that the archaeology predates the drain system, which would have been built without consideration of the archaeological layers. Even if the latter is true the drain system identified is likely older than the modern system also identified.

7.3.2.6. **Modern –** Large swathes of high amplitude amorphous features have been identified throughout the extent of the survey area. Equally spaced at c.8.5m apart and on a general south west – north east alignment this higher density of reflector layers corresponds to the slight topographic undulations noted within the site at the time of survey **[1f]**. Contrasting these higher amplitude bands, a lower amplitude, more uniform sub-surface layering can be seen. Just below the tarmacadum layer a hardcore layer is used to build up the surface and allow water to flow down either side towards a drainage gully and subsequently towards the drainage grates.

7.3.2.7. **Natural –** Throughout the deeper timeslices a more natural presence is noticeable. Areas of spread disturbances **[1g]** attributed to the local alluvial geology are seen close to both the northern and southern boundaries. Representative of a very low amplitude reflector suggests a highly attenuative media, such as a saturated clay layer.

8. Conclusions

8.1. A ground penetrating radar survey has been successfully carried out across the survey area. Survey was conducted over two separate days, with heavy rainfall noted between site visits. Borehole data collected during a previous excavation of the site and its surrounding areas identified water strike overlaying an alluvium clay layer, between 1.4m and 2m. Inhibiting signal penetration and subsequent interpretation and identification of features of both possible and probable archaeological origin past these depths. Zones of greater signal penetration and corresponding anomaly amplitudes correlate with the parking bays rather than the 'roads' of the car park.

8.2. Data collected from previous archaeological excavation of the site, records evidence of a 'Cultural Diamict' and possible Roman wall cobble. Using this information alongside the radar data there is a correlation between studies. Evidence of wall-like features within the radargram figures corresponds to the location of a trial pit where these features were found. Identified to be of probable archaeological provenance numerous isolated anomalies share similar characteristics, suggesting a more widespread built feature or continuation of the wall and rubble within site.

8.3. A drain/pipe system was identified around 1.2 m deep on a different orientation to the modern drainage complex also identified on site. Several evidences suggest an older origin and impinges on the Roman layers identified in the borehole survey but most likely dates to after the roman period

8.4. A wider, more spread high amplitude response can be seen surrounding areas of probable archaeology within the middle depth slices. Identifying closely with the overlaying modern drainage / tarmacadum CBM. Using radargrams to distinguish between reflector layers through a depth profile has identified a distinguishable difference in materials used between the modern surface layer and features below. The same archaeological features continue into the deeper timeslices; a diminished amplitude caused by the surrounding environment has increased signal attenuation, influencing the visible extents of these features within the timeslices and radargrams.

9. Archiving

9.1. MS maintains an in-house digital archive, which is based on Schmidt and Ernenwein (2013). This archive stores the collected measurements, minimally processed data, georeferenced and un-georeferenced images, XY traces and a copy of the final report. A copy of this archive will be included in a disk with the final printed report.

9.2. MS contributes reports to the ADS Grey Literature Library upon permission from the client, subject to the any dictated time embargoes.

9.3. An OASIS form will be filled in on completion of the survey, providing permission from the client.

10. Copyright

10.1. Copyright and the intellectual property pertaining to all reports, figures, and datasets produced by Magnitude Services Ltd. is retained by MS. The client is given full licence to use such material for their own purposes. Permission must be sought by any third party wishing to use or reproduce any IP owned by MS.

11. References

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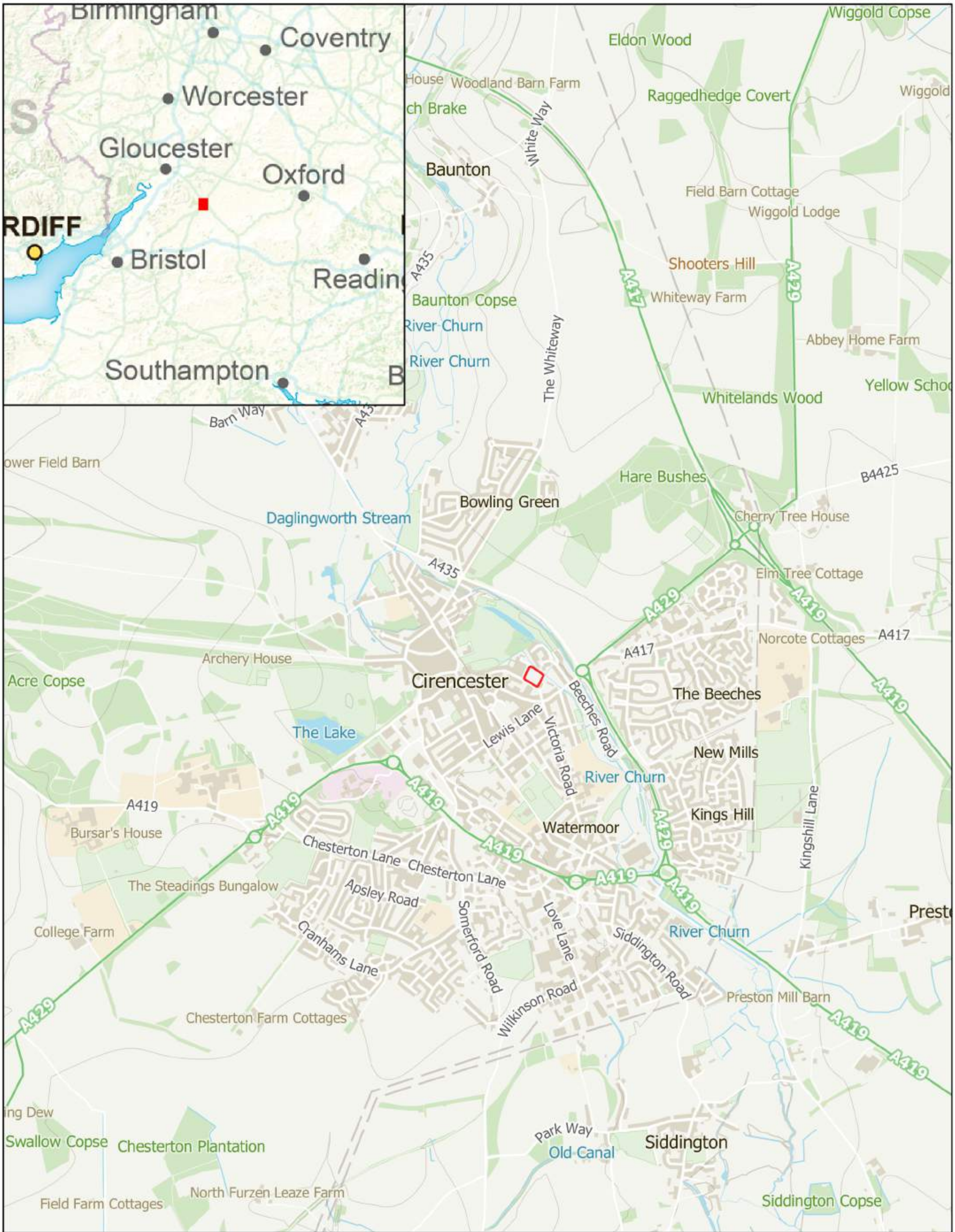


MSSP465 - Waterloo Carpark GPR

Figure 1 - Site Location

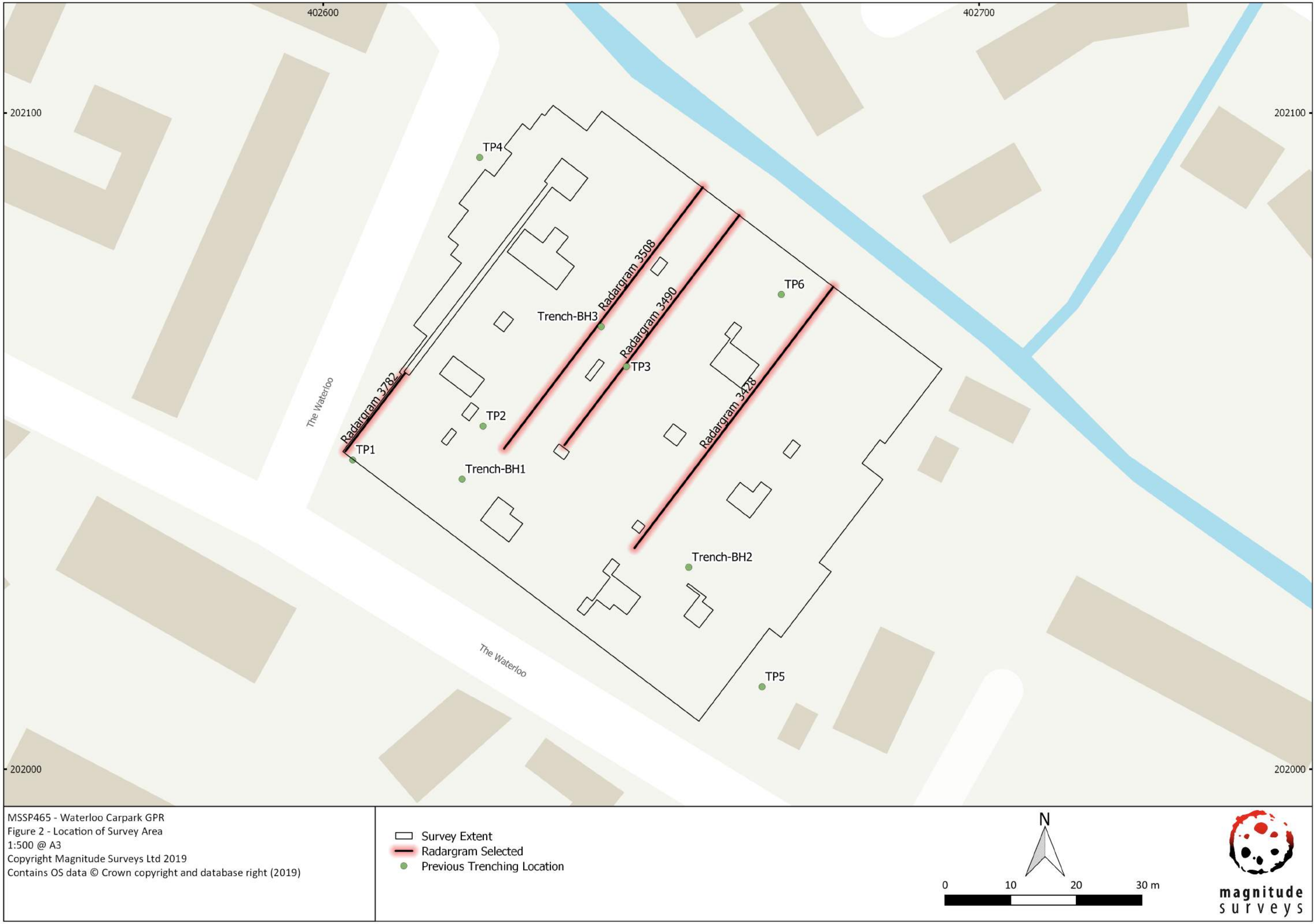
1:25,000 @ A4

N

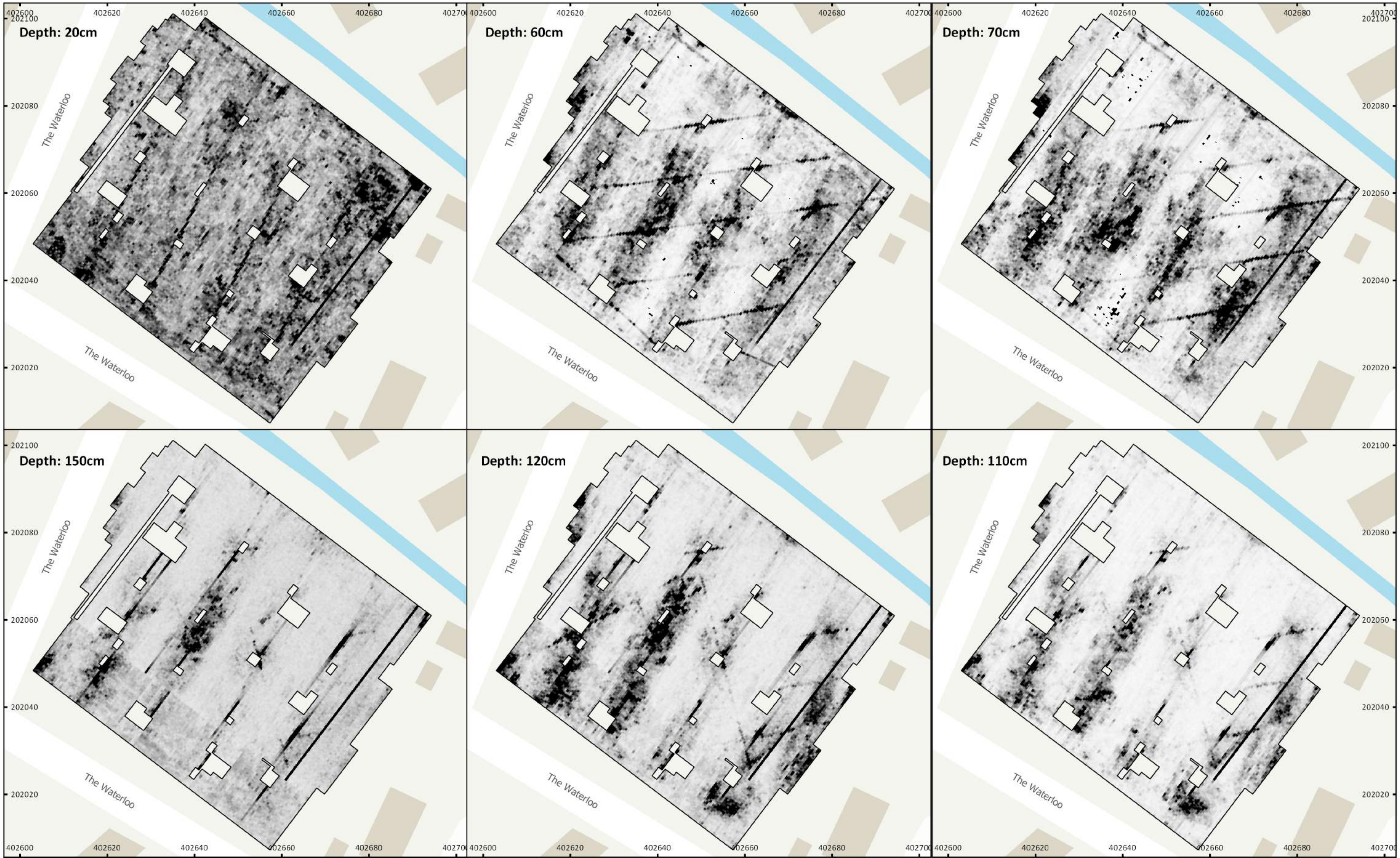
0 0.5 1 km

Location of Survey Area

magnitude surveys



MSSP465 - Waterloo Carpark GPR
Figure 2 - Location of Survey Area
1:500 @ A3



MSSP465 - Waterloo Carpark GPR
Figure 3 - Indicative GPR Timeslices (top-left, moving clockwise): Shallow-Deep
1:800 @ A3

Low Amplitude High

N

0 20 40 60 m

magnitude surveys

MSSP465 - Waterloo Carpark GPR
Figure 4 - GPR Shallow Interpretation (Indicative Timslice depth: 20cm)
1:500 @ A3

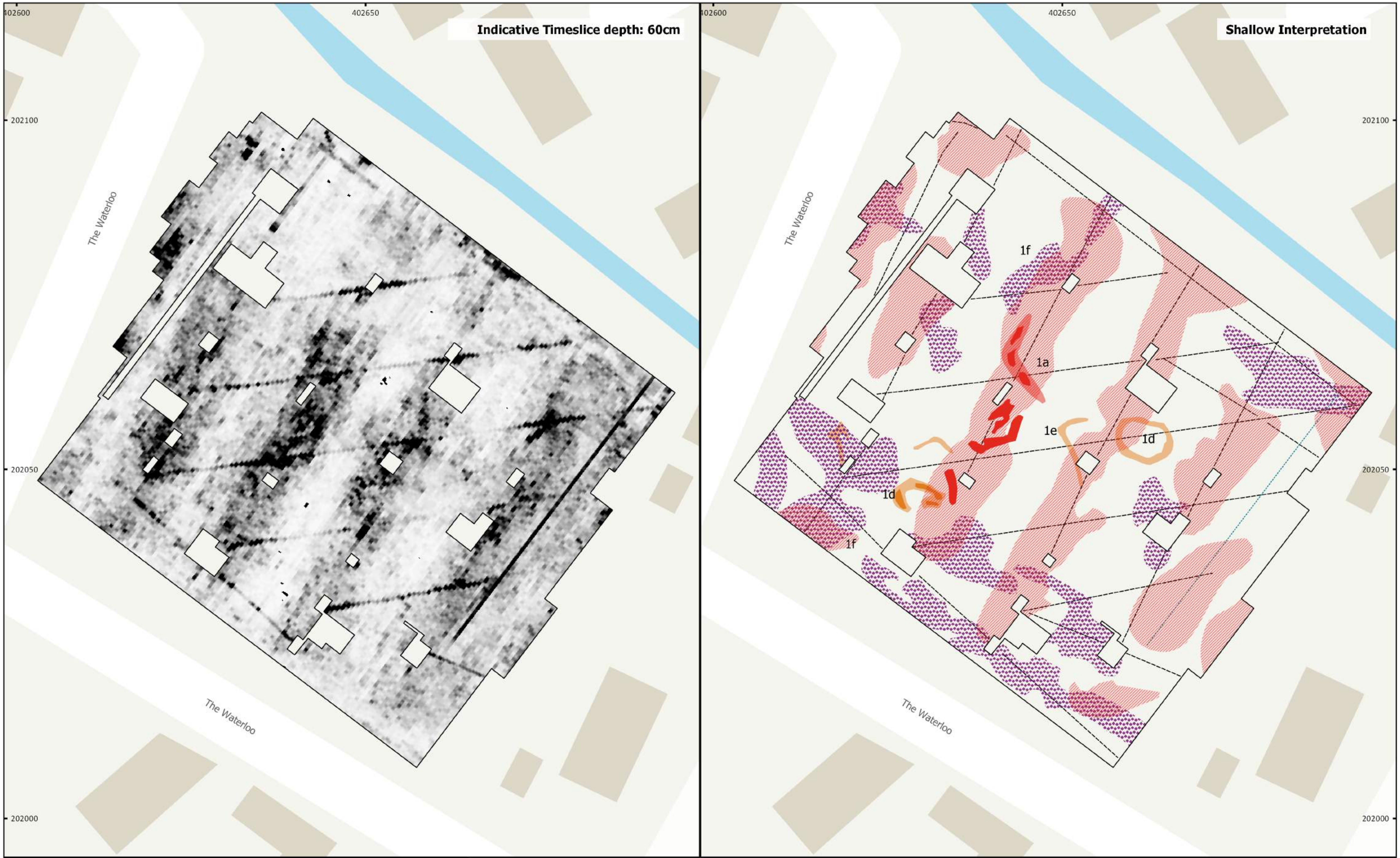
Archaeology Probable (Strong)
Archaeology Probable (Weak)
Zone of Better Signal Penetration
Archaeology Possible (Strong)
Archaeology Possible (Weak)
Modern (Spread)
Drain/Pipe Earlier Phase
Drain/Pipe Current Phase
Collection Artefact

Low Amplitude High

N

0 10 20 30 m

magnitude surveys



MSSP465 - Waterloo Carpark GPR
Figure 5 - GPR Shallow Interpretation (Indicative Timeslice Depth: 60cm)
1:500 @ A3

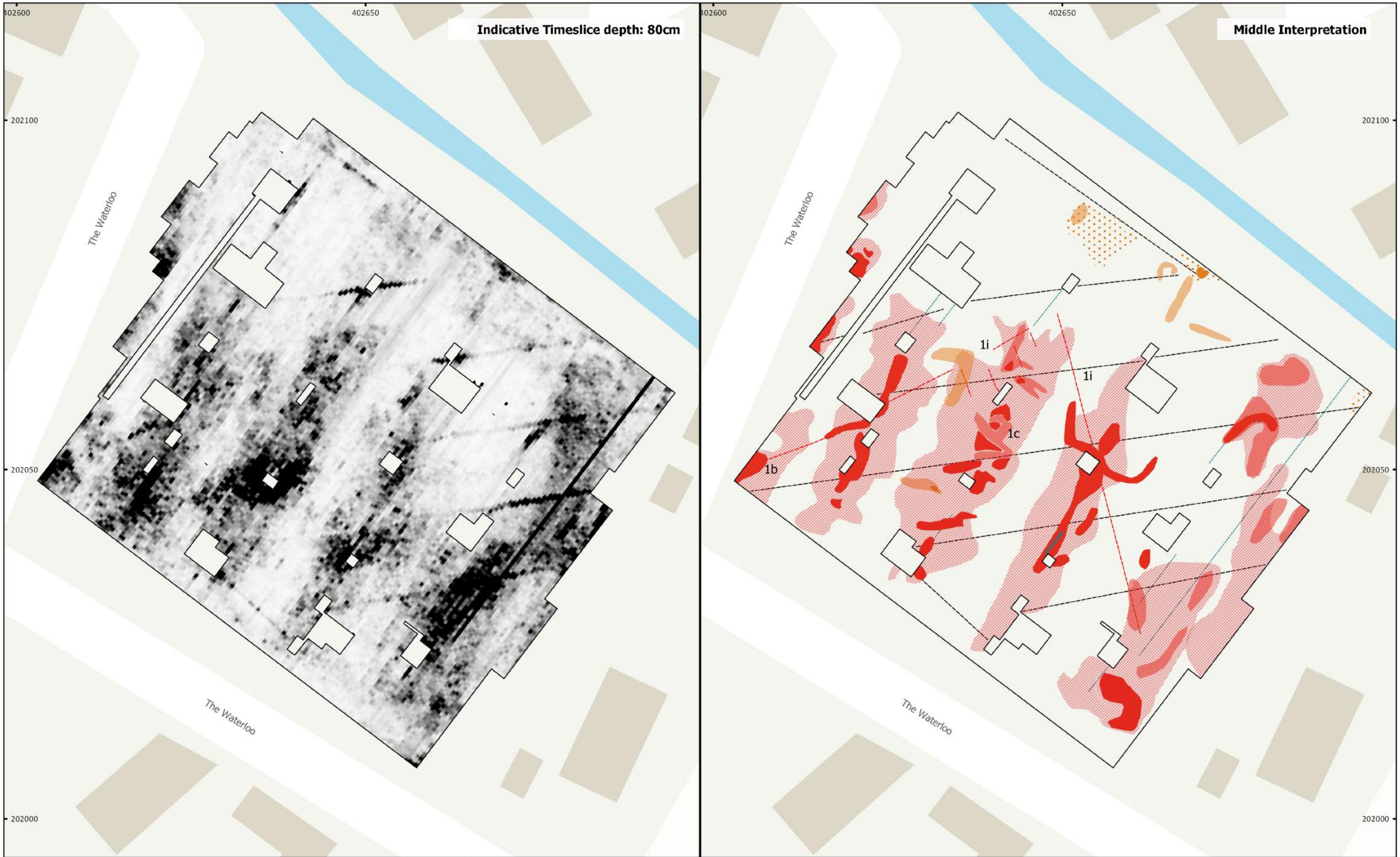
- Archaeology Probable (Strong)
- Archaeology Probable (Weak)
- Zone of Better Signal Penetration
- Archaeology Possible (Strong)
- Archaeology Possible (Weak)
- Modern (Spread)
- Drain/Pipe Earlier Phase
- Drain/Pipe Current Phase
- Collection Artefact

Low Amplitude High

N

0 10 20 30 m

magnitude surveys



MSSP465 - Waterloo Carpark GPR
Figure 6 - GPR Middle Interpretation (Indicative Timeslice Depth: 80cm)
1:500 @ A3

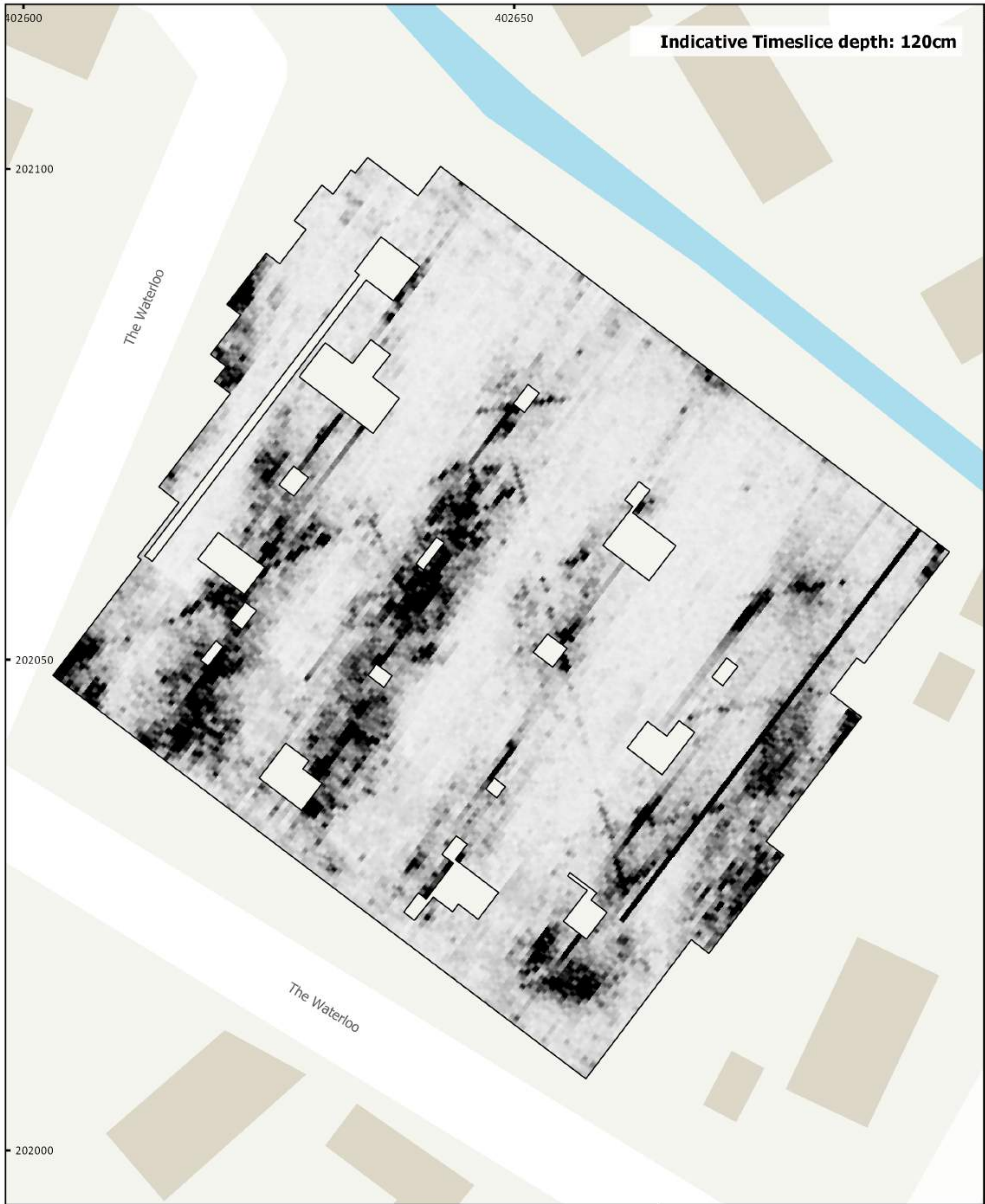
- Archaeology Probable (Strong)
- Archaeology Probable (Weak)
- Zone of Better Signal Penetration
- Archaeology Possible (Strong)
- Archaeology Possible (Weak)
- Archaeology Possible (Spread)
- Drain/Pipe Earlier Phase
- Drain/Pipe Current Phase
- Collection/Processing Artefact

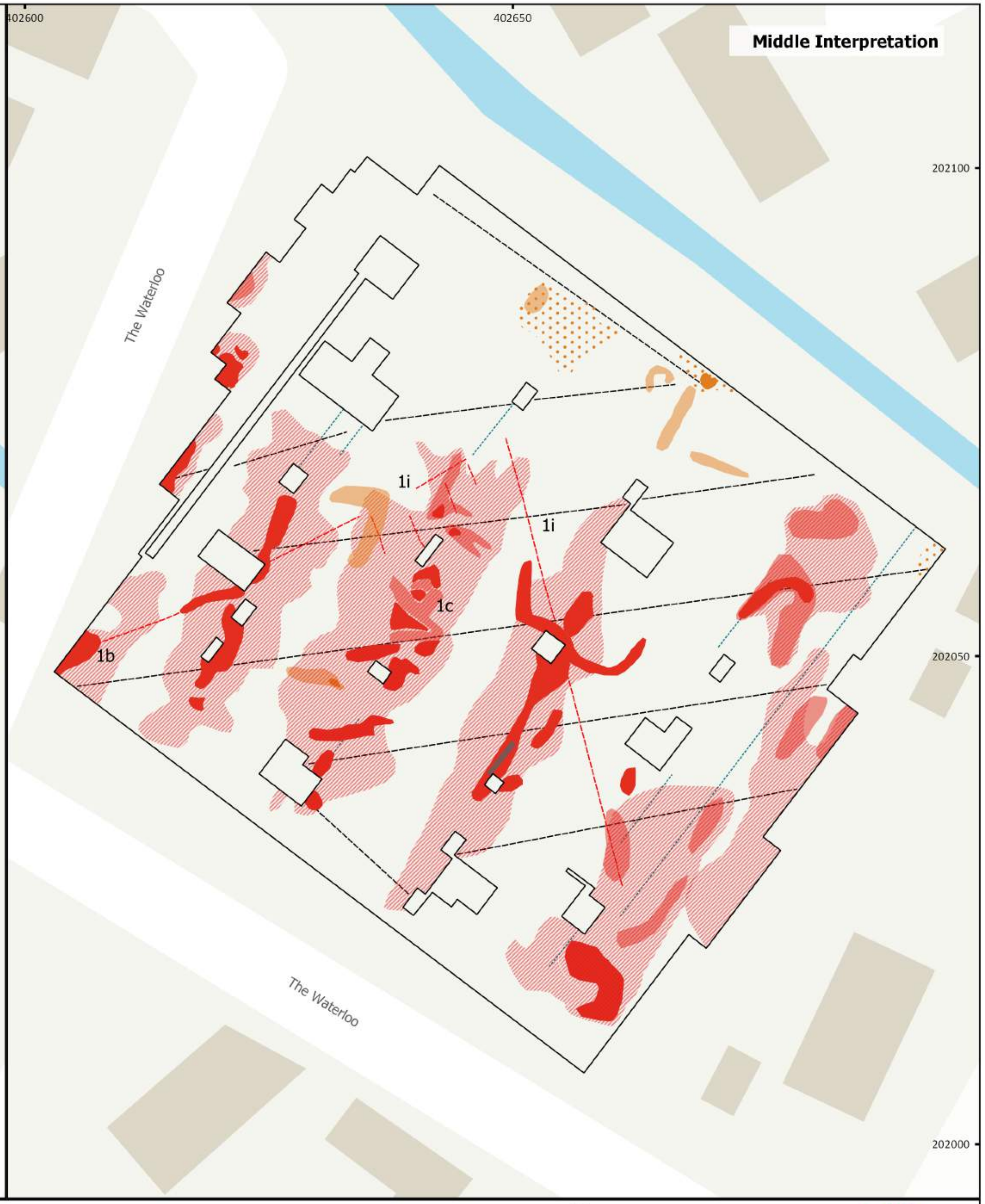
Low Amplitude High

N

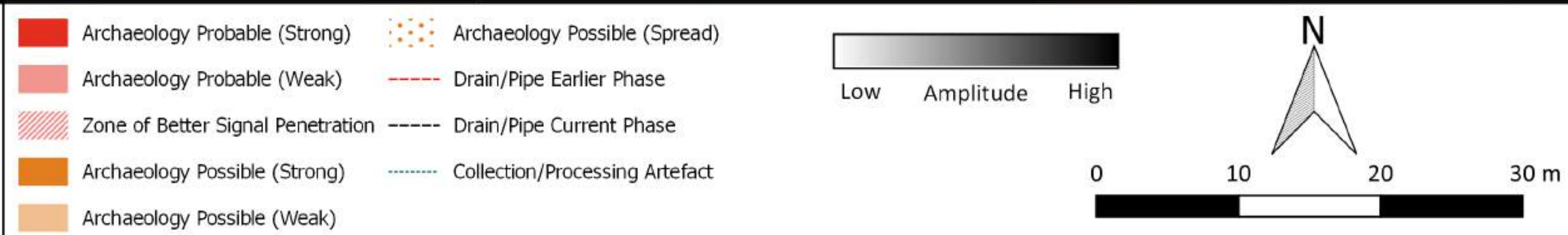
0 10 20 30 m

magnitude surveys





MSSP465 - Waterloo Carpark GPR
Figure 7 - GPR Middle Interpretation (Indicative Timeslice Depth: 120cm)
1:500 @ A3



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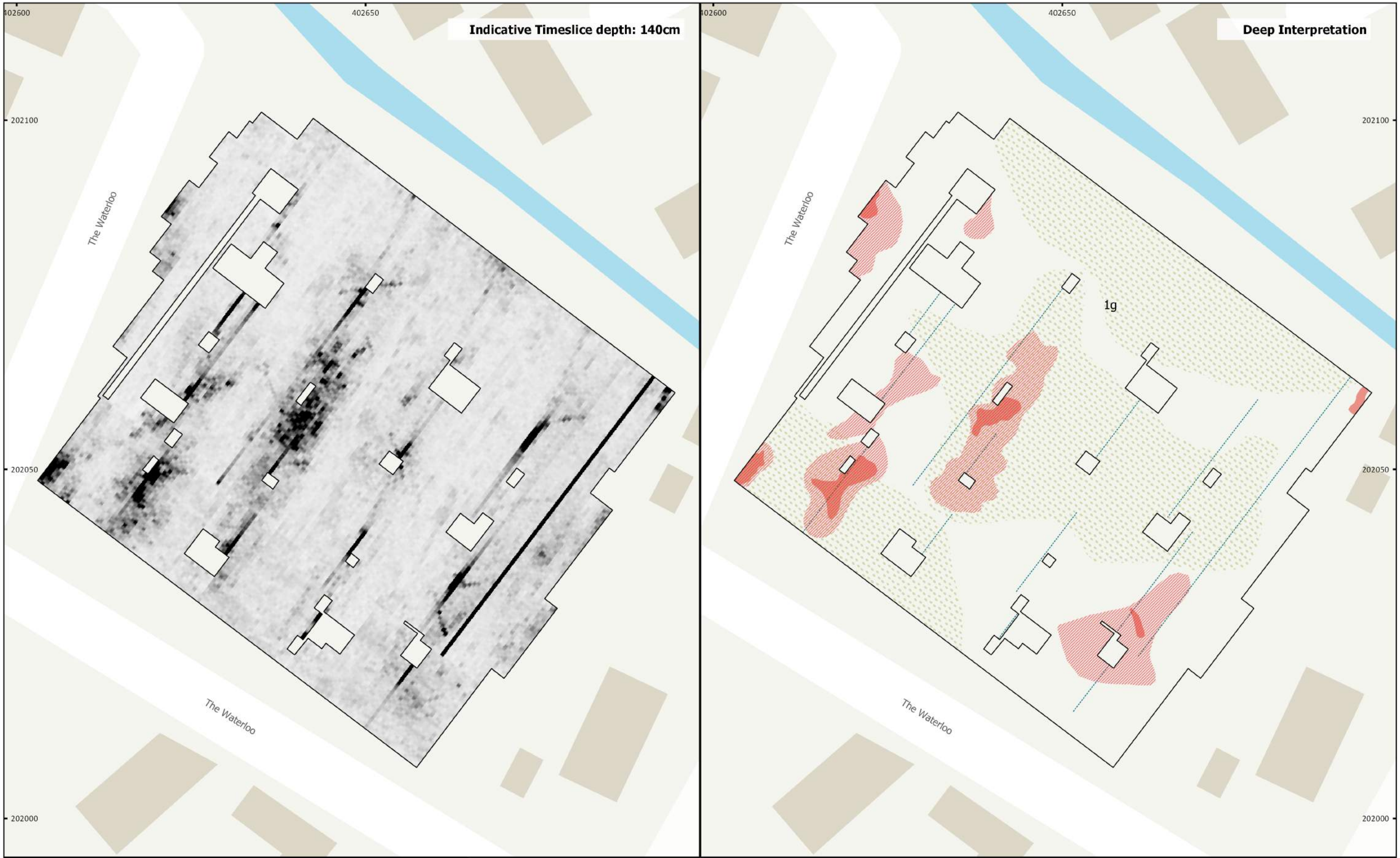


MSSP465 - Waterloo Carpark GPR
Figure 8 - GPR Deep Interpretation (Indicative Timeslice Depth: 140cm)
1:500 @ A3

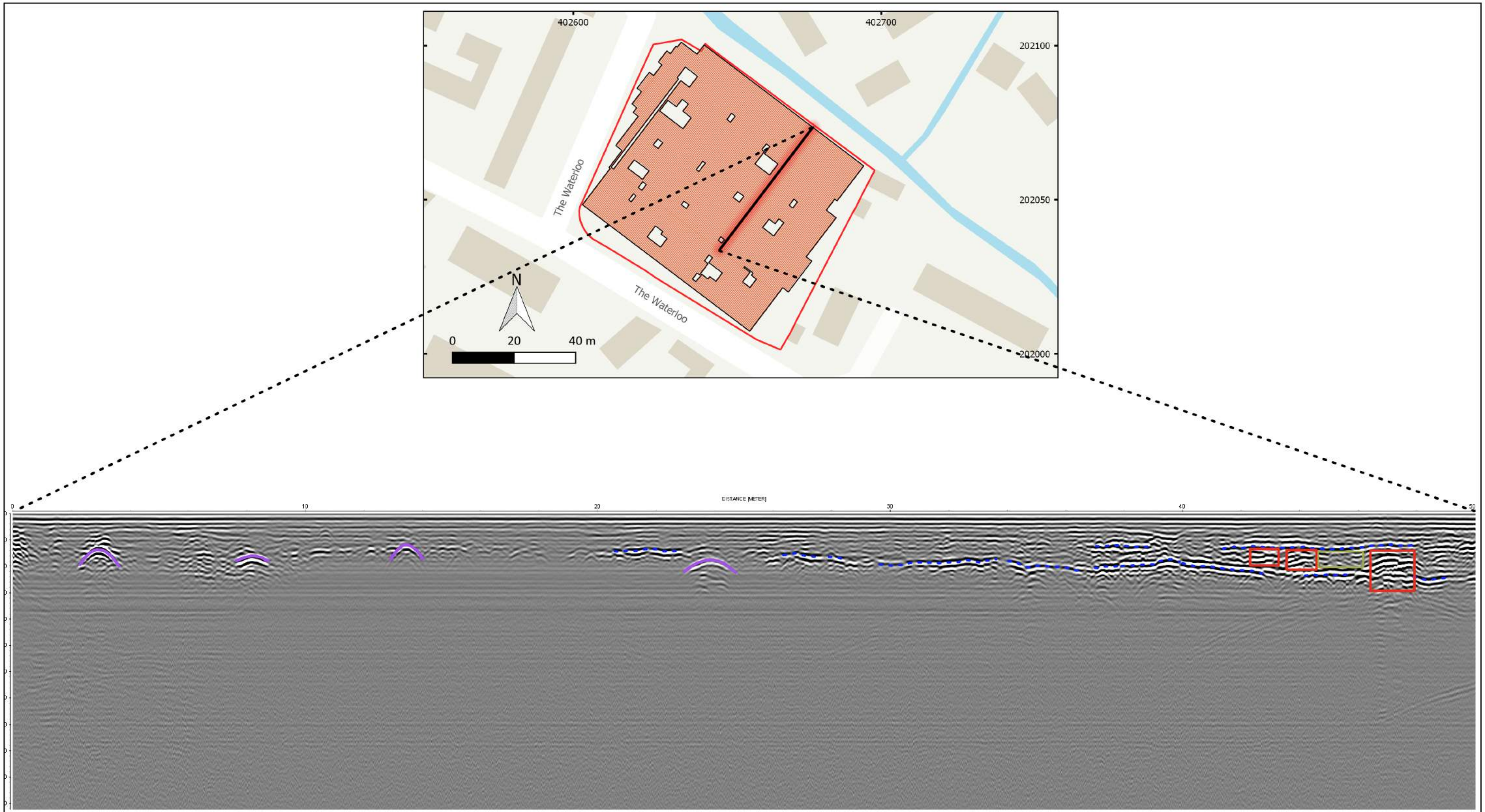
Archaeology Probable (Weak)
Zone of Better Signal Penetration
Alluvial Clay Variation
Collection/Processing Artefact

Low Amplitude High

N

0 10 20 30 m

magnitude surveys



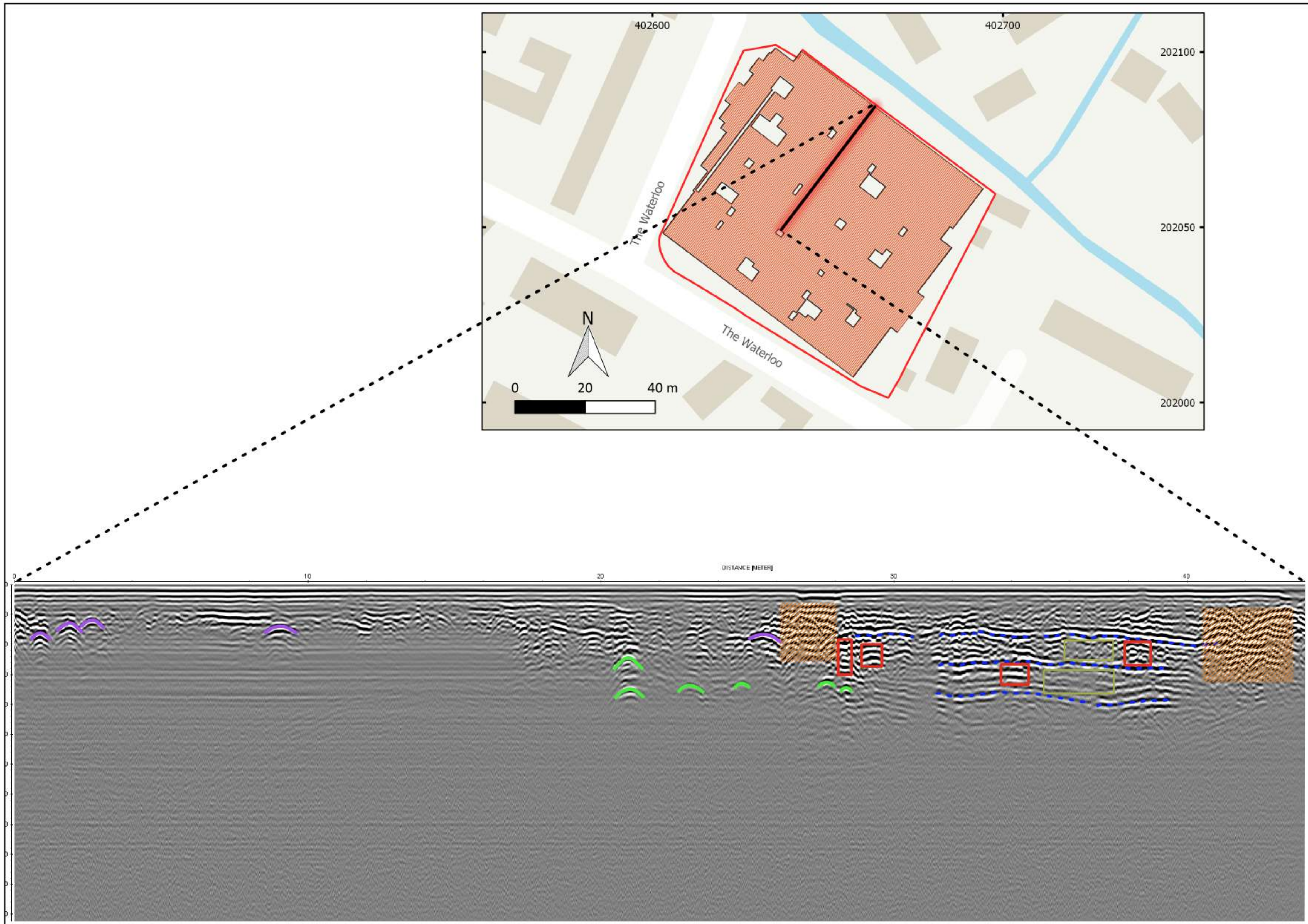
MSSP465 - Waterloo Carpark GPR
Radargram 3428 - Radargram with Interpretation

Contain mapping from British History Online 1981

Low Amplitude High

Structural Response
Possible 'Dark Earth'
Buried Surface
Drain/Pipe Current Phase

magnitude surveys



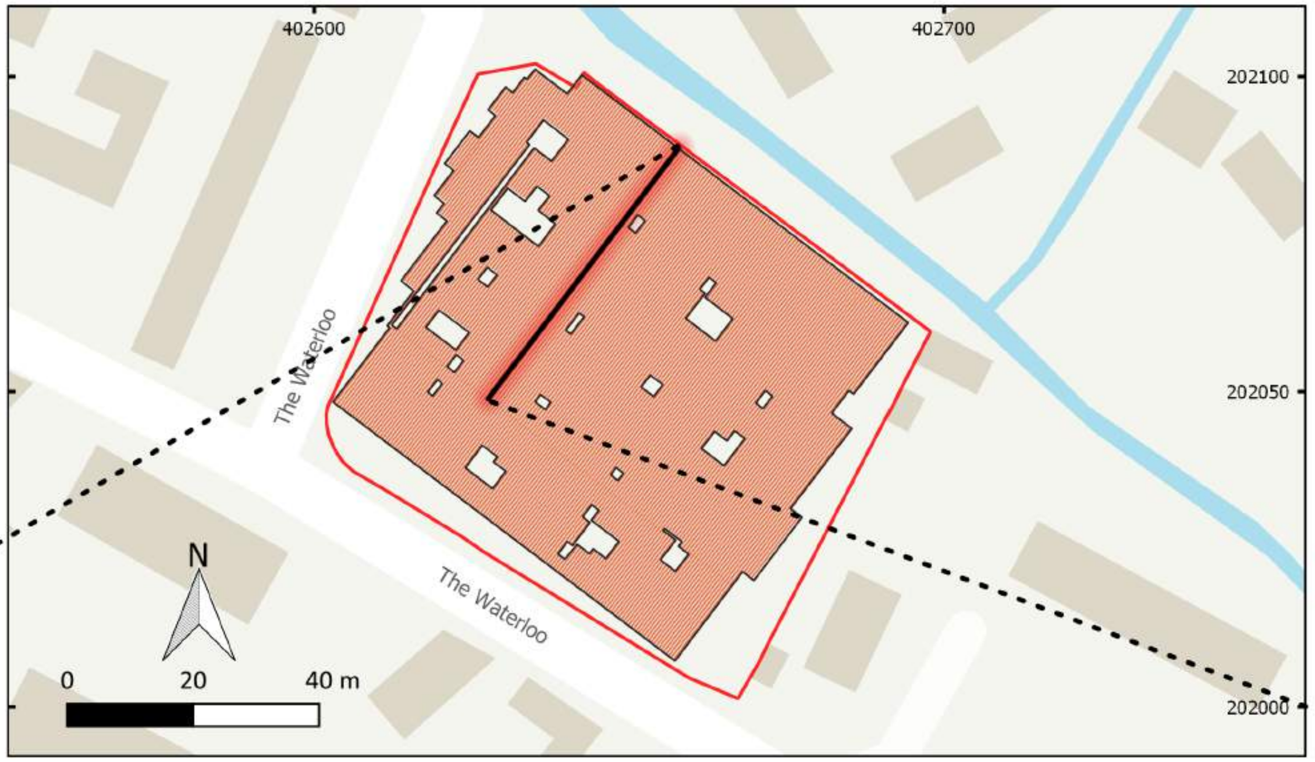
MSSP465 - Waterloo Carpark GPR
Radargram 3490 - Radargram with Interpretation

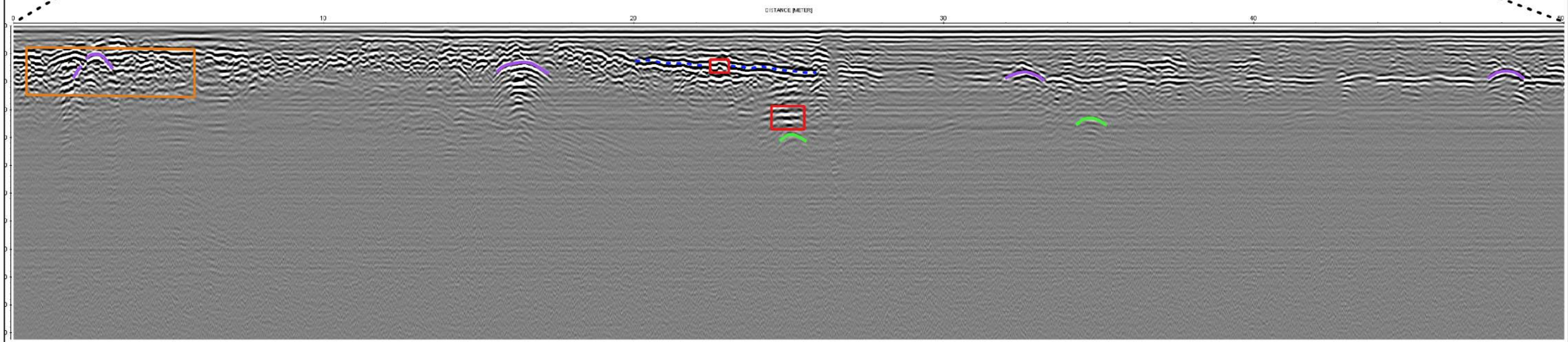
Contain mapping from British History Online 1981

Low Amplitude High

Structural Response
Possible 'Dark Earth'
Modern & Archaeology Zone (Possible)
Buried Surface
Drain/Pipe Earlier Phase
Drain/Pipe Current Phase

magnitude surveys





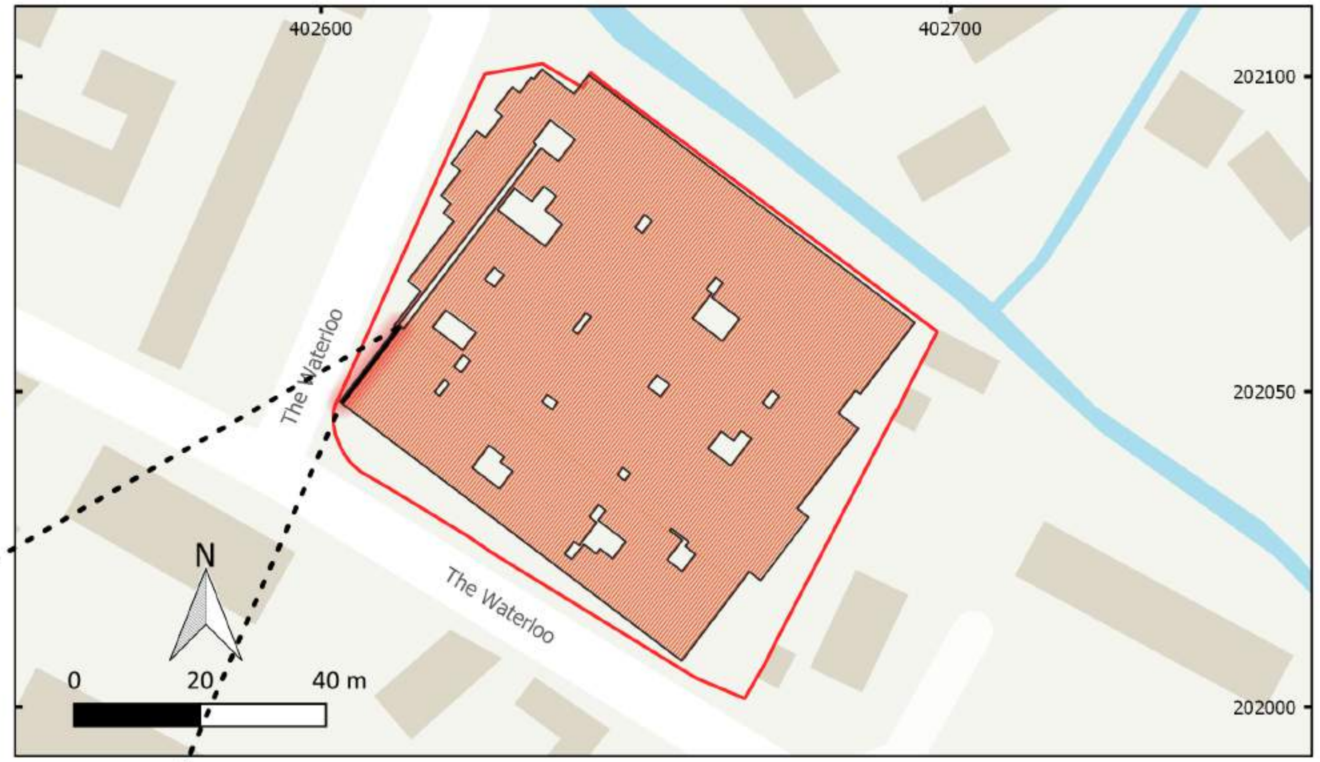
MSSP465 - Waterloo Carpark GPR
Radargram 3508 - Radargram with Interpretation

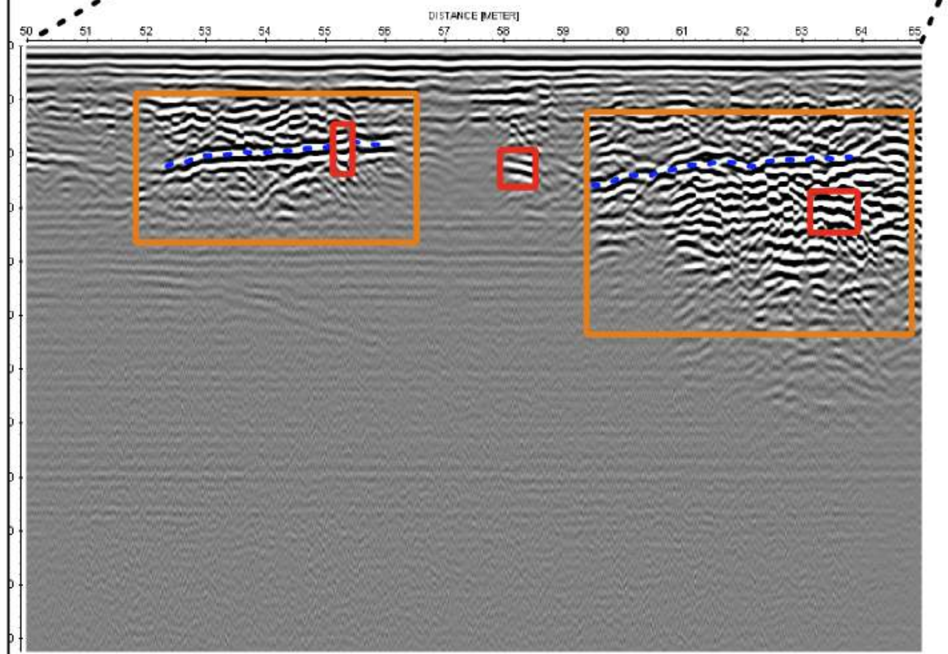
Contain mapping from British History Online 1981

Low Amplitude High

Structural Response
Rubble Zone
Buried Surface
Drain/Pipe Earlier Phase
Drain/Pipe Current Phase

magnitude surveys





MSSP465 - Waterloo Carpark GPR
Radargram 3782 - Radargram with Interpretation

Contain mapping from British History Online 1981

Low Amplitude High

Structural Response
Rubble Zone
Buried Surface

magnitude surveys