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**Geophysical Survey Report
of
York Museum Gardens
York, Yorkshire**

**For
York Museums Trust**

Magnitude Surveys Ref: MSSE249

March 2018



magnitude surveys

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Abstract

Magnitude Surveys was commissioned to investigate the archaeological potential of an area within York Museum Gardens. A ground-penetrating radar survey was successfully completed over c. 0.25ha to the front of the Yorkshire Museum buildings, and numerous anomalies of archaeological origin were detected across the survey area at depths of up to 2m (the maximum depth of investigation). The majority of these anomalies pertain to the remains of St Mary's Abbey, with extensive evidence for the remains of the western range of claustral buildings. Additional responses suggest the presence of a previously unknown structure in the southwest of the survey area, lying on a different orientation to that of the 13th/14th century abbey buildings.

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1. Introduction

- 1.1. Magnitude Surveys Ltd (MS) was commissioned by York Museums Trust to undertake a geophysical survey on c. 0.25ha area of land within the grounds of the Yorkshire Museum, York (SE 5992 5213).
- 1.2. The geophysical survey comprised hand-pushed, cart-mounted ground-penetrating radar (GPR) survey. MS' Ofcom Ground Probing Radar licence number is L1078291/1.
- 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 (CIfA, 2014) and the European Archaeological Council (Schmidt *et al.*, 2015).
- 1.4. The survey area falls within the Scheduled Monument of St Mary's Abbey. Geophysical survey was conducted in accordance with the Historic England Section 42 licence obtained in advance by the York Museums Trust.
- 1.5. The survey was conducted on 8th February 2018.

2. Quality Assurance

- 2.1. Project management, survey work, data processing and report production have been carried out by qualified and professional geophysicists to standards exceeding the current best practice (CIfA, 2014; David *et al.*, 2008, Schmidt *et al.*, 2015).
- 2.2. Magnitude Surveys is a corporate member of ISAP (International Society of Archaeological Prospection).
- 2.3. Director Graeme Attwood is a Member of the Chartered Institute for Archaeologists (CIfA), the chartered UK body for archaeologists, as well as the Secretary of GeoSIG, the CIfA Geophysics Special Interest Group. 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. Director Chrys Harris has a PhD in archaeological geophysics from the University of Bradford.
- 2.4. All MS managers have postgraduate qualifications in archaeological geophysics. All MS field staff have relevant archaeology or geophysics degrees and supervisors have at least three years' field experience.

3. Objectives

- 3.1. The geophysical survey aimed to investigate the subsurface archaeological potential of the survey area, in order to contribute to a greater understanding of the archaeology of York Museum Gardens and their immediate surroundings.

4. Geographic Background

- 4.1. The survey area is located within York Museum Gardens, in the centre of the city of York (Figure 1). The Gardens are situated on the northeastern bank of the River Ouse and comprise a landscaped area of lawns and planting, incorporating historic buildings such as York Observatory and the ruins of St Mary's Abbey. Survey was undertaken over part of the lawns to the front (southwest) of the Yorkshire Museum buildings (Figure 2). Data was collected over an irregularly-shaped area of ground corresponding broadly to the area within a loop of the path, but collection was constricted within this area by specific obstacles – namely, the terrace outside the main entrance of the museum, trees along the western and southern edges of the survey area and the standing remains of St Mary's Abbey to the north. The survey area slopes down towards the south.
- 4.2. The underlying geology comprises Sherwood Group sandstone, overlain by Alne Glaciolacustrine Formation clay and silt, with further superficial deposits of alluvium and Vale of York Formation clay/sand/silt recorded nearby (British Geological Survey, 2018).
- 4.3. Soils are currently recorded as unclassified (Soilscapes, 2018).
- 4.4. Survey considerations:

Survey Area	Ground Conditions	Further notes:
1	Maintained lawn	Slopes down to the south. Terrace/ museum buildings located to the NE, remains of St Mary's Abbey to the N, areas of trees to the W and S.

5. Archaeological Background

- 5.1. The site is part of York Area of Archaeological Importance. The Precinct of St Mary's Abbey, within which the survey area is located, is designated as a Scheduled Ancient Monument (1004919). The Museum Gardens are Registered as being of Special Historic Interest (1012) and contain a number of Listed Buildings. Excavations are known to have been conducted on the site during the 19th and mid-20th centuries by the Yorkshire Philosophical Society and G.F. Willmot respectively, the latter located adjacent to the northwest edge of the survey area.
- 5.2. This section briefly summarises the complex archaeological background of the site, based largely on information contained in the York Museums Trust Conservation Management Plan for St Mary's Abbey Precinct (YMT 2005).
- 5.3. Limited evidence for prehistoric occupation in York exists and no prehistoric activity is currently known from the site (YMT 2005: 10).
- 5.4. The site is located immediately outside the western walls of the Roman fortress that was established in York in c. AD 71, and within the walls of a fortress annex (YMT 2005: 11). It has been suggested that a section of Roman road crosses the site, running southeast from St Mary's gatehouse *i.e.* parallel with the river frontage of the fortress (see YMT 2005: fig 5). Mid 20th

century excavations beneath the area of the northwestern cloister/southeastern nave walls revealed a sequence of probable domestic structures in use during the first to fourth centuries. These excavations also uncovered robbed-out foundations of a rectangular Roman building immediately outside the southern corner of the nave, and a ditch (possibly located beneath the nave) containing quantities of third-century pottery (Gentil 1988: 20-27). The excavator made reference to a “great wall, 8 feet wide” running beneath the north range of the cloister on the direct line of the south-west fortress wall and post-dating second-century features, although no further details appear to exist (Gentil 1988: 24).

5.5. The excavations conducted in the mid-1950s reference pits containing finds of Anglian and Anglo-Scandinavian date, including coins, a strap-end and a pin, although details do not exist (Gentil 1988: 27). During the later Saxon period, the Marygate area became known as the *Earlsburh*, the residence of the Earls of Northumbria (YMT 2005: 13).

5.6. St Mary’s Abbey was founded by William the Conqueror in 1088, after the Benedictine abbey at St Olave’s outgrew its site to the immediate west of St Mary’s. The original Romanesque church, begun in 1089, was replaced by the surviving Gothic-style building completed in 1294, which stood amongst a developing complex of associated ecclesiastical and domestic buildings within the thirteenth-century precinct walls. Prior to its dissolution in 1539, St Mary’s became the richest abbey in northern England, with the physical remains on site reflecting this.

5.7. During the later 16th and 17th centuries, the site was associated with the administration of the Council of the North, with claustral buildings taking on roles as royal apartments. Although some precinct buildings are known to have sustained damage during the Civil War, many features survived and were subsequently incorporated into Telford’s commercial plant nursery, effectively becoming a visitor attraction (YMT 2005: 17-18).

5.8. The site passed to the Yorkshire Philosophical Society in the 1820s, with the Yorkshire Museum building opening in 1830 and botanical gardens laid out in the 1840s.

6. Methodology

6.1. Data Collection

6.1.1. Geophysical prospection comprised GPR as described in the following table.

6.1.2. Table of survey strategies:

Method	Instrument	Traverse Interval	Sample Interval
Ground Penetrating Radar	MALÅ Mini Mira (400 Mhz centre frequency)	0.08 m	0.05 m

6.1.3. GPR data were collected along lines, using the system’s odometer wheel to position sampling points. The lines were set out within a grid established using a Hemisphere S321 GNSS Smart Antenna RTK GPS which is accurate to 0.008 m + 1 ppm in the horizontal and 0.015 m + 1 ppm in the vertical.

6.2. Data Processing

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

DC Shift – The waveform response for each traverse was centred to correct for striping effects caused by small variations in sensor electronics and orientation.

Bandpass Filter – Frequencies outside the normal range of the measuring antennae were filtered out to remove errors from external sources.

Gain Adjust – A gain curve was manually calculated to account for signal attenuation with depth. The gain adjust allows features at depth with a weaker signal to be resolved at the same plotting scale as near surface features.

Hyperbola fitting – Manual fitting of hyperbola curves was conducted to calculate the velocity of the wave. This allows the calculation of response depth from response time.

6.3. Data Visualisation and Interpretation

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

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 has responded well to the survey conditions, demonstrating good signal penetration with depth. A range of responses are apparent in the data, many of which have been interpreted as being of archaeological origin.
- 7.2.2. Particularly evident in the deeper data, these archaeological responses include a complex of relatively strong rectilinear anomalies [1a-g] that are interpreted as reflecting multiple walls and/or structures. When compared with Wilson & Mee's plan of the 13th/14th-century abbey buildings (2009: fig. 124), the location and nature of many of these responses corresponds well with the projected features and structures of St Mary's Abbey, in particular those labelled as the "Cellarer's Store", "Herb Garden", "Common Hall/Refectory", "Kitchen" and "Prior's Hall", which form the western claustral range. See Paragraphs 7.3.2.1 – 7.3.2.7.
- 7.2.3. Further archaeological responses [1h] have been identified in the southwest of the survey area, *i.e.* beyond the extent of Wilson & Mee's plan, which suggest the presence of a previously unknown structure in this area, on a different orientation to the buildings of the abbey complex. Anomalies include a range of discrete responses consistent with the remains pillar bases or similar. The geophysical data alone cannot provide absolute dating evidence; the depth information provided by GPR can sometimes contribute to relative dating of detected archaeological features, but in this case the situation is complicated by landscaping, by sloping ground and by a lack of direct spatial relationship between these and any nearby anomalies, meaning that no relative date can be assigned.
- 7.2.4. Previous excavation indicates the presence of a complex sequence of pre-abbey archaeology on the site – at least in the area to the immediate south of the abbey church – with evidence for Roman timber and stone buildings orientated on the alignment of the Roman fortress. No evidence for such archaeology has been identified in the GPR data, and it is likely that any older remains are too deeply buried to be successfully detected using the parameters employed in this survey: the maximum depth of investigation for a given antenna frequency is determined by the electromagnetic properties of the soil, which determine the rapidity with which signals are attenuated and rendered undetectable. Indeed, the deepest timeslices from this site (which represent information from a depth of c.1.98m) contain responses that are interpreted as relating to the abbey buildings, suggesting that Roman features would be deeper still. This view is supported by a photograph of Willmot's 1950s excavations, which gives an indication of ongoing excavation work at similar depths (Gentil 1988: photograph 1).

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. **Abbey remains (Deep)** – In the deeper timeslices, a range of anomalies have been interpreted as relating to St Mary's Abbey on morphological grounds, given the closeness of their correlation with anticipated structures identified on Wilson & Mee's plan (see Figure 5). These responses are found in a swathe across the higher ground of the north, central and eastern portions of the survey area and are visible at depths of c.1.5-2m. They largely adhere to the alignment of the abbey church and modern museum buildings, and it is notable that in the main there is little overlap between the discrete features, as would be expected of contemporary structures.

7.3.2.2. The northernmost group of these anomalies (centred around [1a]) is located immediately south of the nave of St Mary's and corresponds in location and form with the building labelled as 'Cellarer's Store' on the plan. The geophysical responses indicate the probable presence of a rectangular building approximately 23 x 11m and aligned NW-SE. The southwestern wall of the building has been detected most clearly, while the northeastern wall is apparent from a broader spread of responses. A probable extension [1b], measuring c. 5 x 3.5m, appears to extend southwest from the western corner of the building, while a possible similar feature [1c] is visible as a less-well defined spread of responses extending west from the southern corner of the building.

7.3.2.3. Lying on the same alignment as the 'Cellarer's Store', a linear anomaly at [1d] appears to define the edge of the cloister area identified by Wilson & Mee, continuing a wall line recorded during Willmot's 1952 excavation (Gentil 1988: fig. A). This linear anomaly (c.0.5m wide) runs NW-SE and is separated from the 'Cellarer's Store' by a 4.5m wide corridor that demonstrates few clear geophysical responses, with the exception of two discrete subcircular anomalies (c.0.6m in diameter). One of these anomalies is located centrally within this 'quiet' band, the other 7.5m to the southeast of the first; their origins are not clear, although it is worth noting that they represent strong contrasts with the background soil. At its southeastern end (in line with the southeastern end of the 'Cellarer's Store'), the linear anomaly turns through 90 degrees to return northeast, running out of the survey area. Within this corner, a parallel linear response is discernible, offset from the outer linear by c.1m. The suggested use of this area as a cloister is supported by the paucity of strong geophysical responses within it *i.e.* to the north and east of [1d].

7.3.2.4. The responses from the central part of the survey area are generally less coherent, though still correspond with Wilson & Mee's map. Surrounding [1e], four individual subcircular anomalies, each measuring c.1m in diameter, are arranged in a

rectangle measuring c.3.6m (NW-SE) by c.4.4m (NE-SW). These are consistent with responses expected from column bases and their locations correspond well with such features on Wilson & Mee's plan, which indicates two rows of pillars dividing the 'Common Hall/Refectory' into three aisles of equal width. Linear responses and trends in the radar data indicate the probable position of the walls of this building, located in agreement with the plan and aligned NE-SW. Several penannular anomalies have been identified in this area that possibly represent partially demolished lumps of masonry or structural features such as enlarged buttresses or building corners.

- 7.3.2.5. An L-shaped anomaly, interpreted as reflecting a wall of the kitchen buildings, is located immediately north of [1f], and is particularly visible at 1.7m depth. Less pronounced trends in the data appear to represent other external walls forming a rectilinear building, with the possibility of further internal divisions (marked on the interpretation as trend lines).
- 7.3.2.6. West of [1f], several shorter (c.4.5m) linear anomalies of a similar nature to those identified as wall lines are interpreted as having possible archaeological origins, perhaps indicating extended or additional, though less substantial, building structures at this point.
- 7.3.2.7. Rectilinear anomalies surrounding [1g] suggest the presence of a further rectangular structure, also aligned broadly NW-SE though at a slight angle to other abbey buildings. The structure measures c.10.5 x 6m and may relate to the annex of the 'Prior's Hall' depicted on Wilson & Mee's plan.
- 7.3.2.8. **Archaeology (Medium Depth)** – At depths of 0.85 – 1.1m, a number of sub-circular anomalies are located in the downslope, southwestern corner of the survey area at [1h]. At least nine discrete responses, up to 0.7m in diameter, can be identified, arranged in two parallel lines on a sub E-W alignment. The lines of anomalies are c.5m apart, with each response spaced 2.9 – 3.5m apart along the lines. Faint linear trends (also incorporating discernible discrete subcircular anomalies) are apparent running parallel to these rows, located c.4.8m north of the northern row and south of the southern row. This is a similar, though more extensive, layout to that seen in the 'Common Hall' (Paragraph 7.3.2.4) and may also represent the remains of pillars of a former building structure. Although the distinct subcircular anomalies are distinguishable within the southern row, their locations also coincide with a relatively strong linear response on the same alignment, although this linear response continues into the deeper timeslices (c.1.55m), and the exact relationship between the two is unclear. In any case, the alignment of anomalies in this area is distinct from the alignment of the abbey remains previously discussed.
- 7.3.2.9. To the east of the group of anomalies at [1h], a band of responses of increased strength, demonstrating a slight NW-SE aligned discontinuity, is visible in the mid-depth data (not marked on the interpretation figures). While tempting to note that this corresponds with the postulated line of a Roman road (see Paragraph 5.4), it is also important to realise that this location represents both a 'seam' along which

two data blocks have been combined for processing, as well as a zone of increased slope on the ground – both of these factors can introduce artefacts into the data, and in this case it is considered unlikely that the responses are of archaeological origin.

7.3.2.10. **Unknown anthropogenic features (Shallow)** – In the northern corner of the survey grid, responses of probable archaeological origin have been identified [1i]. These comprise at least 12 small (c.0.25m diameter) sub-circular anomalies. The individual anomalies are arranged orthogonally, with rows positioned 1.5m apart and aligned NE-SW and NW-SE *i.e.* on the same alignment as the abbey church. The responses exhibit a strong contrast with the surrounding background, but their origins are not apparent, although they are consistent with those to be expected from features such as small pillar bases or post pads. While Willmot's excavations revealed Roman buildings and associated postholes in this area, at depths of only c.0.35 – 0.4m, the anomalies in question are shallower than those related to the remains of the abbey buildings.

7.3.2.11. **Services** – Several linear anomalies within the shallow and mid-depth data are interpreted as representing services. These include two parallel anomalies lying on a NNE-SSW alignment in the southeastern corner of the survey area and a similar anomaly running approximately W-E across the centre of the survey area. At a depth of around 0.65m, a well-defined linear response is visible running NW-SE, parallel to the terrace in front of the museum building, with a smoothly rounded corner at its northern end framing the end of the terrace; its origin is unknown.

7.4 Conclusions

- 7.4. A ground penetrating radar survey has been successfully carried out within the Yorkshire Museum Gardens. The method has been generally effective across the survey area, demonstrating good signal penetration with depth and producing well-defined geophysical anomalies that support and complement existing archaeological knowledge of this complex site.
- 7.5. The results display a high level of agreement with existing plans of the western claustral buildings, such as that provided by Wilson & Mee (2009: fig. 124), and confirm the subsurface location of a range of probable masonry structures and features. In particular, the presence of structures identified by Wilson & Mee as the 'Cellarer's Store', 'Herb Garden', 'Common Hall/Refectory', 'Kitchen' and 'Prior's Hall' has been confirmed.
- 7.6. In addition, the survey has highlighted the possibility of the existence of further, previously unknown, structural remains, namely those located in the southwest of the survey area.
- 7.7. However, given the great depth of archaeological remains on this site (as apparent from both the geophysical data and known archaeological evidence), it is probable that pre-abbey occupation layers continue beyond the effective depth of investigation of the ground-penetrating radar employed in this survey.

8. Archiving

- 8.1. MS maintains an in-house digital archive, which is based on Schmidt and Ernenwein (2013). This stores the collected measurements, minimally processed data, georeferenced and un-georeferenced images, XY traces and a copy of the final report.
- 8.2. MS contributes all reports to the ADS Grey Literature Library subject to any time embargo dictated by the client.
- 8.3. Whenever possible, MS has a policy of making data available to view in easy to use forms on its website. This can benefit the client by making all of their reports available in a single repository, while also being a useful resource for research. Should a client wish to impose a time embargo on the availability of data, this can be achieved in discussion with MS.

9. Copyright

- 9.1. 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.

10. References

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MSSE249 - York Museum Gardens

Figure 1 - Site Location

1:25,000 @ A4

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OS (100056946)

 Site Boundary



0 0.5 1 km

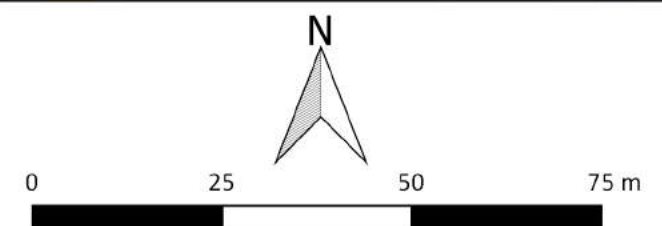



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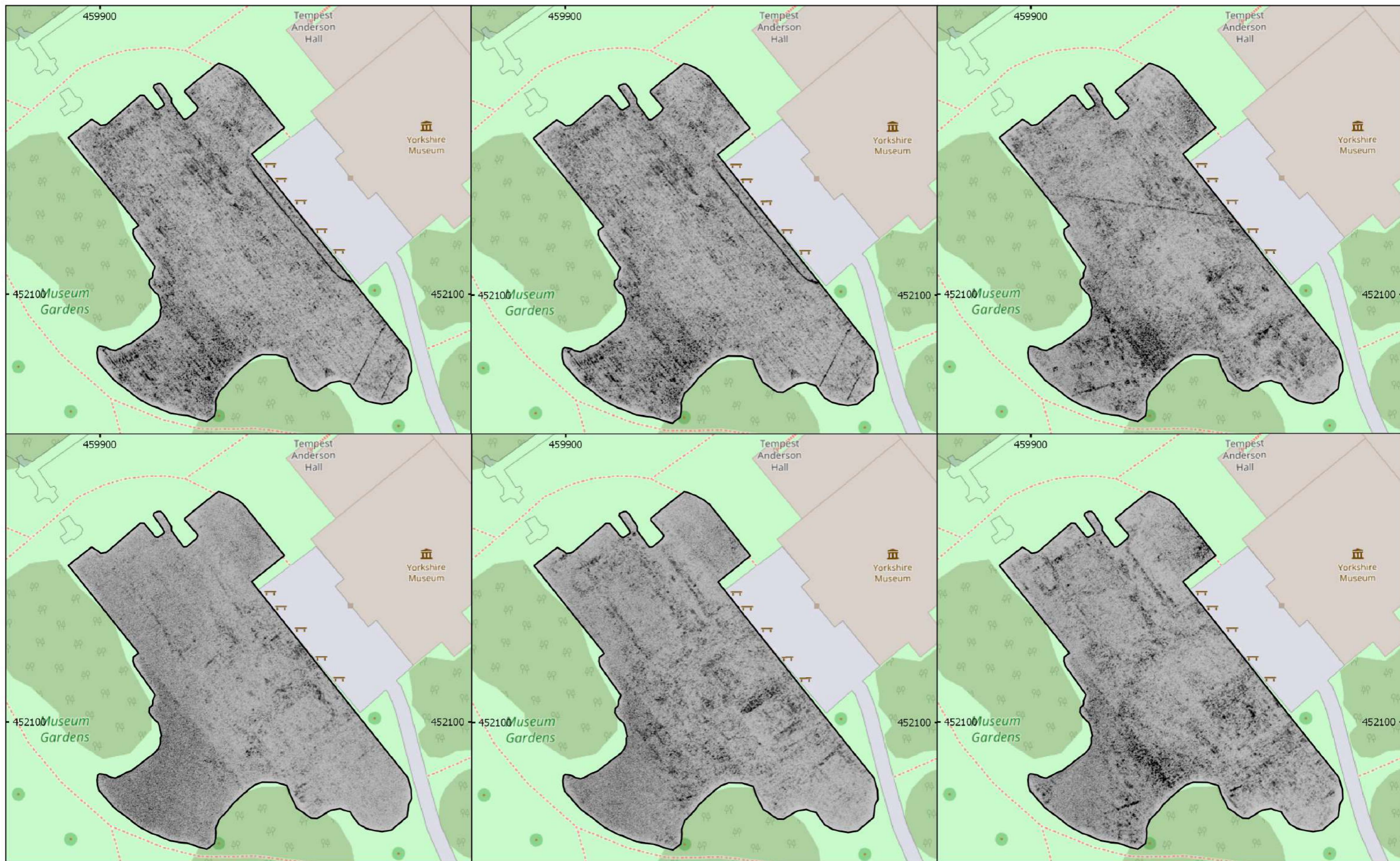


MSSE249 - York Museum Gardens
 Figure 2 - Location of Survey Area
 1:1000 @ A3
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 Background mapping © Thunderforest, Data © OpenStreetMap contributors

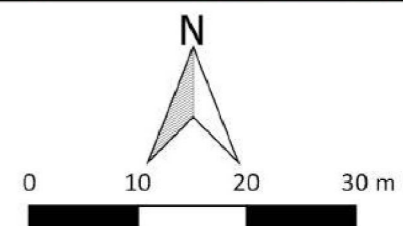
 Survey Extent

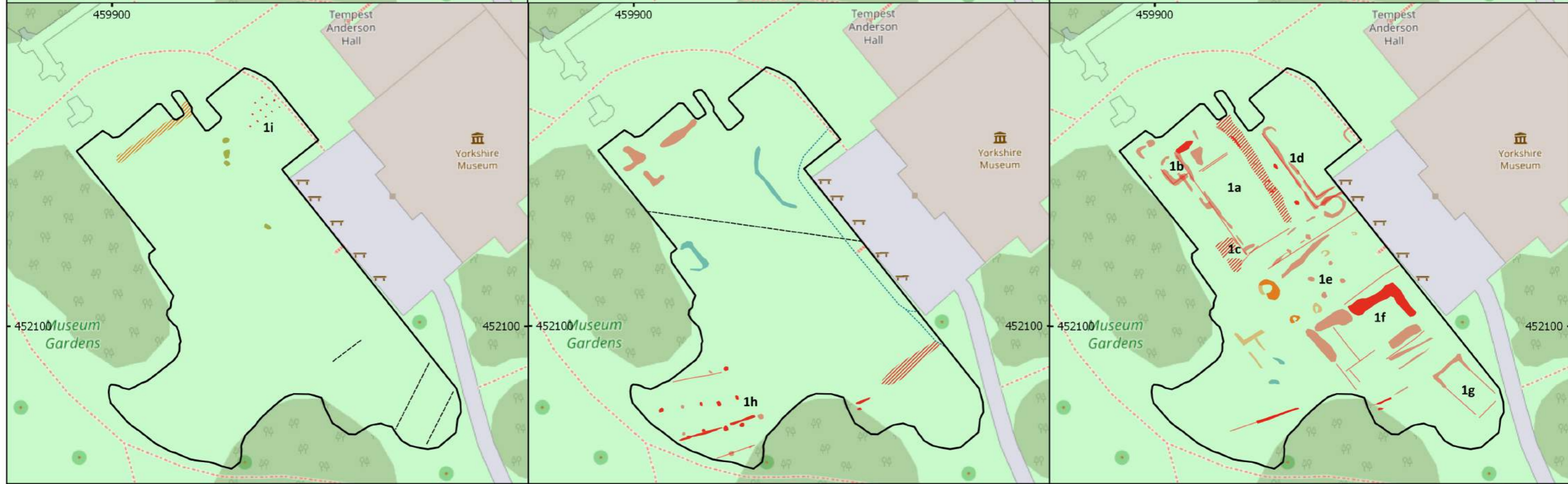
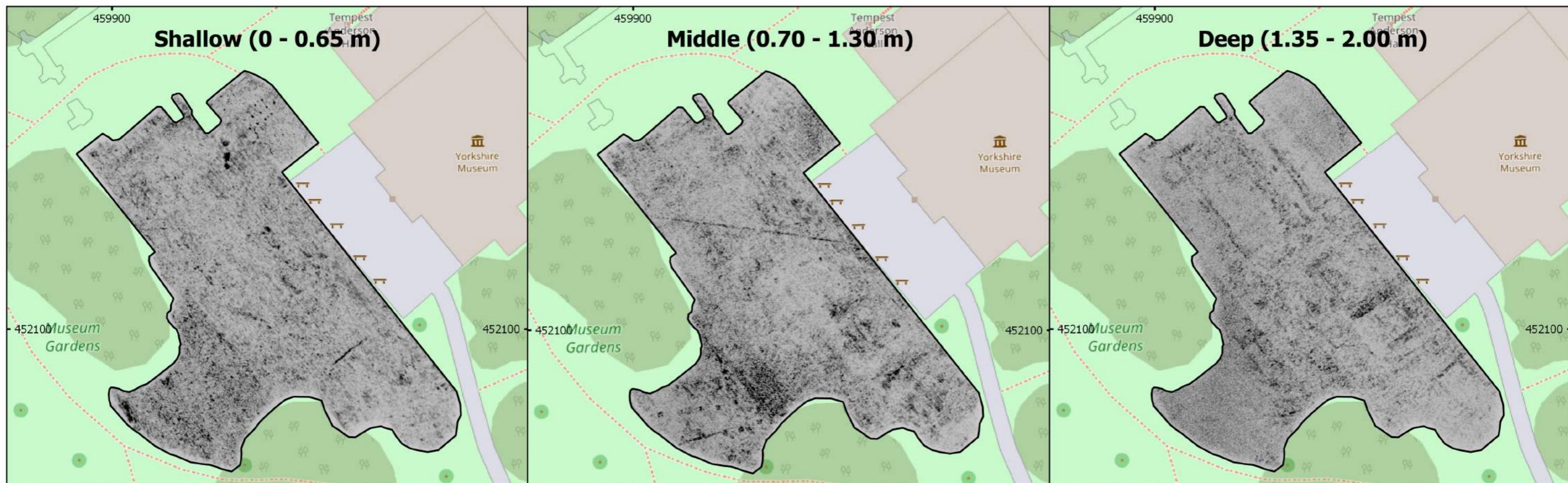


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 Figure 3 - Indicative GPR Timeslices (top-left, moving clockwise): Shallow-Deep
 1:700 @ A3
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 Background mapping © Thunderforest, Data © OpenStreetMap contributors





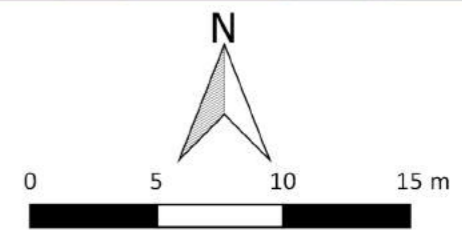
MSSE249 - York Museum Gardens
 Figure 4 - Averaged Timeslices with Interpretation
 1:700 @ A3
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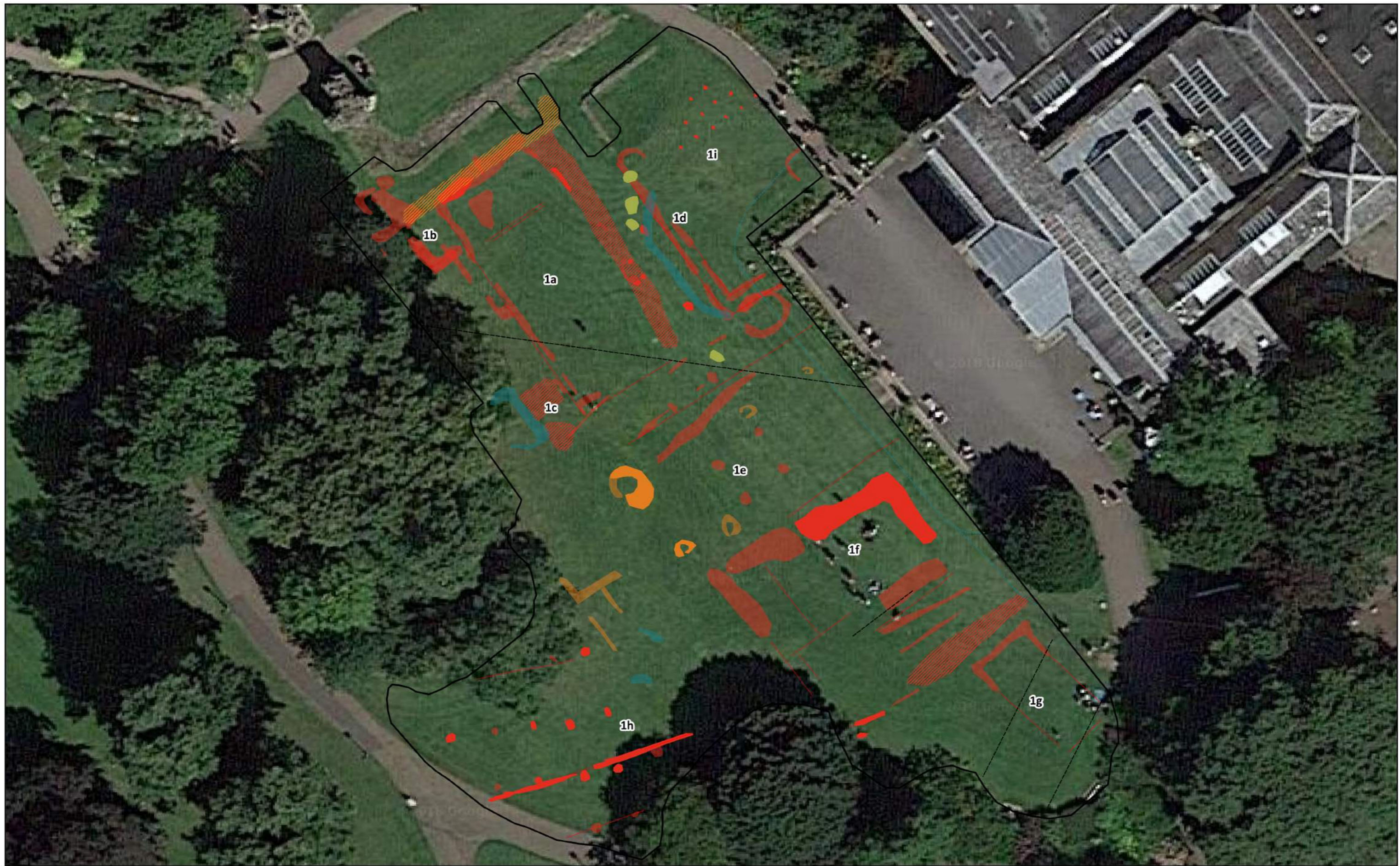
Archaeology Probable (Strong)	Archaeology Possible (Weak)	Archaeology Probable (Trend)
Archaeology Probable (Weak)	Archaeology Possible (Spread)	Undetermined
Archaeology Probable (Spread)	Natural (Strong)	Service
Archaeology Possible (Strong)	Undetermined (Weak)	Low Amplitude High



MSSE249 - York Museum Gardens
 Figure 5 - Combined Interpretations Over Wilson & Mee's Abbey Plan
 1:300 @ A3
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 Plan of abbey from Wilson & Mee 2009, fig. 124.

- | | | |
|-------------------------------|-------------------------------|------------------------------|
| Survey Area | Archaeology Possible (Strong) | Undetermined (Weak) |
| Archaeology Probable (Strong) | Archaeology Possible (Weak) | Archaeology Probable (Trend) |
| Archaeology Probable (Weak) | Archaeology Possible (Spread) | Undetermined |
| Archaeology Probable (Spread) | Natural (Strong) | Service |





MSSE249 - York Museum Gardens
 Figure 6 - Combined Interpretations OverSatellite Imagery
 1:300 @ A3
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 Contains satellite imagery: © 2018 Google

