GSB Survey No. 2009/09

Glastonbury Abbey

NGR	350100 E, 138800 N
Location	Centre of Glastonbury
County	Somerset
District	Mendip
Parish	Glastonbury
Topography	Generally flat with some landscaping & earthworks
Current land-use	Historic site and park
Soils	Soils of the South Petherton Association: deep, well drained silty soils (*Soils of England and Wales. Sheet 5, South West England*. Soil Survey of England and Wales. 1983).
Geology	Jurassic Lower Lias - weak clay or mudstone with occasional bands of limestone
Archaeology	Abbey (multi-phase); abandoned post-Dissolution; extensively excavated in early C20th, records incomplete. SAM No 33050; PRN 23614.
Survey Methods	Magnetic (Gradiometer), Resistance, Ground Penetrating Radar

Aims

To identify and accurately locate features relating to the Abbey and any other anomalies of possible archaeological interest; to identify any responses that might represent excavation trenches, thereby assisting in their accurate mapping. The work forms part of a wider research project being carried out by **Reading University** in partnership with the **Trustees of Glastonbury Abbey** and funded by the **Arts and Humanities Research Council**. The aim of this project is to collate and digitally update all the material arising from the excavations of 1908 to 1979, analysing this archive and furthering the understanding of the physical history of the site.

Summary of Results

The magnetic data are dominated by widespread ferrous anomalies, of modern origin. which will have masked any underlying weaker responses and hindered interpretation of the results. Nonetheless, a few anomalies of interest have been highlighted, some - including the possible ditch of the *vallum monasterii* - relating to the Abbey complex, others representing early OS map features or of uncertain archaeological provenance.

Numerous possible wall foundations and / or stone drains have been identified by the both the resistance and GPR surveys, with the latter providing, for the most part, the greater level of detail. The majority of the responses are likely to relate to the various phases of Abbey occupation, though, as with the magnetic data, early modern features and anomalies of uncertain archaeological origin are also represented. Most of the archaeological responses in the GPR occur in the timeslices between 0m and 1.5m (approximate depth); some responses are visible at 1.5-2.0m and very few are noted below 2.0m.

Project Information

Project Co-ordinator: C Stephens & J Adcock
Project Assistants: J Anderson, J Gater, K Hoggard, A Phillips, J Tanner, G Taylor & E Wood
Date of Fieldwork: First survey phase: 31st March-3rd April 2009;
Last survey phase: 2nd - 6th November 2009
Date of Report: January 2010, Updated for publication May 2012

Survey Specifications

Method

The main survey grid was orientated diagonally to the surviving Abbey remains to enable maximum feature resolution, independent of sample interval. Due to the increase in surface obstructions, GPR survey in and around the Abbey church was carried out on a different grid, aligned parallel to the extant remains, enabling the GPR rig to be positioned (and hence data collected) more closely to these remains.

Both grids were established using a combination of GPS (Trimble R8 Real Time Kinematic system) and tapes and tied in to surface features depicted on the client's survey plan, which is not geo-referenced to the OS Grid. The GPS tie in points, together with additional data provided by the client has been used to subsequently reposition the original survey plan to the OS National Grid.

Technique (Appendix 1)	**Traverse Separation**	**Reading Interval**	**Instrument**
Magnetometer - Detailed	1.0m	0.25m	Bartington Grad 601-2
Resistance - Twin Probe	1.0m	1.0m	Geoscan RM15
Ground Penetrating Radar (GPR) - 250MHz	0.5m	0.05m	Noggin SmartCart^{plus}

Data Processing

Magnetic	**Resistance**	**GPR**
Zero Mean Traverse [1]	Edge Match [1]	User-defined Gain + Dewow/DC Shift [3]
De-stagger [1]	Despike [1]	Migration [4]
Interpolate [2]	Interpolate [2]	Background Removal Filter [5]
	High Pass Filter [2]	Interpolate [2]

Presentation of Results

Report Figures [6] (Printed & Archive CD):	Location diagram - 1:2000, on the OS Grid For each technique: data plots followed by interpretation diagrams superimposed on the base map.(N.B. to fit on an A3 page at the maximum possible scale - 1:1250 - these diagrams have been "rotated" to align with the survey grid, see north arrow on diagrams).
Reference Figures [6] (Archive CD):	For each technique: additional data plots used for analysis, no background map information. Magnetic and Resistance data plotted at maximum scale to fit on an A1 sheet: Magnetic at 1:625; Resistance at 1:500. Individual GPR data-sets plotted at 1:500.
Plot Formats:	See Appendix 1: Technical Information, at end of report.

[1] - "Basic" processing - error correction - applied where necessary.
[2] - To aid interpretation and enhance visual presentation of the results.
[3] - "Basic" first stage GPR processing to amplify and normalise signals.
[4] - Standard geometric correction of GPR hyperbolae.
[5] - For feature enhancement and reduction of near-field effect - applied where indicated.
[6] - A complete list of figures can be found at the end of the report text.

General Observations

Survey Conditions

In general, the conditions for survey were good, the ground cover being closely mown grass. The density of tree cover in the orchard precluded meaningful data collection and was therefore omitted from the survey. Similarly an area of trees, walls and flower beds at the eastern end of the site was deemed unsuitable.

Blank areas in the data sets represent the places where surface obstructions (extant abbey remains, a pond, picnic area and trees) precluded data collection. In the immediate vicinity of these obstructions, it was often more difficult to maintain an even pace with the gradiometer, giving rise to an increased number of stepping errors in the magnetic data; these have been corrected for using a de-stagger process. For the most part, however, their impact on data analysis has been minimal.

Survey was carried out in several stages over the spring, summer and autumn. Seasonal changes in general soil moisture content, at times, made it difficult to "match" background resistance values between survey sessions, resulting in edges in the combined data-set. This effect has been corrected for using an Edge Matching process and has not significantly hindered interpretation of the results.

The seasonal changes have also affected the GPR survey. Spells of very wet weather caused a distinct response differential between adjacent survey areas and, in some cases, even within the same survey block. In addition to the weather effects, long grass beneath some of the trees and at the western perimeter of the site has also caused a lack of signal; this is a result of poor coupling between the antenna and the ground surface. Whilst the effects of both these issues can be minimised through filtering, this can remove some information from the section. As such, both the unfiltered and filtered data sets have been included.

Notes on Data Analysis and Presentation

By far the greatest complication to interpretation and presentation of the results is the sheer amount of human activity at the site. The various phases of building, removal, re-building, post-Dissolution damage, post-medieval and modern landscaping and C20th excavations have given rise to a complex stratigraphy and a considerable amount of unstratified debris, all of which will have left some trace in the geophysical record. The key to the analysis is identifying patterns in the data sets that might suggest discrete *in situ* features. To assist in this process, two interpretations are presented for the gradiometer and resistance data sets. The first - a *Geophysical* interpretation - presents all definable anomalous changes, categorised simply by their geophysical properties, with sub-categories relating to their relative coherence (strength, definition, shape). In the second - *Archaeological* - Interpretation, only those anomalies which display potentially significant patterning are presented, categorised by their most probable origin.

Given the history of the site, most of the archaeological-type responses in the core area of the precinct probably relate to features associated with one of the many phases of abbey buildings and are classified as such (*Possible Abbey Features*), even if their definition is poor. However some anomalies within the core area are classified simply as *Possible Archaeology*; this reflects a reduced level of confidence in the interpretation, either due to the very indistinct or non-linear nature of the responses or a position or alignment that cannot be obviously linked to known abbey structures. All archaeological-type anomalies at the peripheries of the site are similarly classified.

Any depths referred to in the interpretation of GPR data *are only ever an approximation*. The conversion from delay time to depth depends upon the propagation velocity of radar waves through the ground; this can vary significantly both laterally and vertically on sites such as this, especially given the changeable weather conditions throughout the fieldwork visits. Average velocities of between 0.060m/ns and 0.074m/ns have been used after an iterative process of fitting hyperbolic curves to point-source reflections.

Where there is a strong electromagnetic contrast, the GPR signal can be inter-reflected or reverberated, producing a delay in the reflection of the signal. This is termed ‘ringing’ and happens to some extent

with all reflections, resulting in a greater apparent depth extent than actually exists. This effect is apparent in some of the deeper time-slices (where genuine reflections are weakest) in which 'echoes' of relatively shallow anomalies have been recorded at strengths comparative to some of the *bona fide* responses. As a result, it is often not possible to detect the base of features; only the tops of buried deposits are detected with any kind of certainty (Annan 1996).

Some sporadic interference, of unknown origin, was recorded in the radargrams and has subsequently affected the time-slices. The effects of this are near impossible to remove entirely but fortunately it has only affected the data at the bottom end of the section; the worst effects are to be seen beyond 1.80m. It is apparent, in the areas free of this noise, that there are scant few significant anomalies recorded at such depths anywhere on site and it has therefore been assumed that this issue has not had an adverse affect on the overall interpretation.

Various desk based sources, provided by the client and summarised below, have been used in the analysis and interpretation. To assist in this, where possible, available maps (scanned images and digital data) were superimposed over the survey area. It must be stressed that this "best fit" positioning is only approximate and is not intended to replace any more accurate mapping currently being undertaken as part of the wider project. As such, these plans are not included with the report archive but can be provided separately if deemed useful.

Parchmark Survey: CAD file digitised by client; positioned on map	Original source: Hollinrake, C & N: *Glastonbury Abbey Parchmark Survey 1989* (?Unpublished)
Trench Survey: CAD file digitised by GSB based on images provided by client: positioned on map.	Original source: Hollinrake, C & N: *Glastonbury Abbey Parchmark Survey 1989* (?Unpublished) N.B. trench survey is based on published interim reports as the excavation archive was unavailable in 1989 and therefore is not accurate.
Plans of early features: scanned photocopies, positioned on map.	Original source: Rahtz, P & Watts, L 2003. *Glastonbury Myth and Legend*, Stroud: Tempus Publishing. (figs 42-44).
Extent of excavations 1904-79: scanned photocopy; positioned on map.	Original source: Rahtz, P & Watts, L 2003. *Glastonbury Myth and Legend*, Stroud: Tempus Publishing. (fig 41).
Trench plan of vallum ditch: photocopy and updated digital image; visual comparison only.	Original source: Radford, C A R 1981, "Glastonbury Abbey before 1184: interim report on the excavations, 1908-64, in Coldstream, N and Draper, P eds. 1981, *Medieval Art and Architecture at Wells and Glastonbury*, Leeds: British Archaeological Association. pp110-34. (Updated digital image provided on the client's internet database).
OS maps (1:2500) - 1886, 1904, 1930, 1969, 1983-1991: digital images. visual comparison only.	Original source: Astin, T: *Outline of a pilot geophysics project for Glastonbury Abbey (September 2007)* PowerPoint Presentation.
Aerial photographs	Digital images provided from the Glastonbury Abbey Museum Archive.

During the continuation of the wider project, additional information on trench locations and excavated features has been provided by the client. Where appropriate, this has been used to update the interpretations and forms the basis of the geophysics sections in the published work, to which this full report is appended.

Results of Survey

1. Magnetic (Gradiometer) Survey (Figures 5 to 7)

*Labels **Mn** in the text below refer to specific magnetic anomalies highlighted on the interpretation diagrams. References (H-xx) relate to parchmarks and trenches mapped and described in Hollinrake, 1989, and follow the labelling system used in that report. The mapping of the trenches is not accurate (see general notes above); therefore in the text below any references to these trenches is tentative.*

1.1 Modern (C19th and C20th) activity at the site has had a significant impact on the magnetic data, resulting in widespread ferrous disturbance across much of the survey area. The resultant strong anomalies have a variety of surface and buried sources, including: iron/steel and brick of adjacent buildings; buried steel pipes; material such as cinders used in the construction of former paths (the existing paths are not ferrous in construction); iron signposts, railings and other park furniture and, most crucially, the use of iron pins or similar in marking the layout of former abbey features. The presence of so much ferrous material at the site has severely hindered data analysis and interpretation for two reasons. Firstly, the magnetic effect produced by ferrous objects is considerably wider than their actual dimensions. Secondly, within the affected areas the responses are of such a magnitude that they will mask any weaker anomalies which could arise from surviving archaeological features. These problems are clearly illustrated in the data plots. In Figure 2, the data are plotted at levels which would normally be used to highlight anomalies of archaeological interest; the strong blacks and whites of the ferrous responses visually dominate, and, within the main Abbey complex, it is nigh on impossible to locate and define weaker responses. Widening the plotting levels (Figures 3 to 5) reduces the broader effect of ferrous "shadows", but at the same time the weaker, potentially archaeological responses become less distinguishable from general background fluctuations.

1.2 The categories used in the geophysical interpretation (Figure 6), are positive, negative, and ferrous (dipolar); in this diagram, a compromise has been made between representing the levels of ferrous disturbance and highlighting weaker adjacent responses. The archaeological interpretation (Figure 7) presents only those anomalies that have been assigned a specific possible origin, however cautious, as discussed in the text below Because definition of some of the responses is tenuous, in this diagram, individual anomalies are not always indicated, but rather general trends or groups are shown.

1.3 Positive linear anomalies and trends **M1** correspond reasonably well with parchmarks (H-A1, described as walls) and also with features on the 1886 OS map, depicted as paths, and are likely to represent these features. The magnetic anomalies are relatively strong and could indicate remains of brick walls or drains, but could equally reflect a magnetically enhanced ditch fill. There is some correlation with the resistance data (see paragraph 2.4 below), but the match is insufficient to enable a more precise interpretation. Based on their alignment, some anomalies and faint trends in and around **M1** may represent other associated features and as such be archaeologically significant, although this interpretation is cautious.

1.4 The linear alignment of strong positive and ferrous anomalies **M2** corresponds with an 1886 OS map feature, also detected by the resistance survey (paragraph 2.5 presumed to be a wall). The presence of ferrous elements would suggest the feature is relatively recent. Vaguely linear alignments of small scale positive anomalies extend northwards from **M2** and may also represent remnants of paths and walls depicted on the above map, though the correlation is far from certain. Parchmarks (H-A5) in this area suggest buildings; although some of the magnetic anomalies display hints of rectilinearity, they cannot be definitively linked to these features.

1.5 A short linear ferrous response **M3** roughly corresponds with a resistance anomaly (see paragraph 2.6 below) a parchmark (H-B3) and an 1886 OS boundary (?a wall); if it does not represent the feature itself, it may reflect a pipe or similar laid under or adjacent to the feature.

1.6 Anomalies **M4** may represent a short section of parchmark feature H-B4, described as a wall and therefore be of archaeological interest. Based on their alignment responses **?M4** could represent continuations of the same feature; possibly a drain. This interpretation is purely conjecture, however; the anomalies could represent entirely unrelated features. Although on the same alignment as the main Abbey features, any relationship with the abbey complex cannot be determined.

1.7 Within the main Abbey Church many of the ferrous anomalies relate to ground markings of the proposed abbey layout and these are depicted on the archaeological interpretation. One other ferrous anomaly is worthy of note. A distinct rectangular area of ferrous **M5** corresponds roughly with an excavation trench and walls identified therein, described in Hollinrake simply as "…Bond 1919… Loretto chapel cleared" (H-9a). It is unclear whether the ferrous reflects material used in the shoring of the trench or part of the building structure; however the clear rectangular shape denotes some relatively intact feature. Unfortunately, the resistance data are of little help at this point (see paragraph 2.12 below).

1.8 Within the Nave, anomalies **M6** have a position and orientation that indicates features related to the Abbey Church. As weak positives it is doubtful that they represent wall remains, since the Blue Lias and Doulting Limestones used in construction are not inherently magnetic. This "negative" interpretation is supported by the fact that the anomalies lie *adjacent* to very clear wall lines detected by the resistance survey (see paragraph 2.7 below). It is possible that they represent drainage features, robber trenches or, perhaps most likely, an accumulation of magnetic soils (?packing material) in the original foundation trenches.

1.9 A short indistinct positive linear **M7** is difficult to interpret. Having no parallels in the parchmark evidence or resistance data, it completely encompasses an excavation trench (H-21b) in which the *vallum monasterii* was identified. This feature, comprising a substantial bank (6m wide at the base) and ditch (V-shaped, *c.*4.25m wide at the surface and at least 2m deep), runs on a north-south alignment, across the North and South Transepts and Chapter House of the post-Conquest church. Viewed in isolation, the limited extent of **M7** might suggest it relates to the excavations rather than the ancient feature. However, further to the south, a more extensive ditch type anomaly and truncated linear (both labelled **?M7**) are on the same alignment and together these might represent the vallum ditch. The poor anomaly definition and incomplete pattern makes this interpretation cautious; certainly, without the expectation of a feature at this point, it is doubtful whether a link between these three anomalies would be postulated.

1.10 A broad and ill-defined response **M8** might represent the robbed out foundation trench of a wall identified in excavations (H-23c) at the southern end of the anomaly.

1.11 There is little useful information in the magnetic data pertaining to the "monk's cemetery" (located south of the extant Lady Chapel). A weak negative trend **M9** occupies the same position as resistance anomalies tentatively attributed to the southern boundary of the cemetery (see discussion paragraph 2.16 below) but it is doubtful that any significance would be assigned to the magnetic response in the absence of this other evidence. Within the cemetery grounds, some anomalies form patterns that could indicate archaeological significance, but nothing can be said about their precise function and even this most generic interpretation is tentative.

1.12 Immediately south of **M9**, vaguely rectilinear weak positive responses have been identified which partially overlie parchmarks (H-N2) and a corner of the Abbot's Hall and are therefore very tentatively associated with this feature, possibly indicating foundation trenches.

1.13 Moving to the west of the Abbot's Lodge and Abbot's Kitchen, hints of weak negative anomalies **M10** form an incomplete rectilinear pattern that partially corresponds to parchmarks (H-Q) and resistance anomalies suggesting a range of buildings and walls or banks. The definition of the negative responses is hindered, especially on the western side, by adjacent ferrous noise; nonetheless, given the corroborative evidence, they are cautiously interpreted as remnants of wall lines or banks, likely to be associated with the Abbey complex. Some adjacent positive responses have an orientation which suggests they might also relate to the same building complex, possibly reflecting rubble or a build up of magnetic soils in foundation trenches. Other

distinct linears are on differing orientations; while they might be archaeological (?possible ditches or drains), their relationship to the Abbey complex is uncertain.

1.14 A rectilinear pattern of positive and negative anomalies and trends **M11** may represent sections of walls, drains and robbed foundations at the southern corner of the Abbot's garden. There is a considerable amount of corroborative evidence to support this interpretation: parallels in the resistance data; an adjacent extant wall line; parchmarks (H-P2) and excavations (H-21a).

1.15 Trends **M12** define a rectilinear band of indistinct positive anomalies that partially surrounds the Monk's Kitchen. The western and eastern arms have parallels in the resistance data (suggestive of walls or banks) and the western arm also follows the line of an extant wall. The overall impression is of features (?ditch ?foundation trenches ?drains) that enclose the Monk's Kitchen. It may be that the responses represent the edges of a deliberately landscaped platform on which the kitchen was constructed, though there is no other geophysical evidence to corroborate this interpretation. The weak nature of the responses makes it difficult to accurately define their limits, particularly along the southern arm, nonetheless, it seems that **M12** does not respect **M11**, thereby representing a different phase of activity at the Abbey.

1.16 The northern, western and southern arms of the post-Conquest Cloister are marked out on the ground and therefore defined by strong ferrous anomalies. Truncated positive linears underlying the extant eastern wall are attributed to an accumulation of magnetic soils in the foundation trench. Within the Cloister, a weak negative response **M13**, in places, barely more than a trend in the data, suggests the remnants of a wall line. It roughly corresponds with a resistance anomaly which would support this interpretation. Immediately north of **M13**, a broadly rectangular arrangement of positive anomalies appear to form a smaller enclosure, though the pattern on the northern side is incomplete. Three short, parallel positive anomalies, extending southward from **M13** may also be of interest, but since nothing can be said about their probable origin and function, they are depicted simply as *?Archaeology*.

1.17 Aside from indistinct responses associated with extant walls, no anomalies have been identified that can be related to the South Transept or Chapter House. Anomaly **M14**, comprising two parallel weak negative trends, crosses the latter, but does not appear to respect its western or eastern walls. A trench (H-24b) is noted at approximately this position and **M14** might represent this feature, reflecting a backfill of soils with no particular magnetic enhancement. Alternatively the negative form of the trends could indicate two separate non-magnetic features, possibly stone drains or service trenches.

1.18 The eastern wall of the Dormitory is extant; the ferrous anomalies along its line are likely to reflect material used in its maintenance/reinforcement. Weak negative trends **M15**, suggest the lines of the western wall and a possible internal division; corresponding resistance anomalies (paragraph 2.30) support this interpretation. A few other positive linears and trends are noted within the Dormitory, but the absence of corroborative evidence for these makes interpretation more tentative.

1.19 Little of significance can be gleaned from the data immediately east of the Chapter House and Dormitory. Two rectilinear anomalies may be of archaeological interest since they partially overlie parchmarks (H-F2 and H-J) but the limited extent of the magnetic anomalies precludes any firm interpretation. Some indistinct parallel trends have been identified that, in a rural setting would suggest ridge and furrow; in the current context they might indicate drainage ditches and on the archaeological interpretation they are depicted as *Uncertain*.

1.20 Anomalies **M16** correspond roughly with parchmarks (H-D3); if both surveys represent the same features, the ferrous nature of the magnetic responses suggests these features have a modern (post-medieval or C20th) origin.

1.21 Ferrous anomalies **M17** and **M18** are likely to relate to a compound and boundary depicted on the 1969 OS map, though linear response **M18** is indicative of a buried pipe, presumably beneath or alongside the mapped boundary. Similarly **M19** could represent a pipe laid along the line of a former boundary shown on OS maps between 1886 and 1930.

1.22 In the eastern portion of the data set, a number of primarily weak and ill-defined positive anomalies have been highlighted as potential archaeology as they form patterns suggesting enclosures or former land divisions. Anomalies **M20** and **M21** may be represented on aerial photographs (IA1269g, 1971 and IA1281_n, 1930s, respectively); **M21** also corresponds with a slight topographic bank and, partially, with a high resistance anomaly (see paragraph 2.36 below). However, their precise function and relationship with the Abbey remains uncertain. Interpretation of some of the trends is particularly cautious due to their indistinct nature.

1.23 Anomalies and trends **M22** form rectilinear patterns that might suggest an archaeological origin, but they are represented less confidently, as *Uncertain*, for two reasons. Firstly, they lie on a direct line between the two ponds which are known to be linked by a service pipe; any one of the east-west trends could reflect this service trench (the absence of ferrous indicates a plastic or other non-magnetic pipe). Secondly, the stronger but more amorphous responses at the western end of the group appear to coincide with a feature on aerial photographs (e.g. IA1269c, 1944) that gives the impression of disturbed ground. The proximity of ferrous anomalies to **M22** might suggest a modern source of disturbance.

1.24 Ferrous and positive anomalies delimited by **M23** have been produced by the boundary of a former football ground, first shown on the OS map of 1930. Most of the anomalies within the ground are likely to arise from this modern usage, though a weak linear which crosses the northeastern corner represents an entirely unrelated feature, of uncertain origin.

1.25 While it is tempting to suggest that a discrete negative anomaly **M24** might represent a wall line of some archaeological significance, its proximity to ferrous disturbance at the grid edge makes the interpretation uncertain. Moreover, a parchmark/soilmark at this location is shown on an AP (IA1269i) dating to 1983, but not on any earlier photographs, arguably suggesting a modern feature such as a service trench. A similarly uncertain origin is assigned to nearby trends whose parallel alignment is suggestive of former cultivation but could equally reflect drainage features.

2. Resistance Survey (Figures 8 to 13)

*Labels **Rn** in the text below refer to specific resistance anomalies highlighted on the interpretation diagrams. References (H-xx) relate to parchmarks and trenches mapped and described in Hollinrake, 1989, and follow the labelling system used in that report. The mapping of the trenches is not accurate (see general notes above); therefore in the text below any references to these trenches is tentative.*

2.1 The resistance data display a broad range of values across the site, a result of the intensive human activity over time. In places, the visual dominance of extremes of high and low resistance has made it difficult to accurately define and interpret smaller ("weaker") changes that might be archaeologically significant. The four data plots presented in the main report illustrate this: compare the colour plot and greyscale image of the "basic" data (minimal processing) with the high pass filtered data set and relief plot that aim to highlight specific anomalies of interest. A level of caution is applied when viewing the filtered data, however, since this mathematical process can also produce some spurious anomalies.

2.2 In the geophysical interpretation (Figure 12) anomalies are categorised as either high or low resistance, and whether they are discrete and well-defined (generally "strong" and easily visible) or "weak" and ill-defined (more difficult to identify). In general, features causing high resistance include walls, areas of building rubble, compacted earthen banks or platforms, stone or brick drains. Low resistance anomalies are commonly attributed to ditches or other "cut" features (e.g. trenches) containing increased soil moisture. A variety of factors can affect the strength and definition of an anomaly and factors which may be significant at this site are: feature size (e.g. substantial wall or narrow drain), depth of feature (a deeper feature can produce a "weaker" response) and preservation (damaged or robbed out features tend to give rise to "weaker" or ill-defined responses). On the Archaeological Interpretation (Figure 13) the terms good / poor definition are used to encompass these causative factors.

2.3 One of the remits of the wider project is to accurately position the early C20th excavations on the modern mapping and it was hoped that the geophysical survey could assist with this. Given the broad range of resistance values across the dataset, and the sheer density of both features and excavation trenches, an individual backfilled trench might not have sufficient soil moisture contrast to produce well-defined anomalies (low resistance would be expected); indeed no responses have been identified that can be conclusively linked to trenches. Levels of feature preservation might be significant in this regard. It merits noting that, based on a perfunctory visual comparison of anomalies and trench positions, many of the apparently weaker anomalies correspond to areas of trenching and in some cases linear anomalies are obviously truncated. However, since the excavations themselves revealed "robbed out" features, this link is not definitive.

2.4 A rectangular pattern of marginally higher and lower resistance anomalies **R1** is on a different alignment to the main Abbey buildings, therefore suggesting a different phase of activity at the site. Some of the high resistance responses partially correspond with parchmarks (H-A1 and H-A3, interpreted as walls), and also (arguably more closely) with paths and a wall shown on the 1886 OS map. Only one short high resistance linear suggests a narrow intact length of wall. The other anomalies are broader and very weak (some little more than trends) which seem more likely to represent denuded paths indicated on the OS, possibly representing a formal layout with garden features. Within the wider low resistance, a smaller, discrete rectangular very low resistance anomaly can be seen. If the above path/garden interpretation is correct, then this could also indicate a formal garden feature. The weak circular high resistance anomaly in the centre of the group has been caused by tree roots removing moisture from the soil.

2.5 Anomalies **R2** and **R3** appear very different in shape and form at first glance: **R2** - amorphous and broad with hints of right angled turns at either end; **R3** - narrower and more discrete but much weaker with a hint of a right angled turn at the eastern end. However, in the filtered data and relief plots they appear to form a single narrow linear with the apparent "right angles" dissolving into more amorphous responses that correspond with the positions of modern trees. The linear has a position and orientation that probably relates to a feature (?wall) indicated on the 1886 OS map. The varying form is likely to reflect differing levels of preservation. Some linear magnetic anomalies (positives and ferrous) follow this line; the ferrous suggests some modern (at least post medieval) elements within the feature. Immediately north of **R3**, there are no coherent responses that can be related to parchmarks H-A5; but a few very weak high resistance linear anomalies and trends seem likely to reflect the remains of paths indicated on the 1886 OS map.

2.6 Moving eastwards, a well-defined low resistance anomaly **R4** corresponds reasonably well with a parchmark (H-B3) and also a feature (?wall) on the 1886 OS map. If the mapped feature is, indeed a wall (which seems probable), the form of the resistance data suggests it has been largely, if not completely robbed out, leaving a narrow trench in which moisture has collected.

2.7 Generally well-defined linear anomalies **R5** to **R8** represent structural remains relating to the Great Church; respectively the Nave, the Choir, the Presbytery and the Edgar Chapel. The strongest and best defined responses are in the Nave and Choir (**R5** & **R6**), suggesting relatively intact and substantial wall foundations. However, it should be noted that at the western end of the Nave all bar one of the responses terminate abruptly and this coincides roughly with the edge of a large excavated area. In the Presbytery and Edgar Chapel the anomalies are weaker, suggesting robbed out, less substantial or deeper features. Discrete low resistance anomalies are apparent within and around the walls of the Edgar Chapel, indicating a marked increase in soil moisture content at this location. It is uncertain whether this reflects "ponding" of water over an intact floor surface, moisture accumulation within a backfilled excavation trench, or relates to modern landscaping of the site.

2.8 At the western end of the Nave, somewhat ill-defined, but roughly rectilinear high resistance anomalies **R9** may represent the denuded structural remains of the early Saxon Church.

2.9 West and north of the main church elements, interpretation is complicated by the presence of surface obstructions (historic and modern), trees and topography / landscaping. To the west, the large blank area of data is the site of the restored Lady Chapel. Immediately north of this is a

relatively coherent rectilinear low resistance anomaly **R10** which appears to correspond to a possible path indicated on the 1886 OS map, the low resistance suggesting the feature has been completely robbed out.

2.10 The map shows this path leading northwards to a wall and buildings labelled "chapel lodge", the majority of which lie under the modern museum, outside the survey area. Hollinrake's trench notes for this area (H-32b) indicate a possible medieval wall. High resistance anomalies **R11** on or close to the grid edge are tentatively highlighted as possible archaeology, as they might represent material associated with these features; but, it must be stressed, they could equally reflect modern material associated with the existing building.

2.11 A few other (mostly high resistance) anomalies to the north and west of the Lady Chapel form vague linear and rectilinear patterns that could indicate archaeological potential. For the most part, however, they are somewhat indistinct; this together with the aforementioned modern factors, makes any archaeological interpretation extremely cautious. What can be said is that there are no distinct anomalies (high or low) that can be obviously matched to the layout of St Dunstan's Chapel (marked on the ground).

2.12 North of the Nave, a number of high resistance anomalies are present, mostly ill-defined and broad, but nonetheless quite strong. Unfortunately these also coincide with the positions of mature trees, a topographic change and several excavation trenches. It is difficult to see how these three factors alone would account for such high resistance values (similar in magnitude to those produced by the Nave sleeper walls) and it is possible that they partially reflect building rubble associated with the Abbey complex. This ambiguity is reflected in the archaeological interpretation; all bar one of these responses is assigned to the *Uncertain* category. The category of *?Abbey Rubble* assigned to **R12** is based on its shape - broadly rectangular - and its position - overlying the site of the North Porch. It should be stressed that this interpretation is still tentative, not least because, although some more discrete responses can be discerned within zone **R12** (largely as a result of filtering), the resulting patterns appear to be on an entirely different alignment to the North Porch.

2.13 Similar levels of caution surround the interpretation of indistinct high resistance linears **R13.** They appear to form a pattern suggesting denuded Abbey structural remains, but they lie within a small area containing numerous modern and historic surface obstructions (Chapel of St Thomas Martyr, Site of North Transept, gravel paths, trees and landscaping). The resulting gaps in the data have hampered a precise definition of the anomalies and analysis of their patterns; moreover the surface features themselves are likely to have contributed to the recorded resistance values.

2.14 The complications of topography / landscaping and trees continue to prevail in the data north of the Choir / Presbytery / Edgar Chapel. Two parallel and relatively distinct high resistance linears have been highlighted. **R14** may correspond to a parchmark (H-B5, described as "wall aligned on the North Porch"); the response is consistent with partially intact wall remains and may therefore be of archaeological interest, but is not precisely aligned with the parchmark and there is nothing in the results to enable a more accurate determination of its function. Anomaly **R15** is also suggestive of wall remains, but lies at the top edge of a pronounced tree lined bank. It is uncertain whether the response is a direct product of this landscaping or reflects an underlying feature, possibly pre-existing, that has been incorporated into the current topography. Immediately south of **R15**, at the bottom of the bank, is a relatively discrete low resistance anomaly. This is likely, at least in part, to reflect moisture collection at the foot of the bank, but at the eastern end the response displays hints of linearity that might suggest a trench, ditch or robbed out wall line (the whole response is categorised as *Uncertain*). (The available early OS mapping is of little help at this location: it shows paths, earthworks and trees, but the scale does not enable a reasonable comparison).

2.15 A modern path separates the Great Church from the other Abbey buildings to the south. The resulting narrow gap in the data has had a minimal impact on data analysis. The land to the south is largely free from trees and modern surface obstructions, although some historic walls are present, the lines of the main features are marked in stone in the grass and there are some topographic changes which reflect the Abbey layout.

2.16 Beginning at the western end of the site, the land immediately south of the Lady Chapel is the location of the cemetery, remodelled by Abbot Dunstan in the mid-10th century. It measured roughly 70m by 20m and was enclosed by a stone wall. The western and southern limits of this have not been clearly established, the wall lines shown in published plans (in Rahtz & Watts, 2003) have been extrapolated from limited excavation data. These also show a small chapel (St Michael) appended to the south wall. Broad linear anomalies **R16** (varying in definition) partially correspond to a low bank and, although offset from the postulated line, are on approximately the correct alignment; as such they could represent largely denuded remains of the Cemetery's southern wall. Supporting this interpretation is the presence of a small rectangular anomaly extending southwards from the eastern end of **R16**; this could represent part of St Michael's Chapel. However, an element of caution remains, since the 1886 and 1904 OS maps show a linear feature (?boundary, ?wall) at approximately this location and it is entirely possible that this feature (of unknown antiquity) has produced the recorded resistance anomalies. Alternatively, lying roughly 8m to the north of **R16**, several narrower high resistance linear anomalies and trends **R17** share the same alignment and it could be these that reflect the OS mapped feature (they are shown as such on the archaeological interpretation). The proposed line of the cemetery's western wall extends from the centre of St Dunstan's Chapel, under a picnic area and close to a modern gravel path, which will have contributed to the recorded resistance values. That said, no obvious linear anomalies can be seen which would indicate wall remains at this location. Indistinct high and low resistance linears **R18**, although offset some 5m east of the postulated line, are on the correct orientation and as such may be a candidate for this feature, representing severely denuded / robbed out remains. However they could equally reflect sections of a former path and wall indicated on the 1886 OS map.

2.17 Radford (1981, p 115) describes a trench "dug obliquely across the cemetery, near its centre"; this was aligned NW to SE with the northwestern end close to the Lady Chapel south door. Within the grounds of the cemetery, the background resistance values are generally low, but some more discrete low resistance anomalies are apparent (it is assumed that a backfilled trench would retain moisture and therefore display lower resistance). However, none of these have the correct position or alignment to suggest they represent this trench. Both anomalies **R16** and **R17** are truncated in several places, but these breaks are insufficient in themselves to confidently extrapolate a trench alignment. The excavations revealed closely packed slab lined graves, several small buildings, presumed to be of wattle and daub construction and two hypogea (sunken chambers). Several rather weak / indistinct high resistance anomalies appear vaguely rectangular and could represent the remains of these, assuming the anomalies represent *in situ* features. However because the responses are small and non-linear, this assumption cannot be confidently made (general unstratified debris could produce such responses) and the interpretation has been downgraded to the less certain ?*Archaeology* category.

2.18 South of the Cemetery are located the West, South and East Ranges of an early (pre-conquest - St Dunstan's) Cloister, of which only parts of the East Range have been proved by excavation; and three phases of the later, medieval Abbot's Hall, of which a small corner still survives. A broad zone of high resistance covers much of this area and this might have been produced by general spreads of rubble from any or all of these features. However, within the zone, few discrete responses can be discerned which might be related to specific elements. Of the West and South Ranges there is no obvious trace; a somewhat amorphous high resistance anomaly **R19** may represent rubble specifically from the East Range, though this interpretation is highly tentative (more on the East Range in paragraph 2.25).

2.19 Based on their position and alignment, anomalies **R20** seem likely to correspond to the Abbot's Hall; the western anomaly relating to the main wall, the eastern response possibly representing a short section of an internal screen/passage. A few other anomalies lie within the outline of the Abbot's Hall; they may be of archaeological interest but the general lack of coherent patterning makes it difficult to formulate any precise interpretation. The presence of former trees in this area (indicated on early OS mapping) adds another level of uncertainty to their interpretation.

2.20 The zone of high resistance mentioned in paragraph 2.18 above continues southwards around the extant Abbot's Kitchen and westwards, forming a rectilinear shape that roughly matches a group of parchmarks and earthworks (H-Q) attributed to a range of buildings and the medieval

western precinct wall. Data analysis at this location is once again complicated by trees and modern planting; nonetheless, within the zone, some relatively discrete high resistance anomalies **R21** can be discerned which are likely to reflect a combination of building rubble and collapsed / denuded wall lines from these features. There are hints of structural features returning along the southern edge of the survey (**R22**), though definition and interpretation of these is more cautious due to the above mentioned modern factors.

2.21 Moving to the east of the Abbot's Kitchen, the high resistance anomalies **R23** lie on the northern edge of the Abbot's Garden. A tree is present in the centre of the responses, but it seems unlikely that this could be responsible for the apparent rectilinear patterning, which rather suggests possible building remains. Although the anomalies are on the same orientation as the other Abbey elements, a firm correlation cannot be made and they are categorised simply as *?Archaeology*. South of **R23**, weaker high and low resistance linears form a pattern which also suggests archaeological significance; given the context, possibly garden features, though this interpretation is far from conclusive.

2.22 The anomalies at **R24** comprise parallel relatively weak high resistance linears, aligned north-south leading to a group of stronger, but somewhat amorphous high resistance anomalies at the southern end (the latter adjacent to surface wall remains). These could represent features identified in published studies: a wall at the eastern edge of the Abbot's Garden, a possible building (the Abbot's Lodge) at the southeastern corner of the Garden and a second wall returning northwards to the Monk's Kitchen.

2.23 The anomalies in and around the Monk's Kitchen provide little additional detail to the surface layout; in fact, the most coherent responses are seen running alongside the extant wall south and west of the Kitchen and are likely to have been largely generated by this feature. However, immediately east of the Monk's Kitchen, anomalies **R25** suggest the presence of partially intact wall foundations; their alignment and position suggests they may be related to the Abbey complex. The responses vary in strength and definition; the most coherent at the southern end partially correspond to parchmarks.

2.24 The Refectory Undercroft occupies a low lying position enclosed on all sides by extant walls and banks. This would account for the general low resistance values encountered throughout this building area (accumulation of moisture). Within the low zone, faint parallel marginally higher resistance trends **R26** can be discerned. Their function is unclear (?remnants of pillar supports, ?drains), but, given their position, they seem likely to be archaeologically significant and directly related to the Refectory. Other trends on differing alignments have been classified as *Uncertain*, though the possibility that these too are archaeologically significant, cannot be dismissed.

2.25 The pattern formed by anomalies **R27** suggests a range of buildings along the western side of the Cloister; the main walls are possibly reasonably well preserved but with no indication of internal subdivisions. These anomalies coincide in part with sections of the pre-Conquest East Range (see paragraph 2.18 above) and the east wall of Dunstan's Cemetery.

2.26 No comparable discrete linears are apparent along the north, east and south sides of the Cloister; some amorphous high resistance responses might represent spreads of building rubble, while weak linear trends and a rectangular low resistance anomaly could reflect deeper or narrower features (?drains) or robbed out wall lines, but the interpretation is tentative.

2.27 The site of the South Transept occupies a raised grassed platform, bound to the north, west and south by stone retaining walls, at least 1m high. It is these walls and any associated packing material that are likely to have contributed substantially to the vaguely rectilinear zone of high resistance **R28**. Some more discrete high resistance anomalies can be discerned; those which extend at right angles from the extant walls might represent remnants of structures within the South Transept, but no more precise interpretation can be offered.

2.28 The anomalies **R29** represent the remains of the Chapter House. The main walls are indicated, possibly varying considerably in preservation (based on anomaly strength and coherence) and

there are hints of internal features, denuded or robbed out foundations, drains or possibly trench cuts.

2.29 Just outside of the Chapter House to the east are two high resistance linear anomalies, varying in strength and definition, which partially coincide with parchmarks (H-F1, a possible building) and have therefore been highlighted as potential archaeology. Nearby, to the south, a more amorphous spread of higher resistance displays a vaguely rectilinear pattern that corresponds partially to parchmarks H-F2 and surviving earthworks - this reduced anomaly coherence and feature comparison is reflected in the interpretation of *Uncertain*.

2.30 The main walls of the Dormitory (the eastern wall survives on the surface) are represented by relatively coherent high resistance anomalies **R30**. The data show hints of internal divisions and footings for individual column bases, although it is possible that the modern stone ground markings for the columns may have contributed to some of the latter responses. A discrete rectilinear anomaly extends from the eastern wall of the dormitory southwards to the reredorter. It is unclear whether this is a small extension wall or a drain: The strength and definition of the resistance response is no help in this regard; merely suggesting a fairly well preserved substantial feature, associated with the Abbey complex.

2.31 Immediately east of the Dormitory, some ill-defined higher and lower resistance linears might represent the denuded / robbed out remains of a possible building indicated on the parchmark survey H-J.

2.32 Before moving on to the eastern portion of the survey (outside the main Abbey complex) it is worth mentioning one feature that has left no apparent trace in the resistance data, namely the bank and ditch of the *vallum monasterii*, (see paragraph 1.9 above). In an undisturbed context, the bank would be expected to produce a high resistance anomaly, while the ditch could yield either low or high resistance values, depending on drainage and the levels of moisture in the near-surface fill. The absence of any such clear linear anomalies is likely a product of the complicated stratigraphy of infilling of the ditch and the sheer number of other superimposed features and their associated rubble whose resulting anomalies visually dominate the results.

2.33 Although, not in precisely the same position, the shape of discrete high resistance anomalies **R31** correspond most closely with the line of a path marked on the 1886 OS map, leading from the orchard and gardens in the south to the main Abbey Church in the north. (The anomalies are, arguably, positioned closer to a boundary feature -?wall- running alongside the path, but this does not curve at the southern end, but rather continues towards the fish pond). The resistance anomalies do not extend the full distance at the northern end; instead two somewhat amorphous groups of responses **R32** lie on this line. These form vaguely rectilinear patterns which might suggest former building platforms (both on an entirely different orientation to the Abbey complex) but also correspond with two mature trees, making any interpretation uncertain.

2.34 On either side of the postulated path, zones of high resistance **R33** partially cover a group of parchmarks (H-D4 to H-D6) suggesting buildings and rubble spreads. Within the zones, some more discrete anomalies are apparent in the filtered data, which have linear or rectangular patterns that might support an interpretation as building remains. The less definitive interpretation *Uncertain* origin is assigned for two reasons. Firstly, both zones are currently occupied by trees, which are likely to have contributed to the recorded values. Secondly, and perhaps more crucially, the zones lie on the western and eastern edges of a compound first indicated on the 1969 OS map (and removed by 1983) and therefore modern debris is likely to have made a major contribution to these responses.

2.35 The high resistance anomalies at **R34** form a rectilinear pattern suggesting remnants of discrete wall lines, on a different alignment to the main Abbey complex. Neither the parchmark survey nor the early OS mapping indicate any possible features at this location. The archaeological interpretation is cautious due to the presence of nearby trees and because some of the responses appear as little more than trends in the filtered and relief plots.

2.36 At the eastern end of the survey, where generally low resistance predominates, some marginally higher resistance anomalies may be of archaeological interest as they form patterns that suggest

banks and robbed out wall lines associated with former land parcels / field divisions. Some of the responses correspond with topographic features noted on the parchmark survey; one - **R35** - partially corresponds with a magnetic anomaly and possibly an aerial photographic feature (IA1281_n - post 1930s), but none appear to be represented on any of the OS mapping. An archaeological interpretation is cautious, however, since some of the anomalies could have been produced by buried modern features such as drains.

2.37 The origin of very indistinct low resistance linears **R36** and **R37** is uncertain. Although at first glance appearing to form part of a single rectilinear feature, the two are not necessarily related. The alignment of **R36** suggests it might be part of a modern water pipe trench linking the two ponds. **R37** extends into a very curious zone of marginally higher resistance, within which linear striations appear, particularly in the filtered data. Little can be said about the function or origin of this zone, other than that it appears to have a very well-defined edge which could indicate a deliberately constructed (i.e. anthropogenic rather than natural) feature.

3. GPR Survey

*Labels **Gn** in the text below refer to specific GPR anomalies highlighted on the interpretation diagrams. References (H-xx) relate to parchmarks and trenches mapped and described in Hollinrake, 1989, and follow the labelling system used in that report. The mapping of the trenches is not accurate (see general notes above); therefore in the text below any references to these trenches is tentative.*

3.1 The summary GPR diagrams contain examples of both filtered and unfiltered data, in 0.5m slices. However, the interpretation diagram for each interval is based on the combined analysis of both the filtered and unfiltered 0.3m slices (printed at a small scale, *in situ*, in Figures 34 – 39) and, independently, at a larger scale in Figures G1 – G103 on the Archive CD) as well as the raw radargrams. As 'overview' plots, the summary slices may not show all the interpreted features clearly hence the inclusion of the 0.3m sliced data. The use and inclusion of both filtered and unfiltered data is necessary due to the fact that, whilst enhancing certain feature types, by its nature the background filter will also remove some information, especially near-surface.

3.2 As with the other two geophysical techniques, the survey has produced an incredibly complex data set resulting from not only the many successive phases of development and construction on the site, but also the phases of destruction such as the robbing of building material and the more methodological excavation for research. Even with the extra detail and depth information afforded by ground penetrating radar, this rich history has resulted in a degree of ambiguity in a number of areas as to the exact origin or antiquity of the recorded responses. For example, many apparent services (i.e. drains, pipes, cable runs) have been detected some complete, some partial, but often it has been difficult to determine whether these features are relatively modern installations or historic elements of the site. It may be necessary to compare the results with any service plans of the grounds to help resolve these issues. Around most of the mature trees, anomalies associated with not only the root mass but also overground reflections from the trunks have been recorded.

3.3 A rectilinear series of anomalies **G1** show a very close correlation with the early edition OS mapping and the other geophysical techniques (see **M1**,**R1**); the reflectors appear relatively shallow – but their effect can be seen 'ringing' down through the section - with a character suggestive of paths (possibly cinder construction given the magnetic response). There is a reasonable co-registration with parchmarks (H-A1). The reflections down the eastern side are somewhat stronger and may be attributable to a former garden wall as well as the path. An unusual curved feature **G2**, approximately 4m – 5m in diameter and extending from around 0.25m depth to almost 1.0m below ground level (BGL), lies on the southeast corner but is not represented on any maps of the site. There is an associated high resistance response but little in the magnetic data – it would not be unusual to find dovecotes of this size and response character. A much weaker sub-circular trend to the west is coincident with a low mound – an associated ferrous response in the magnetic data would imply a relatively modern origin.

3.4 A number of isolated, increased amplitude reflections **G3** seem to be largely coincident with small structures shown on a 1909 map of the site with the northernmost also mirroring parchmarks H-A4. There is a linear band of reflections which shift south through the time-slices, away from this northern boundary; these are merely the effect of overground reflections from the adjacent wall. The possibility exists that the southernmost example, coincident with resistance anomalies **R11**, may be associated with a medieval wall encountered by Woods in his 1987 excavations (H-32b); however, this remains somewhat tentative.

3.5 Further linear anomalies **G4** associated with footpaths and / or boundaries recorded on maps from 1886 – 1991 can be seen to the east, in the region of magnetic and resistance anomalies **M2** and **R3**. Whilst there is a partial relationship with parchmarks H-A5 and H-A6, at least one linear anomaly is simply a pipe or drain. Potential garden features or the remnants of a small structure may well have caused increased response **G5,** sat within one of the 'compartments' defined by the paths and wall lines. A further pipe, associated with a ferrous magnetic response has been recorded to the east and between this and the aforementioned garden features are two zones of increased response **G6**, the origins of which may well be archaeological – it seems to be formed of a buried surface and a broad zone of disturbance, sitting within an area of parchmarks. There is a suggestion of a broad cut feature running through this area, which could be the remnants of the *vallum monasterii*. Although very faint, this is the only place in the GPR data that even a hint of the possible Saxon ditch has been detected beyond the confines of the church (see paragraph 3.11).

3.6 A sporadically apparent line of increased response **G7** extends across this northern area, and forms a limit to the majority of responses pertaining to former land divisions and paths in this northern part of the survey area. It seems likely that this demarks a former northern boundary to the precinct as recorded on early OS mapping onwards. There is no suggestion of the potential 'returns' seen on the corresponding linear anomaly **R2** in the resistance data, it may be that these are a facet of the adjacent trees.

3.7 A linear increase in response **G8** lies in a similar orientation to **M4** and **R14**, and the shallow nature of the reflectors would seem to imply that this is another former footpath.

3.8 Through the abbey church, responses directly attributable to surface markers delineating the missing sections of the abbey superstructure are clearly apparent in the shallowest slices. However, very quickly these give way to clear strong anomalies from the main structural elements. It is not obvious as to why the shallowest slices from the chancel have such an elevated level of response in comparison to the nave. The radargrams show a stronger near-surface response which may simply be a facet of the soil type. Alternatively, the difference could be an inherent feature of the surviving construction or the effect of some kind of later intervention.

3.9 The footings for the outer and sleeper walls are clearly defined through the eastern half of the nave and the chancel, directly comparable with the resistance anomalies **R5** – **R7**. Successive phases of excavation have had a dramatic effect (**G9**) on the data from the western end of the church, where it seems all remnants of the structure have been removed. Where the footings remain *in-situ,* the variation in response is likely to indicate the levels of preservation, with the shallowest responses perhaps indicating a greater height, albeit buried, of surviving material.

3.10 It is important to note that the edges of the trenches, from which the material was removed, are not visible other than where the footing reflections are cut-off. This has been the case right across the site, where few anomalies directly attributable to the trench cuts themselves have been recorded.

3.11 There is a distinct deepening of responses associated with the wall footings from east to west. This is perhaps due to the original topography of the site, and a greater depth of material was required in the west to compensate for the falling ground. At the west end of the chancel, there is potential evidence for the *vallum monasterii* but it is only really only noticeable in the radargrams. Across the sleeper walls on each side of the Chancel, the reflections deepen abruptly at the same point east-west and is assumed to be where the footings dip into the remnants of the ditch. However, this interpretation is highly speculative and, if it was not for *a*

priori knowledge of the feature from excavation records, it is unlikely that this interpretation would have been made. There is little to define the line of the ditch south of the church other a further deepening of responses along the path which runs through the southern transept.

3.12 Perhaps the most intriguing area of the abbey church is around the Loretto Chapel, on the north side of the nave. Here, the reflections from the outer wall **G10** turn north and extend out parallel but west of the transept's outer walls **G11** (when compared with the southern transept). Between **G10** and **G11**, the time-slices indicate that there is a clear break **G12** in the reflections; this appears somewhat incongruous with the expected pattern of response. Indeed, the radargrams do not show a complete lack of material here, rather a less substantial depth of deposits. There is a relatively shallow, strong planar reflector which could be masking deeper features, but why this zone should have such different characteristics remains uncertain. There is a suggestion that **G10** is a double wall line, which could suggest a corridor out towards the position of the Loretto Chapel; that said, the 'double' appearance may be the result of stronger reflections off the outer edges of the footing material. There are rectilinear responses **G13** coincident with the rectangular magnetic anomalies **M5** and although the resistance data is not particularly revealing, it seems likely that this is the footprint of the Loretto or perhaps an even earlier chapel. The lack of clearer responses may be due to robbing of material from this area as suggested by the Hollinrake quote "…Bond 1919…. Loretto Chapel cleared" (H-9a).

3.13 In both the nave and chancel there are confined zones of reflections that lie along the centre of the structure and also between the sleeper walls and the outer walls. It is assumed that some of these may well be burial features, for example **G14**. The possibility of localised areas of consolidation material or earlier monastic structures cannot be entirely ruled out. There is a slight increase in disturbance in the radargrams toward the western end of the nave, adjacent to the Lady Chapel. In this region, resistance anomalies **R9** have tentatively been interpreted as remains of the early Saxon church – the distribution of the GPR results do little to either support or refute this interpretation being, as they are, somewhat amorphous. Again, there is clearly the prospect of this disturbance being a result of landscaping to level the site.

3.14 The GPR data from over the north porch shows far better definition that the resistance data and reveals a mass of construction material remaining *in situ*; this is predominantly on the western side, with less material to the east. The rectilinear increases in response between the porch and the Loretto Chapel, coincident with a high resistance spread, may indicate another ancillary structure although the complication here is the presence of large root masses from the line of mature trees running north of the church.

3.15 Scant extra information has been added in the region of the Edgar Chapel, with the GPR largely paralleling the responses recorded in the resistance survey.

3.16 The south transept, which is bisected by a footpath, has been partially detected. The strongest reflections **G15** have been recorded over and along the outside wall; an interpretation given weight by the correlation between the distance from **G15** to the south wall of the nave and the size of the northern, extant, transept.

3.17 On the north side of the Lady Chapel, there is a band of high amplitude and increased response anomalies **G16** that are coincident with the break of slope across this part of the site. It is assumed that the reflectors are primarily the result of landscaping as they appear to be bulk changes in the near-surface material rather than individual features, however post dissolution features are noted in this area and may have contributed to the results. Towards the eastern limits of this band, reflections **G17** become more focused and these might indicate structural remains. It may simply be the edge of the footings for what would have been the corner buttress. Between **G16** and the north wall of the Lady Chapel lie a series of anomalies that resemble a narrow building abutting the extant remains. The rectilinear grouping **G18** seems to be the external wall, whilst very strong reflectors inside this could be further subterranean structure, such as the vaulted recess **G19** seen on the south side of the Lady Chapel, which houses the well.

3.18 St. Dunstan's Chapel, at the western end of the abbey church, is poorly defined and, although there are reflections directly beneath the surface markers, the wall lines do not show particularly

deeply. Reflections **G20** toward the centre of the chapel may be evidence of flooring and possibly a burial feature at depth but the radargrams are not very clear. North of St. Dunstan's Chapel, a certain rectilinearity to some of the responses **G21** matches up with an area of increased resistance. It may be part of a further ancillary feature, however the radargrams and overall pattern of response, coupled with potential service routes and landscaping, leave some ambiguity in the interpretation.

3.19 South of the Lady Chapel, aside from the potential services and / or former pathways, there is little definite structure until the swathe of reflections **G22**. This matches well with the resistance anomalies **R17**, tentatively attributed to a feature on early OS mapping. It should be noted, however, that this feature has been detected in timeslices up to 2m BGL, making the interpretation uncertain. A distinct diagonal break **G23** in the feature, coincident with a weak linear trend in the deeper slices, is coincident with a documented trench (Radford, 1981, p.115) dug obliquely to the predominant strike of the abbey features. Documentary evidence reports the presence of burial slabs and sunken chambers associated with the churchyard, but there is little to see of these; other than the small, high amplitude anomaly **G24** – possibly a burial slab or stone casket.

3.20 The line of the cemetery's western wall is somewhat unclear as the reflections from the area where it is supposed to be to be are quite complex and potentially influenced by latter-day interventions. Two parallel linear bands of increased response **G25** extending southwards from **G22**, on either side of the modern path; both show some correlation with the resistance data, but both are too far west. Anomalies **G26** form a rectilinear pattern, the north-south arm of which corresponds to resistance anomalies **R18** (attributed to the cemetery wall); however the east-west arm aligns with **G22** (not the cemetery wall). Moreover in the shallowest time-slices, several north-south alignments are visible and the corner of **G26** has the appearance of a circular feature (not matched in the resistance data) comparable in size, though not in depth extent to **G2** (a possible early modern feature). If **G22** and **G26** are related (which seems logical given their relative positions) it could be an indication that the postulated western wall of the cemetery is actually a former path or garden feature.

3.21 The southern wall of the cemetery is similarly elusive, defined less by any one linear but more as the northernmost extents of a group of possible buildings **G27**. The linearity of this northern edge appears clearest in the 1-1.5m time-slices, where it correlates reasonably well with resistance anomalies **R16**. The main body of **G27** comprises rectilinear anomaly spreads possibly indicating elements of an early (pre-conquest) cloister, part of the St. Dunstan's complex, though some reflectors towards the northern edge are likely to represent St Michael's Chapel. Adjacent is the Abbot's house and it can be seen that not only are there strong reflectors **G28** within the footprint of the building – a possible floor material or demolition spread – but also directly to the east, perhaps pertaining to a different phase of construction or ancillary structures.

3.22 More surface markers that are clearly picked out in the data demarcate the post-conquest Cloister. However, there are a few anomalies **G29**, offset from these surface features, which lie within the footprint of the Cloister ranges. Across the southern half of the Cloister there are clear reflectors **G30**, which are believed to be the remnants of earlier structures, although preservation does not appear to be particularly good with individual wall-lines not readily apparent. It is not clear as to whether the southernmost of these reflectors are from earlier structures, the south range of the later Cloister or a combination of the two.

3.23 The Abbot's Kitchen, the best-preserved structure on site, has revealed a strange pattern of reflectors **G31** down its eastern side. The radargrams reveal a shallow dipping, planar surface, with more disturbed material over-top. This would suggest that the site has been landscaped to level it out, but what this dipping feature was originally is unclear. It may have been a natural hollow or channel but, if this is the case, the antiquity of the remodelling is not apparent and thus whether it served any other purpose is also questionable. Abutting the southern side of the Kitchen, a single range of buildings **G32** seems to extend south, with evidence of at least two wall lines (one seemingly buttressed). There is little internal detail, such as cross-walls but there is a zone of amorphous reflection immediately to the east, which could be out-buildings or other less substantial ancillary structures.

3.24 Further east, into the Abbot's Garden the time-slices are relatively devoid of strong reflections, perhaps suggesting a temporal continuity of open space in this area of the precinct. Some poorly defined linear anomalies may be the remnants of drains and former garden features. The only exception is the anomaly group **G33** associated with elevated resistance values **R23**. Both data sets show a rectilinear distribution to the responses but the complication is that they lie towards the base of a mature tree. However, the pattern of response is not clearly the result of the root-mass and as such may hold some archaeological potential. In the southeastern quadrant of the Abbot's Garden is 'dog-legged' section of exposed wall footings. Whilst there are hints of linear trends running up the western side, the most substantial reflectors exist immediately to the north and to the east, with the latter showing the clearest pattern of potential rooms (especially near **G34**), as was the case with the resistance data (**R24**). The southernmost linear (running east-west) on this eastern side, possibly extends right across the bottom of the Abbot's Garden **G35** but the adjacent path has complicated interpretation, and could be partially responsible for this response.

3.25 The purported ranges of buildings in the southwest of the site, which may be the source of the broad high resistance anomalies **R21**, have not been clearly imaged with the GPR. It is possible that these were timber structures and, as such, may not have had large stone footings or substantial floor surfaces, which would give rise to stronger radar anomalies. Assuming this is the site of further buildings, the resistance data are probably picking out the lower moisture content within the more compacted soils that lay beneath the buildings, an effect which may not be noticeable with the GPR. That said, there is a general correlation in the shallowest slices between the resistance data and slightly elevated response levels in the GPR around the edge of the survey area. Up the western edge of the survey area is a trend and linear increased response **G36**, which could be part of a range of buildings. This linear assemblage runs up to a strong reflector **G37** in what would have been the corner of this range of buildings – however the authenticity of this feature as *bona fide* archaeological remains is debatable. The latter anomaly has a modern appearance and looks as though it may be a junction between services / drains; this obviously has implications on other linear anomalies and trends running near it. This information, coupled with the fact that the traverses run into undergrowth and mature trees on the northern side means that the most convincing responses are probably those along the southern and eastern edges of the survey area. In the deeper slices, there are poorly defined trends with a rectilinear distribution through the centre of this part of the precinct and their weak nature may suggest that, if genuine, these mark out planting plots or other garden features.

3.26 Moving back east, immediately south of the Cloister is the Refectory Undercroft and, although it is a particularly small survey area, there are a large number of linear trends running north-south. There are two possible explanations for this: firstly, that this is part of the floor construction lying beneath the grass – either support structures or edges of slabs – or, secondly, these are small drains. Circumstantial evidence may point toward the latter interpretation as a small spring runs out of the north wall of this structure and, being a sunken chamber, water would tend to accumulate here.

3.27 South again from the Cloister, lies the Monk's Kitchen, another feature whose position is laid out with surface markers. There is a good depth extent to reflectors within the footprint of the building but the response character is not typical of a cellar or similar; most likely these reflections are merely an effect of the floor and footings. North of the kitchen and also to the east, between it and the remains of the dormitory block, there are a number of trends and linear bands of increased response, most of which lie in a similar orientation to the other Abbey features. This loosely parallels the resistance results (**R25**) and to a lesser extent the magnetic data (**M12**). A number of these are certainly drains (as indicated on the interpretation), probably predominantly of some antiquity, whilst others may well indicate the presence of further buried structures, albeit either badly denuded stone or largely timber features, hence the lack of definitive response patterns. Perhaps the most difficult to interpret is the linear anomaly **G38** as it looks like a drain in some radargrams but, at the same time, sits within a broader zone of reflectors that look more like the faint remnants of structure. The anomaly is coincident with both resistance anomalies **R25** and parchmark features H-P4; it may be that a drain ran down alongside, or beneath, said structure thus accounting for this duality – certainly **G38** appears to stop at the pipe / culvert running out of the Reredorter.

3.28 The Dormitory is partially extant (a low wall runs down the eastern side with 'islands' of *in-situ* masonry through the rest of the building) and the GPR has obviously picked out the footings of the missing sections of the western and southern walls, as well as some faint internal detail, probably cross-walls or footings for pillars. Further clear correlation with the resistance data is noticeable with potential structures down the outer side of the eastern wall. North (**G39**) and south (**G40**) these are particularly strong (albeit confined in the northern case) whereas between these two end-members the anomalies are weak and ephemeral, but distinctly rectilinear. All of these must hold archaeological potential, although the potential for **G40** being a drain into the Reredorter from the Dormitory (and so probably contemporary with the Abbey) remains high. At its northern end, the radargrams over **G40** seem to suggest a deposit more akin to footings, but further south it does take on a more culvert-like character. As alluded to earlier, there is no convincing evidence of the *vallum monasterii* through this area.

3.29 The Chapter House lies immediately north of the Dormitory and the three buried walls **G41** can be clearly seen coming out, turning and returning back to the extant Cloister outer wall. There seem to be at least two drains running through the centre of the Chapter House but these are the last clear-cut definitions in this vicinity: south and east of the building, ideas regarding the exact source of the anomalies remain fairly speculative. For example, the vaguely rectangular enclosure that seems to come out from the southeast corner of the South Transept area and encompass the Chapter House has some issues with it. The alignment is not quite right on either the eastern end, or the southern arm. Furthermore, the northern arm **G42**, could conceivably be a continuation of on of the drains **G43** given that it not only lines up with the latter anomaly, but runs close to potential drains **G44**, with further (more recent?) drainage **G45** coming off it. Again, there is no clear expression of the *vallum monasterii* in either the time-slices or radargrams.

3.30 Heading east, toward the footpath running north-south through the eastern end of the main abbey complex, an older path (as shown on earlier OS maps) manifests itself as a broad trend of increased response **G46**. This feature runs through a zone of zone of strong reflections, coincident with high resistance anomalies **R33** and magnetic disturbance **M17**, all attributed to a compound shown on both old maps and aerial photographs up until the 1970's. A similar, second group **G47** to the west is probably related but the interpretation is marginally less confident owing to the proximity of the Dormitory, anomalies **G40** as well as the presence of tree roots. Within this compound there was at least one small building in the region of **G48** which is the zone of strongest anomalies. The remainder of the reflections in this area of the complex seem to be relatively shallow reflector groups (other than beneath the trees) probably resulting from gardening practices and / or changes in the topsoil.

3.31 The pattern of response across the easternmost survey area, out into the open parkland of the Abbey Precinct, is very unusual and difficult to interpret precisely; suffice to say many of the anomalies and spreads of reflections are most likely a combination of landscaping and drainage, though admittedly of uncertain antiquity. There are landscaping / grass-cutting features around the bank running up to the pond as well as a drain-line running away from here, following a line of access covers. The rectilinear spread of reflections **G49** initially looks promising as possible building footings and compacted ground (especially with the associated resistance rise) but, on closer inspection, many of the more coherent reflectors within this zone look more drain-like as opposed to more significant archaeological deposits. This spread of reflections appears to be bound by a pair of low banks as recorded in Hollinrake's report.

3.32 The *zig-zag* drainage pattern would ordinarily be attributed a modern origin, though in this case, given the location and history of land use at the site, it may not be so. The band of increased response and discrete linears **G50** may be considerably older. The latter feature is not easy to define – it looks as though it may be a shallow, in-filled channel, possibly through which drains have been laid, which might account for the linear responses. However, it shows as a high resistance feature (**R35**) which is not the expected response over a back-filled 'cut feature'. Immediately north of the *zig-zag* drains is a broad anomaly **G51** with an equivalent resistance response – both data sets show a strong, well-defined anomaly at the western end (including a rectilinear broadening adjacent to the present footpath) which becomes more diffuse to the east. The western end, in the radargrams, is the result of a broad and shallowly rounded reflector –

the question is therefore whether this might be a culvert or similar. A former metalled path could possibly produce a similar response, however this reflector appears to become deeper to the east (accounting for the diffusion of the response) and this is unlikely to occur if it were simply a former path. One might expect that if this is a culvert, it may be of contemporaneous with the Abbey's development. It is difficult to formulate an explanation for this unusual data set, but one explanation might be that this open area was home to large scale water management, perhaps a series of water meadows or similar.

3.33 There are a number of areas where increased response is thought to be an effect of landscaping. The largest of these is in the very southwest of the data, where a number of linear trends seem to arc outward in a fan-like shape, bound by the sinuous band of reflections G52. In this area, the radargrams show a dipping reflector with disturbed material over the top, which forms the current, level, ground surface. In places **G52** almost appears to have structure to it, rather being simply a spread of rubble or similar, but it is difficult to imagine what this might be.

3.34 Slightly less clear are the origins of two zones of reflections **G53** and **G54**. The former lies on the limits of a broad zone of a high resistance group **R34**, which shows a rectilinear distribution. The nearby trees complicated the interpretation of the resistance responses and there is scant documentary evidence to help firm up any hypotheses. The GPR data show a mass of reflectors with very little form to them although their distribution as a whole seems to be rectilinear. This is not to say that they are definitely of significant archaeological origins and the possibility of modern intervention remains high. The tree roots, and overground reflections from the tree trunks, have definitely influenced the deeper responses. The spread of reflectors **G54** is, again, coincident with a band of high resistance values. In the shallowest slice, **G54** is bound to the east by a low bank (as shown in Hollinrake) and with depth elongates to mirror the line of said bank, turning a right angle eastward at its southern end. The purpose and antiquity of these banks is not obvious.

4. Conclusions

4.1 Due to the prevalence of modern ferrous disturbance across the site, the magnetic survey has provided only limited information regarding possible features within and around the abbey complex. The levels of noise have made it especially difficult to identify weak negative or "neutral" responses that are commonly associated with (non-magnetic) stone walls. That said, some of the positive anomalies recorded may relate to former wall lines (rather than ditches), since it is possible they represent an accumulation of magnetic soils and debris within robber or foundation trenches. The survey has succeeded in identifying, albeit tentatively, the ditch of the *vallum monasterii*.

4.2 The resistance survey has produced numerous anomalies that are likely to represent Abbey features. Substantial surviving wall foundations have been detected, together with less distinct responses that could indicate badly damaged or robbed out walls or drains. However, the *vallum monasterii* has not been identified; it is suggested that the various phases of infilling of the ditch has produced insufficient soil moisture contrast to leave a discernible trace amongst so many other strong responses from other nearby features.

4.3 Away from the core of the Abbey complex, both techniques have revealed anomalies of possible interest; the patterns suggest a combination of possible buildings, early park features, former land plots (field divisions) and drainage. Some can be related to features depicted on late C19th OS mapping; the archaeological origin of others remains undetermined.

4.4 The GPR survey has provided wealth of three dimensional information, the complexity of which reflects the numerous phases of construction, destruction and landscaping that the site has been subjected to over its long history. The data have helped to clarify the nature (and in some cases, levels of preservation) of features detected by the other two techniques and identified a number of additional features of possible archaeological/historic interest, although the *vallum monasterii* has remained largely undetected.

4.5 While all three techniques have been successful in detecting walls, drains, paths etc. associated with the Abbey and later land use, very few anomalies have been identified in any of the data sets that can be definitively related to excavation trenches, except where such trenches have resulted in the abrupt removal of substantial stone features. It is suggested that, where this has not occurred, the soil contrast between trench backfill and the surrounding matrix is insufficient to produce well defined anomalous changes that are easily visible amongst the numerous other responses. It is possible that, once accurate trench mapping is complete, some weaker geophysical anomalies may be comparable to excavation features.

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