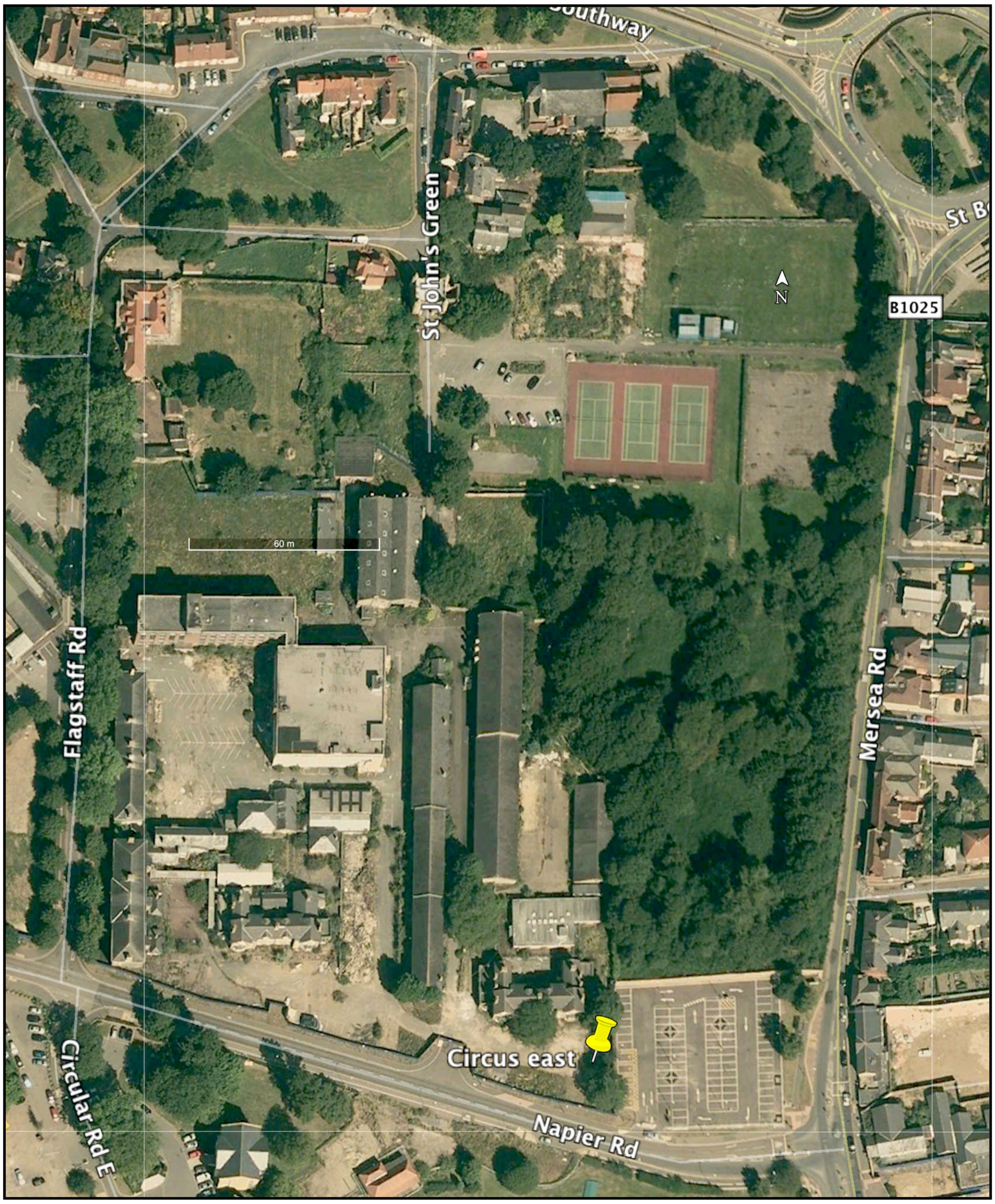

Google Earth

Geophysical surveys at the former St John's Abbey site, Colchester 2015

NGR TL99862460

T J Dennis, June 2016

Summary. Geophysical surveys using ground resistance and ground penetrating radar (GPR) were carried out in 2015 over part of the St John's Abbey site west of Mersea Road, Colchester and immediately northeast of the Colchester Roman Circus. Both media detected features from the former Abbey Gardens, mid 20th century tennis courts and modern services. Resistance located a backfilled ditch crossing the southern section of the site and parts of a rectangular outline, also detected by GPR, at the southern end. There were no indications of the Roman amphitheatre conjectured to have been at the location.

Introduction

Colchester Archaeological Group in 2015 were invited to carry-out trial excavations at the southern end of a site south of the location of St John's Abbey, on behalf of Colchester Archaeological Trust and targeting a possible location for a Roman amphitheatre. The area was formerly part of the Colchester Officers' Club site, and lies close to and north of the eastern end of the Roman Circus. It is immediately west of Mersea Road.

The excavated areas were two trenches, approximately 50 m (A) and 33 m (B) in length and 2 m in width and arbitrarily sited without reference to prior survey work. Trench A occupied the area immediately south of The Mount, an elongated mound of unknown origin. Trench B was placed further north on a lower part of the site. Fig.1 shows the locations of A and B relative to fixed site features, while Fig. 2 is an overlay on a 1907 military plan: the area at that time appears to have been landscaped or terraced and was known as Abbey Gardens. It is shown as such on maps of the early 1800s. The gardens were later converted to tennis courts associated with the Colchester Officers' Club and existed until they were abandoned in the late 20th century.

By March 2015 when the trench layout was set, the site was densely vegetated, including numerous trees, mostly sycamore, which had self-seeded from originals that probably bordered the former tennis courts. There had been an undergrowth of brambles and ivy, cleared the previous autumn. Extensive re-clearance was necessary when geosurveys followed by, and in parallel with, the excavation started in June 2015.

The report gives information on the site topography, the survey methodologies and their results. The conclusions section has suggestions on possible extensions to the survey. The appendix has photographs of the site and work in progress.

Site topography

LIDAR measurements of the ground surface, aligned to the Ordnance Survey Grid, are freely available from the UK Environment Agency[1] and a relevant area has been processed to generate Figs. 3a and 3b. The data are the Digital Surface Model, which includes such as buildings and trees. Fig. 3a interprets as greyscale video a 2 km x 2 km array of samples covering mostly the western part of Colchester. The picture demonstrates how the town centre, the area within the Roman wall, is on a promontory bounded by the floodplain of the Colne on its northern side and a shallow valley to its south. The St John's Abbey site is further south still, on the north-facing slope of the valley; the slope flattens to the area bordering Abbey Fields, and which accommodated the Roman circus.

Fig. 3b is a 400 x 500 m enlargement covering the St John's Abbey site overlaid by a series of paths, inserted manually. The coordinates of the nodal points on these are extracted and subsequently used to generate sets of uniformly-spaced samples interpolated from the 1 m array that can then be plotted to illustrate the vertical profile along each original path. They all follow a roughly south-north alignment, avoiding buildings and trees, starting and ending on baselines 350 m apart with fixed Y-coodinates. Figs. 4a - 4c plot sets of the profile values versus their OS Y-coordinates. Profiles 3, 4 and 5 illustrate the terracing process that has been carried out over the area: exactly when this was done is not known, but still-surviving elements

1. E.g. to download data for grid square TL92 in ASCII format see: http://www.geostore.com/environment-agency/survey.html#/survey?grid=TL92

of the Abbey Gardens in Fig. 2, in particular a set of steps, suggest it might have been for their construction. Further levelling must also have been done to accommodate the later conversion to tennis courts. Profile 6 may match more closely the 'natural' slope of the landscape, at least as far as point 8 which is at the edge of large-scale earthworks carried-out in the 1970s to construct the St Botolph's roundabout and Southway.

Geophysical Survey Methodology

Two of the three 'standard' geophysical methods were used on the site with magnetometry excluded because of extensive ferrous debris, and known underground service feeds.

Ground Resistance. The survey used a TR Systems Resistance Meter, type TRCIA 1.31 (Fig. A1). This is a twin probe device where a current source[2] produces a small fixed alternating current (≈6 mA) that flows between one remote fixed electrode and one on the instrument. Voltage is measured between the other two electrodes, remote and on the instrument. The complication is to overcome effects of electrode contact resistance and electrolytic polarisation. The probes are of stainless steel and spaced at 0.5 m on the instrument. Full details of the technique are available in Clark[3] and operating recommendations are in the TR Systems manual[4].

The ratio of voltage and current gives a value in ohms which is dependent on the characteristics of the soil at both mobile and fixed electrode pairs. Because the remote pair do not move, any *variation* reflects conditions at the mobile locations only. Absolute values do not matter, but can lie in the range 20 Ω to 6000 Ω. Around 200 Ω is typical. Variations are caused by soil type and moisture content, both of which can in turn be affected by subsurface features of archaeological significance. The system is sensitive to depths about 1.5 times the probe spacing, so here 0.75 m.

The operating mode used a maximum traverse length of 30 m with 60 samples at 0.5 m intervals. Tracks were spaced at 0.5 m intervals, and covered using a zig-zag pattern. Up to 60 tracks could be done at a time, limited by the length of the cable to the fixed electrodes; for orientation-independent measurements, these have to be at least 15 m from the nearest part of a survey block. This site contained inaccessible points or areas, mostly due to trees, in which case null readings were recorded. This site was relatively small, so the remote probes could be left in place between blocks; they were also replaced in the same holes between sessions on different dates so as to minimise mean level offsets between blocks. However, offsets can still occur between dates if soil moisture levels change, for example due to rainfall.

For complex surveys like this one, it is useful to extract data for each survey block into an intermediate 'XYZ' format; by adding appropriate offsets to the X and Y coordinates (Z represents resistance), and using a 'globbing' option[5] on the main processing application, it is then possible for that program to read-in and use the XY coordinates to set-up an image data array of the appropriate size to contain all blocks; this can then be processed as a single unit, so

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2. An electrical current source is designed to maintain a fixed current through a load, whatever the load resistance. The upper limit of resistance is determined by the maximum output *voltage* the source can support.
3. *Seeing Beneath the Soil.* A. Clark, Batsford Ltd., 2000.
4. *TR Resistance Meter, Instruction Manual*. TR Systems Ltd., Peterborough, 2002.
5. 'Globbing' is a command-line option in Unix-like operating systems that allows selection of groups of files sharing similar names. For example, a specification like '`res*.xyz`' will generate a list of all files whose names begin and end with '`res`' and '`.xyz`' respectively.

avoiding block boundary artifacts. Duplicate points at block edges (sampled more than once) are averaged. Offsets can be added to the resistance values of each raw block to minimise residual mean-level difference effects. A further adjustment of gain is available in an attempt to compensate for changes in sensitivity that can be caused by differences in moisture levels between sessions. Missing samples or blocks will be interpreted as transparent in subsequent processing.

Ground Penetrating Radar. The system used was a Groundvue 3 unit supplied by Utsi Electronics Ltd (Fig. A2). It is fitted with a 400 MHz antenna system and uses a WiFi link to communicate with a laptop PC which controls sampling rate and time window, and stores the raw data collected. The laptop and its batteries are carried on the antenna box itself. Sampling is controlled by a shaft encoder fitted to a sense wheel attached to the antenna box.

Survey parameters summary

Ground Resistance (TRCIA 1.31)

Nominal survey block size	30 x 30 m
Traverse length	up to 60 samples
variable?	Yes, up to current maximum.
Traverse spacing	1 m (exceptionally 0.5 m)
Sample spacing in traverse direction	1 m (exceptionally 0.5 m)
Sample averaging time	0.5 s ('Rural' mode)
Mobile electrode spacing	0.5 m
Fixed electrode spacing	≈0.5 m
Instrument range setting	200 Ω typ.

Ground Penetrating Radar (Utsi GV3, 400 MHz)

Nominal survey block size	Typically 40 x 40 m
Traverse length	As necessary, but as long as possible
variable?	Yes
Traverse spacing	0.5 m
Sample spacing in traverse direction	2.5 cm (40 samples/m)
Traverse speed	Not critical. Up to ≈2 $m.s^{-1}$.
Time window	40 ns (Assuming Er[6] = 10 which is typical for sandy soils, the maximum sub-antenna depth detected will be approximately 2 m.)
Samples per time window	256

6. Er = relative dielectric constant of a medium. Propagation velocity of RF through physical media is $v = c/\sqrt{Er}$, where c is velocity of light *in vacuo*.

Results

Ground resistance. Fieldwork for Area A was carried out over eight sessions between 25 June and 23 July 2015, and for Area B one session on 27 July 2015. The extended period for A means that soil moisture levels will have changed significantly between sessions, and affected the results, most likely reducing dynamic range when wet.

Results are in Figs. 5a and 5b. 5a is relative to the overall mean level while 5b uses a highpass filter which allows the video dynamic range to be reduced, hence increasing contrast, and so enhances small-scale features that would otherwise be swamped by wider range variations. Fig. 6 gives statistical distributions (histograms) of the raw data; the wider range (increased σ) for Area A reflects its larger area and hence greater scope for contrasts. It is noticeable that the 'noise' level (graininess) is highest towards the eastern side of the site, probably a result of electrical interference from vehicles and services, especially mains electricity, on Mersea Road nearby.

Area B was surveyed late in the season after the opening of Trench B. It has few natural features. Voids on its western side are due to the spoil heap. The dark strip is from samples within the trench itself.

<u>Numbered features</u>

R1. Low-resistance linears, representing fence lines of the former tennis courts. Physical remains of these were exposed during the excavation of Trench A.

R2. Surviving stone wall constructed from dressed stones, almost certainly remains of the demolished abbey buildings (photograph inset in Fig. 2), and presumably a survivor from Abbey Gardens. The wall serves as a retainer for the path bordering Area B, which is at a lower level than A.

R3. 'Tramlines'. Remnants of a footpath in Abbey Gardens, marked on the 1907 map in Fig. 2.

R4. Low-resistance linear that correlates with a gas main also indicated in Fig. 2.

R5. Water main on Fig. 2.

R6. Unidentified broad varying-intensity linear on a marginally different alignment to the recent features elsewhere – it may also curve slightly. Characteristic of a ditch or channel backfilled with more water-retentive material than elsewhere. It has reduced contrast towards its eastern end, but this may be an artifact connected with the time of the survey over that part of the site. The western end of R6 connects with a wide (≈5 m) low resistance band aligned southwest to northeast.

R7. High-resistance 'L' shaped linear, narrow on its east-west section. This correlates with a rectangular response on the ground radar.

R8. Low-contrast ovoid feature. Its 'sharpness' is characteristic of a near-surface origin, but nothing was visible during the survey or later.

R9. Low resistance rectangular corresponding to a depression of recent origin.

R10. Chaotic responses close to the lower boundary of The Mount, marked by survey points 25 to 32. This region had dense vegetation cover, mostly ground ivy and saplings of elderberry and sycamore, both standing and fallen.

Ground Penetrating Radar

The GPR survey was carried out over eight sessions between June and September 2015. To maximise coverage of a site with as many obstructions as this one, blocks were mostly small, at varying orientation with frequent overlaps. The output images are in the form of mosaiced timeslices; the image takes the average of values from overlapping blocks where this happens. The coordinate system is the same as for ground resistance, but later extended to include a strip within the Officers' Club grounds to the north of the excavation site: this was chosen because it was easily accessible and may not have been landscaped in recent times.

The raw data can be thought-of as generating a series of images stacked on their long edges like a pack of cards: each image is a vertical slice showing the reflection pattern below ground, its horizontal axis distance along a track, vertical time which is proportional to depth. The preferred display is in 'timeslice' format which is effectively a horizontal slice through the cards, taking one line of the output image from each card, and gives a plan view of the signals at a fixed time delay. Ideally this also means constant depth, but may not if subsurface conditions are highly variable.

The main signal processing operations are:

1. Normalise the number of samples per track to that expected for track length and sample spacing: variations are in the range ±2%, typically due to uneven surface conditions, and there may be a systematic error from the sense wheel. Straightforward processing using a standard image scaling routine with bicubic interpolation.

2. Filter-out fixed near-surface (short delay) reflections which are due to direct transmit-receive antenna coupling. Perform 'full wave rectification' to obtain the signal magnitude.

3. Compensate for increasing signal attenuation with time delay/depth. This attempts to equalise the signal RMS value over all timeslices, which typically requires attenuation of near-surface slices and amplification of deep ones. The dynamic range can be large, 70 dB or above.

4. Scale as necessary to equalise resolution in X and Y. All images are 10 pixels/metre.

Results. The outcomes of the GPR survey are given in Fig. 7 in the form of representative timeslice images. Features are numbered and described briefly in the figure captions; any that appear on more than one slice are identified with the same number.

The shallow timeslices, Figs. 7a and b, are dominated by typical near-surface features, mainly radiating tree roots, remnants of the former tennis court fences and garden footpaths. There can also be effects due to vehicle tracks, either from surface indentation or soil compression which increases signal reflection potential.

In Fig. 7c, G5 and G6 are identifiable from the 1907 map of Fig. 2 as sewer and gas mains respectively. Both were later exposed during the excavation, G5 as a large diameter earthenware pipe and G6 as 4 inch iron. The latter connects with an inactive gas metering station inside the Mersea Road wall. G7 is another response characteristic of a pipeline, but has no counterpart in Fig. 2 and is on a slightly different alignment to such as footpaths in the former gardens. In Fig. 3b it lies west of profile 5, on a bank that slopes towards a (post-1907) landscaped edge to a modern carpark. Detection of pipelines is useful in giving assurance that soil conditions allow solid subsurface objects to be detected at all and it calibrates the actual depth of features when they can be confirmed by excavation, as here in two places.

G10 is a feature of probable archaeological significance, but of unknown origin; it is also detected by ground resistance as R7, showing most clearly as locally higher resistance in Fig. 5b.

In Figs. 7d and especially 7e, G12 becomes increasingly structured, suggesting coherent but low-density foundation remains.

In Fig. 7f, G10 has disappeared, with the striated features of G15 becoming the most significant. In this slice the region containing Trench A has a vaguely ovoid area of strong responses, centrally located and bisected by the possible ditch G13.

Conclusions

Both of the active geosurvey methods detect more than obviously recent features, and others, especially on resistance, that are likely to be of geological origin. There is nothing characteristic of the large-radius curving outline or outlines that might be expected of a Roman amphitheatre. This does not prove that an amphitheatre does not exist, but makes it less likely for this site[7]. The results do show indications of surviving subsurface remains, like foundations, that could be of Roman or Mediaeval origin. Roman is the more likely, as that was the principal origin of the extensive scatter of artifacts, mostly pottery and tile, recorded during the excavations.

On this site it is unfortunate that the limited excavation area permitted was set-out before the geosurveys could be carried out: the GPR especially points to areas that may have been more productive, for example associated with feature G10. In addition, delay in accessing the site for surveys meant that full coverage was not possible. Should access become available in future a recommendation would be to extend noninvasive survey coverage to include the full width of the northern section of the site containing Trench B.

Acknowledgements

Thanks are due to CAG members who assisted in the layout and clearance of the site, and during the survey work itself.

7. The more likely possibility is said to be in the Roman and Castle Roads area of Colchester. See: http://www.eadt.co.uk/news/expert_homes_in_on_roman_riddle_1_192639

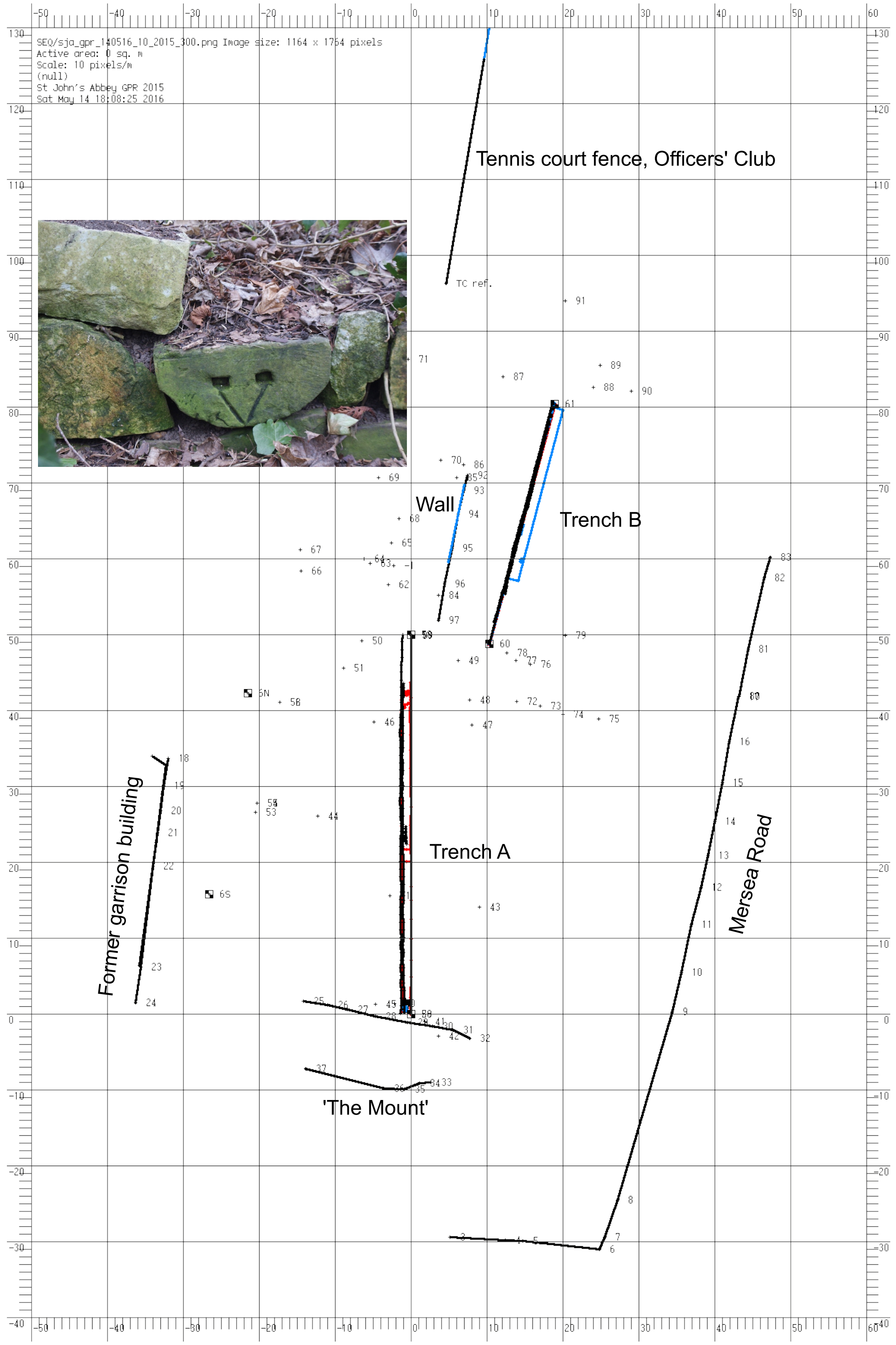


Figure 1. The site grid with reference measurements plotted-in. The feature labelled 'Wall' borders what is presumably the north-south path in Abbey Gardens. It is constructed from recycled shaped stone blocks as shown in the photograph. Isolated points correspond to larger trees.

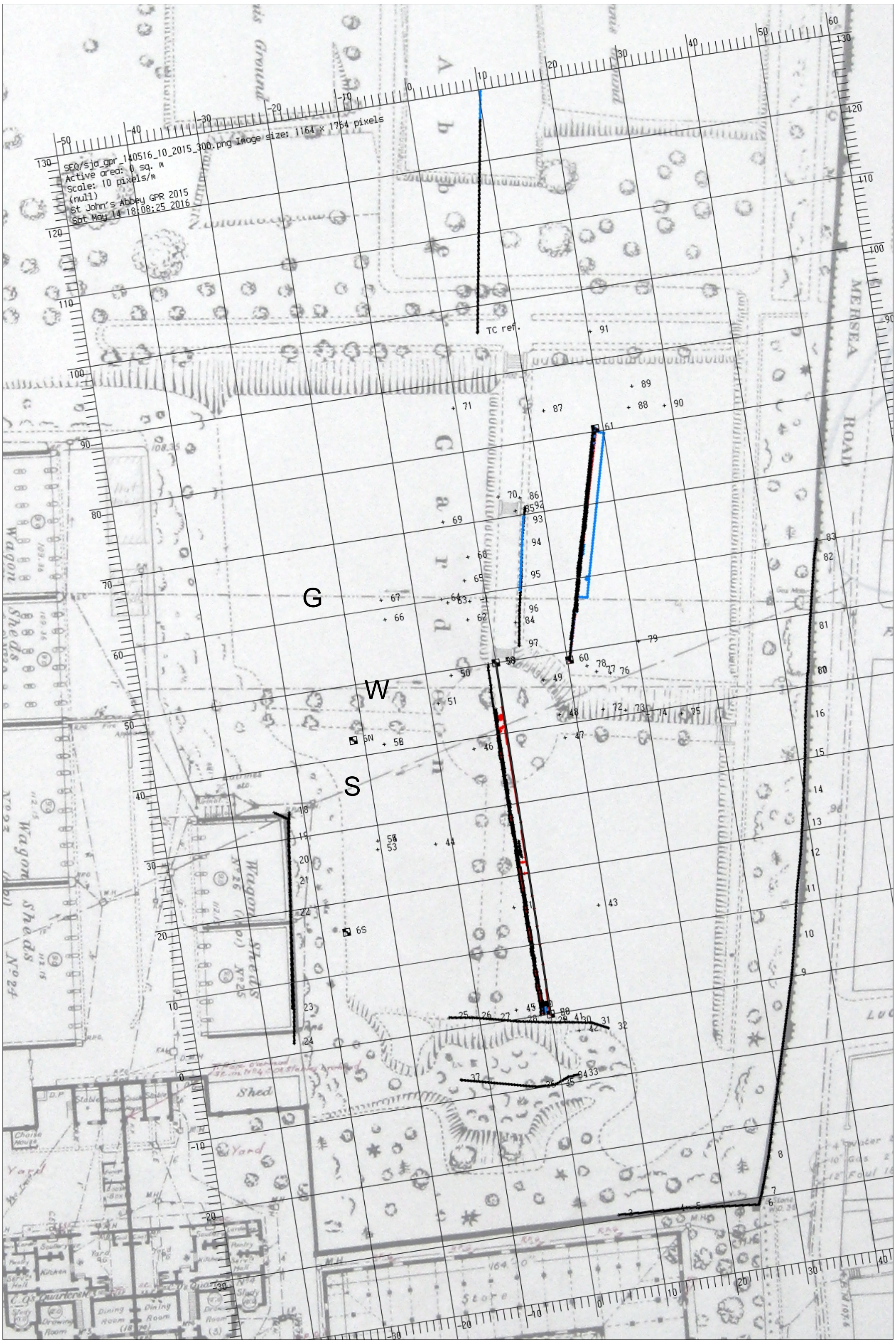


Figure 2. The 2015 site layout aligned with a 1907 military map. W, G and S are water, gas and sewage mains respectively.

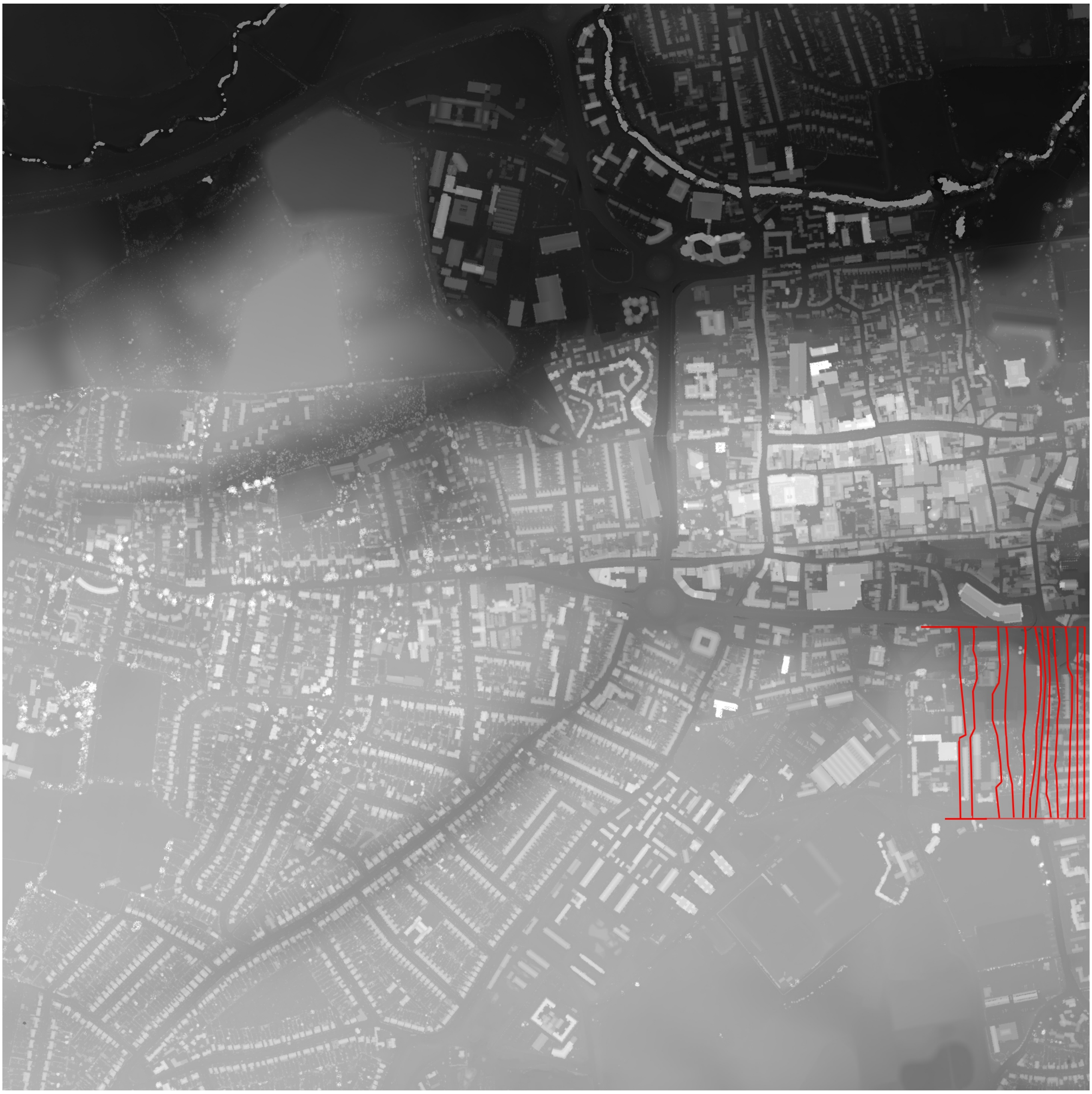


Figure 3a. 'Digital Surface Model[8]' LIDAR data interpreted as greyscale, video dynamic range 50 m, mean level subtracted. Red lines identify sources of profile plots. The image shows a 2 km x 2 km area covering western Colchester. Source data resolution is 1 sample/metre; the data are georeferenced to OS Grid and the southwest and northeast corners are at OS 598000, 224000 and 600000, 226000 respectively.

8. DSM includes all surface features like trees and buildings, as distinct from Digital Terrain Model (DTM) which attempts to construct the underlying natural ground surface.

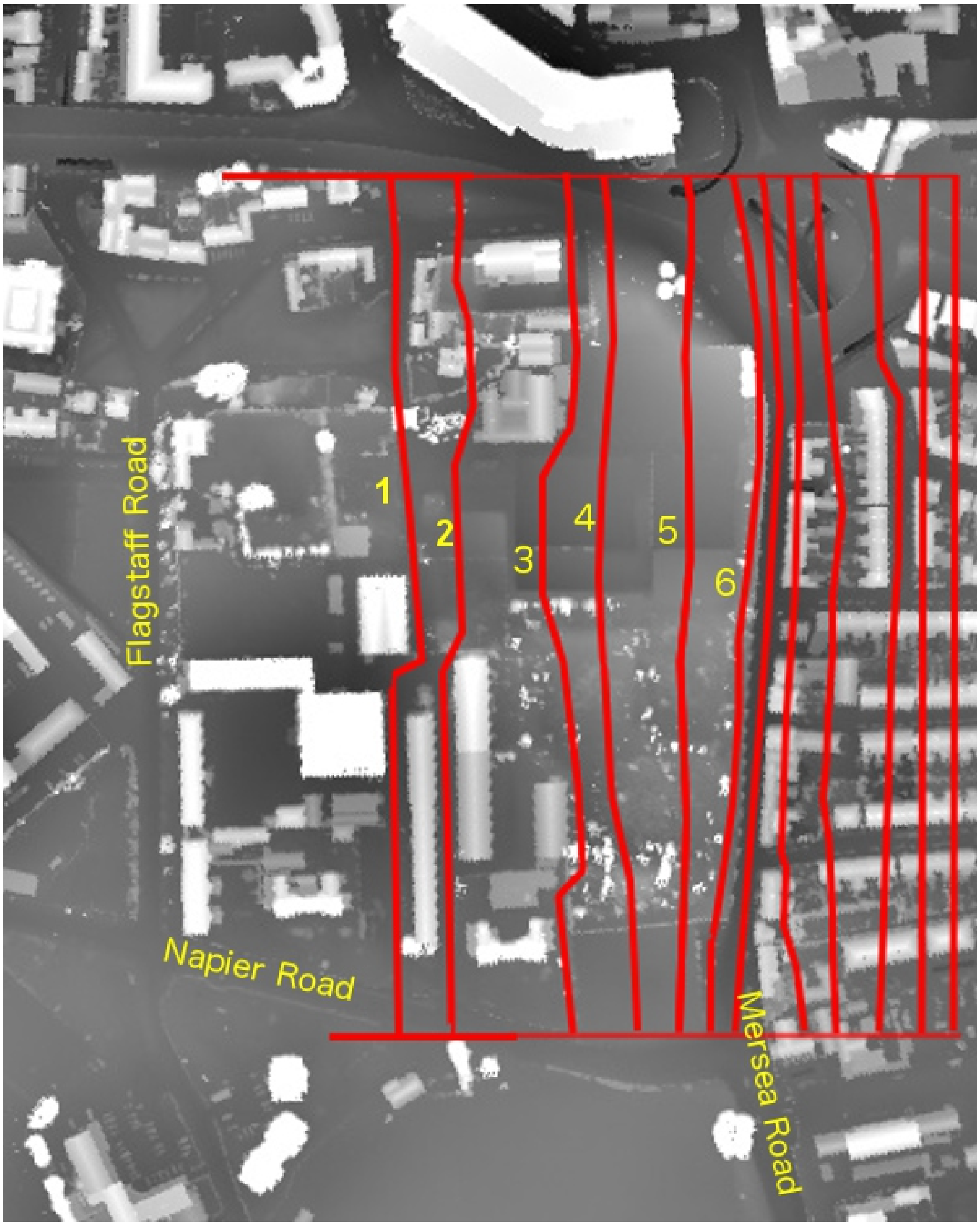
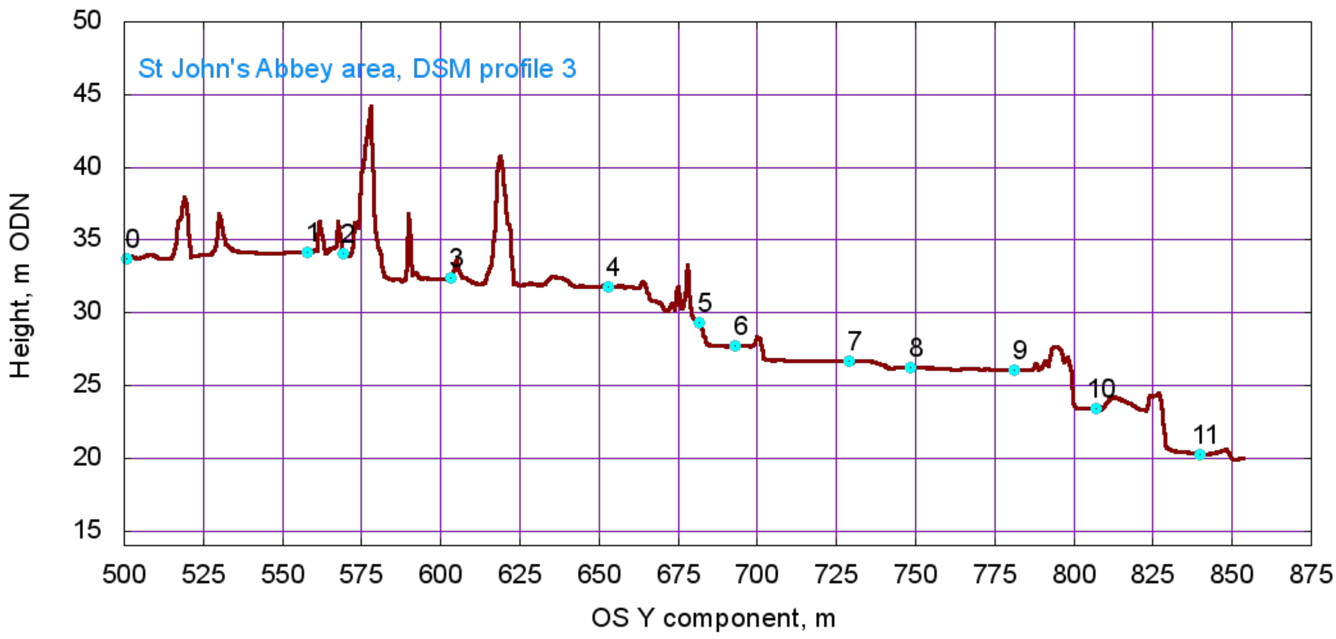


Figure 3b. Closeup of the profile data source paths. Nos. 3 to 6 target the excavation site.



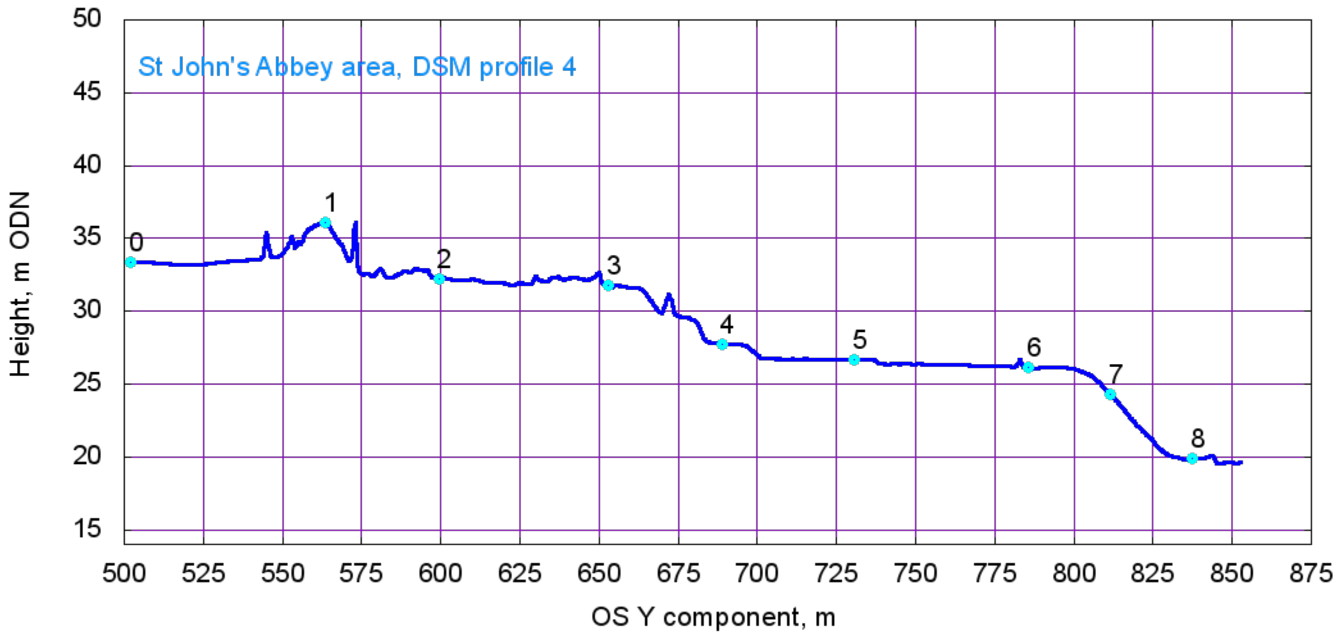
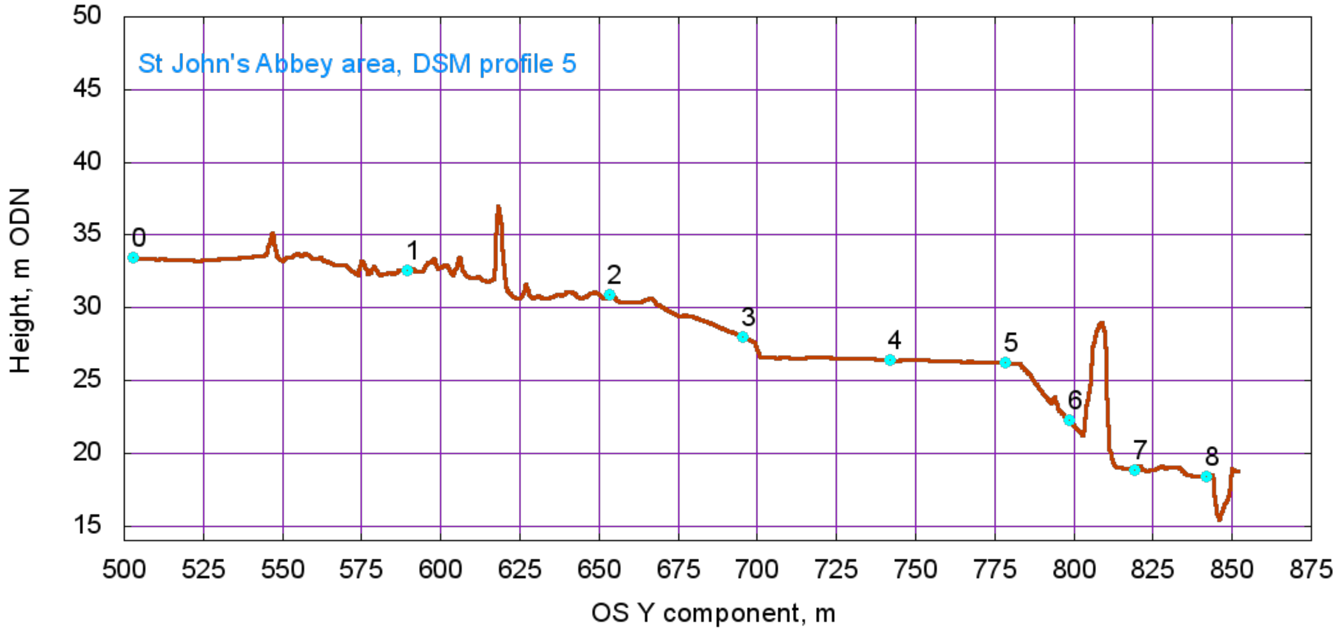


Figure 4a. South to north vertical profiles for paths 3 and 4 (Fig. 3b) plotted versus the Ordnance Survey Y-component relative to 224000. Numerical labels indicate starting points of individual straight-line segments in which values are interpolated from the original 1 m sample grid at 0.25 m radial intervals. Near-horizontal sections correspond to the various terraced levels on the site. Point 1 on profile 4 is where it crosses The Mount.



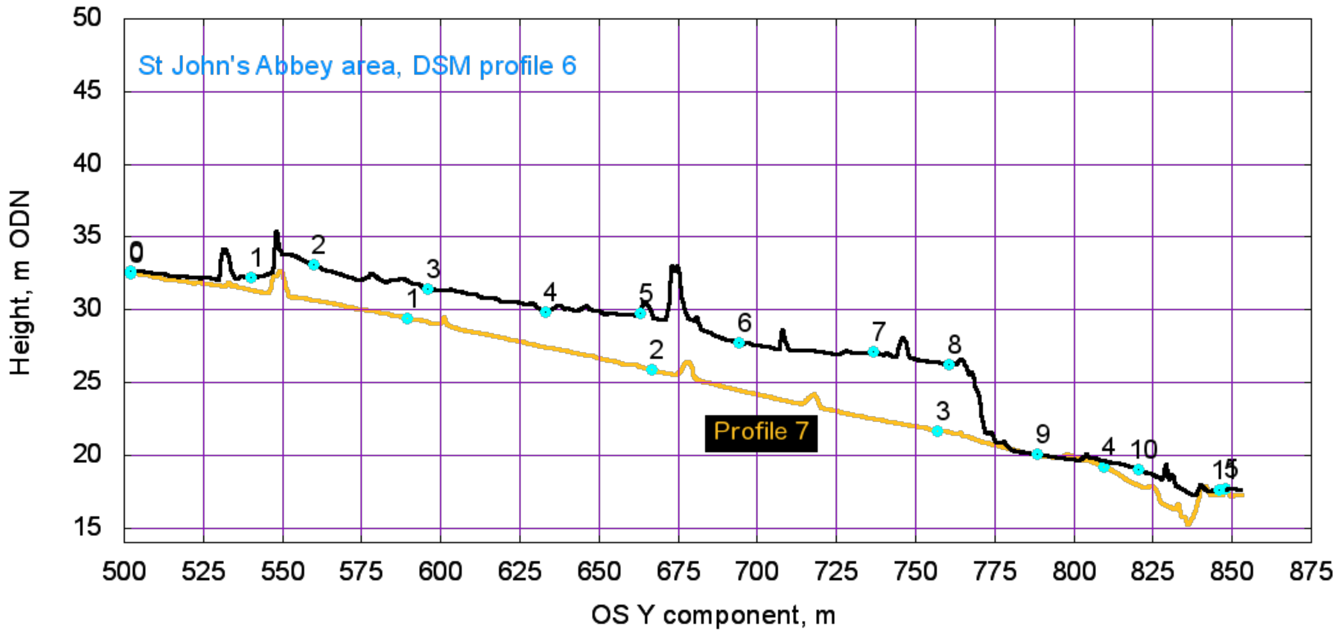


Figure 4b. Vertical profiles 5 and 6. No. 6 targets a narrow strip immediately west of the retaining wall along Mersea Road, and may provide an indication of the natural slope of the site, at least as far as point 8. The profile taken along Mersea Road itself (no. 7) is included in the plot. On plots 4 to 7, the spike on or adjacent to 550 m on the horizontal axis corresponds to the surviving section of Abbey Wall that forms the southern boundary of the site.

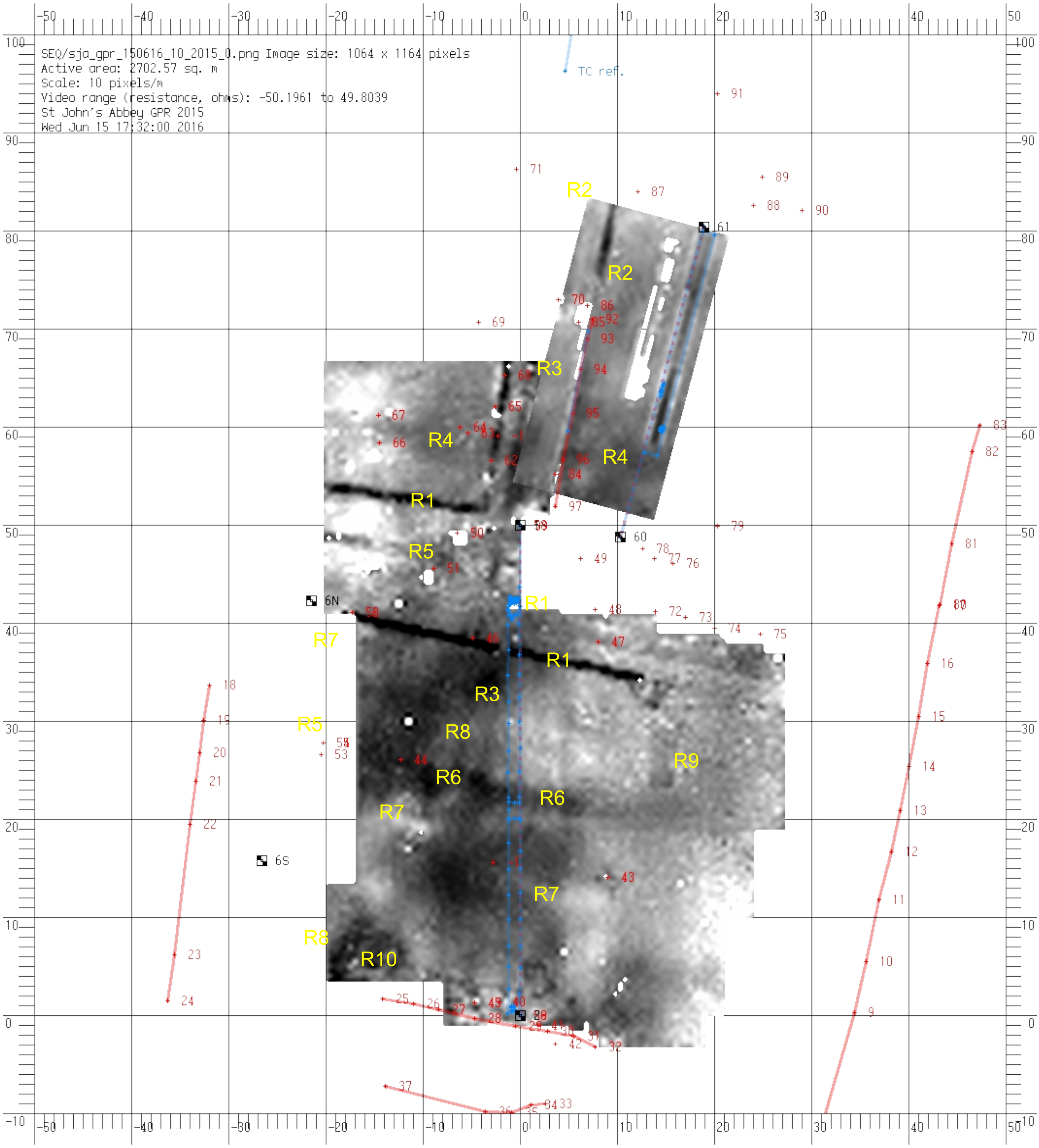


Figure 5a. Ground resistance image on the site grid covering areas adjacent to Trenches A and B, mean level subtraction only. The dynamic range is ±50 Ω. The mean (zero) level is represented by mid grey. Darker implies lower resistance than the mean, bright higher. Spurious features at overlapping sub-block boundaries are likely to be artifacts due to varying soil conditions when areas were surveyed at different times. Voids are where samples could not be taken due to physical obstructions. Labelled features are discussed in the text.

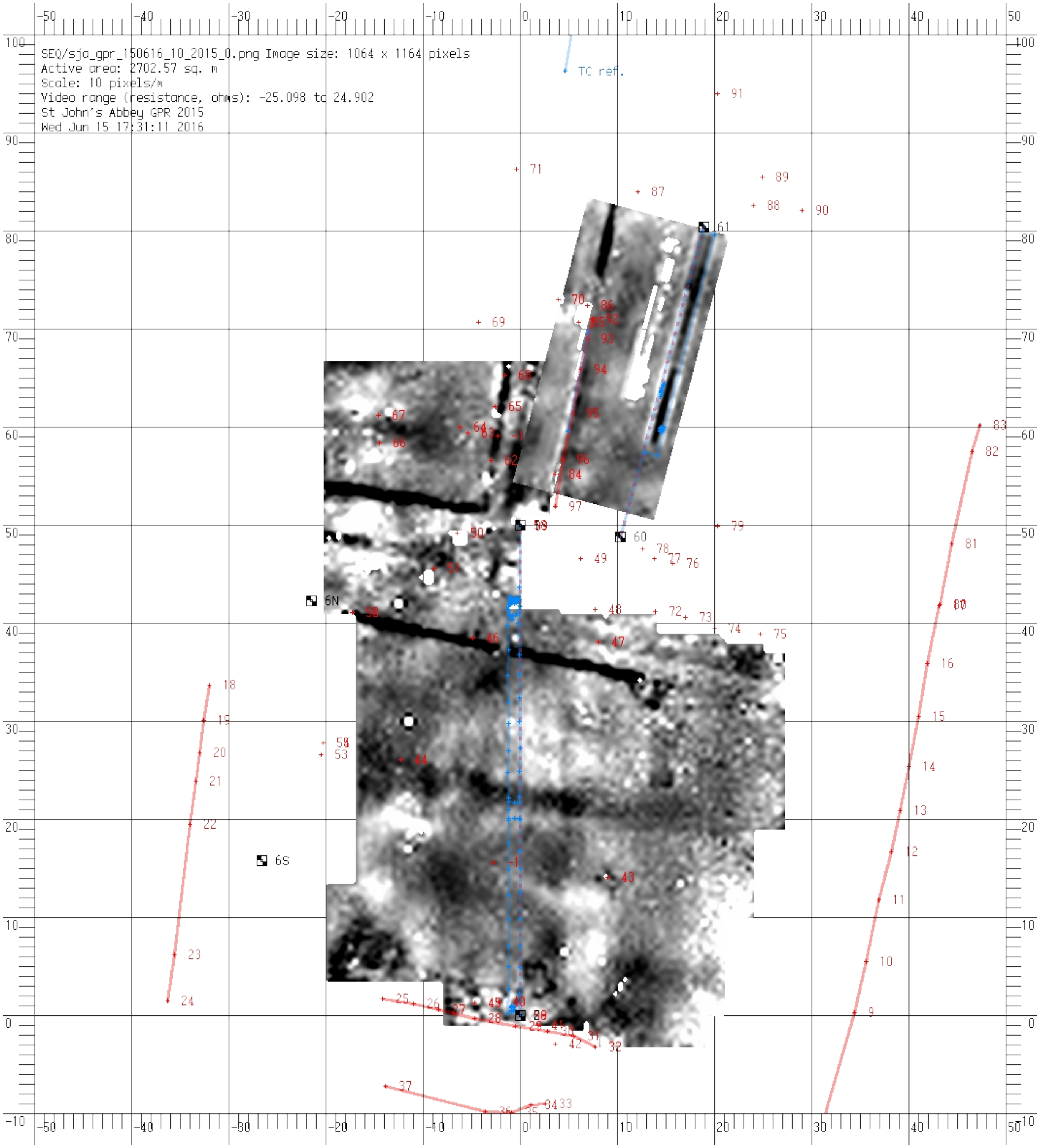


Figure 5b. Ground resistance highpass filtered (2D Gaussian, sdev 8 samples ≡ 4 m). Dynamic range ± 25 Ω.

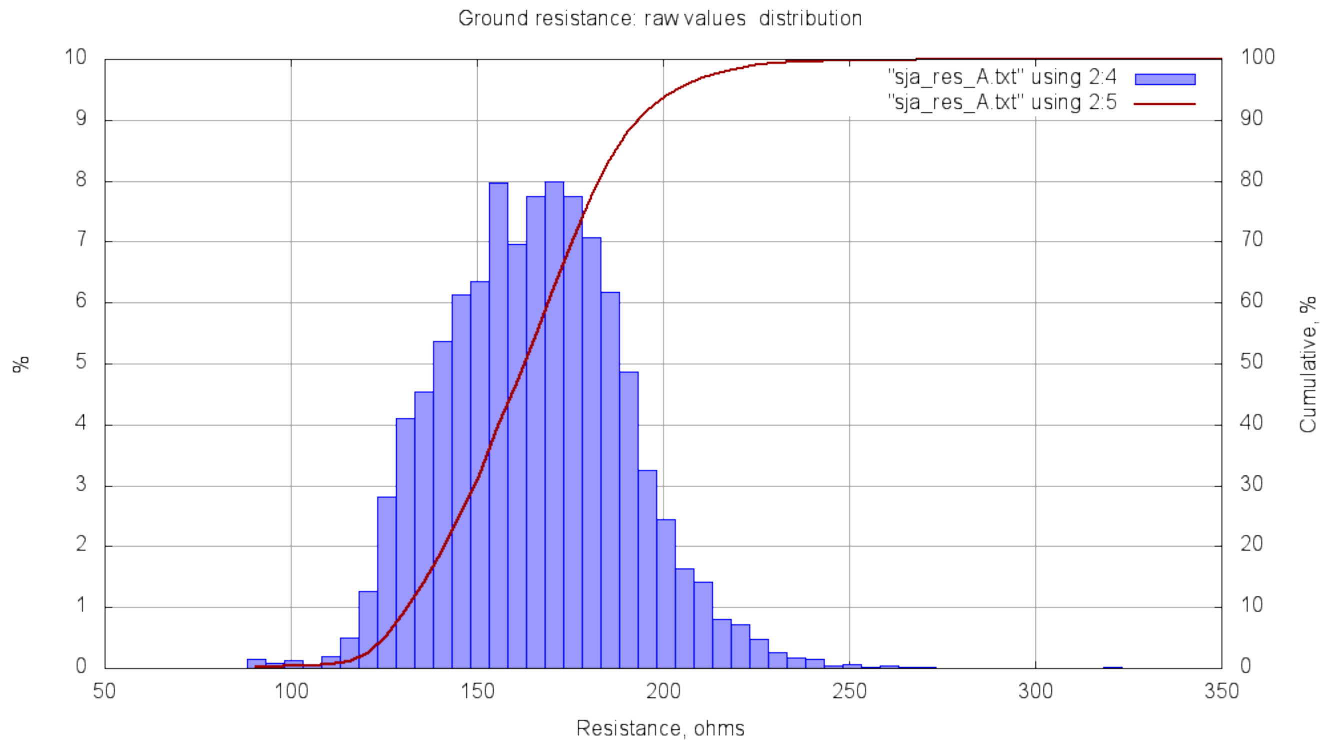
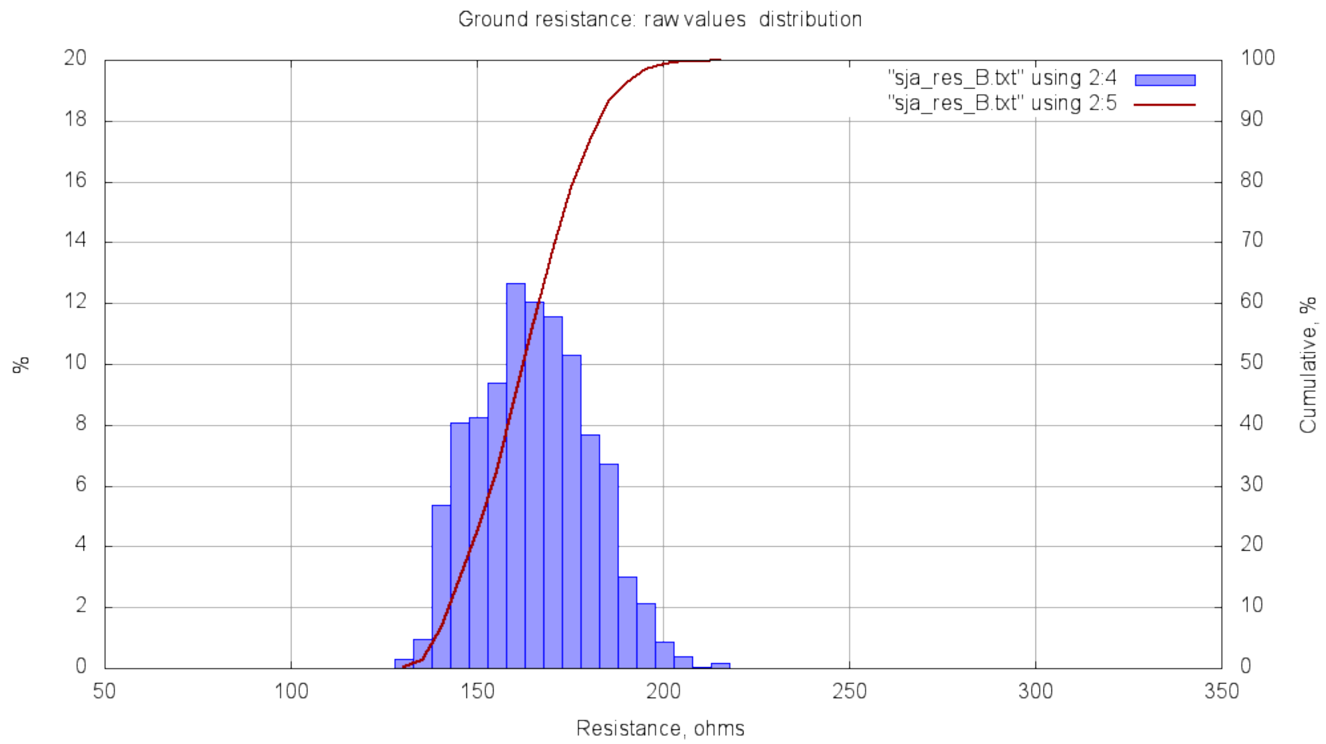


Figure 6. Statistical distribution of raw resistance data for the area containing Trench A (above), and Trench B (below). Histogram bin size 5 Ω.

Trench A: max, min: 370.858 90.539. Mean, sdev: 167.929 24.7367 (all Ω)
Trench B: max, min: 218.006 130.255. Mean, sdev: 167.682 15.0674



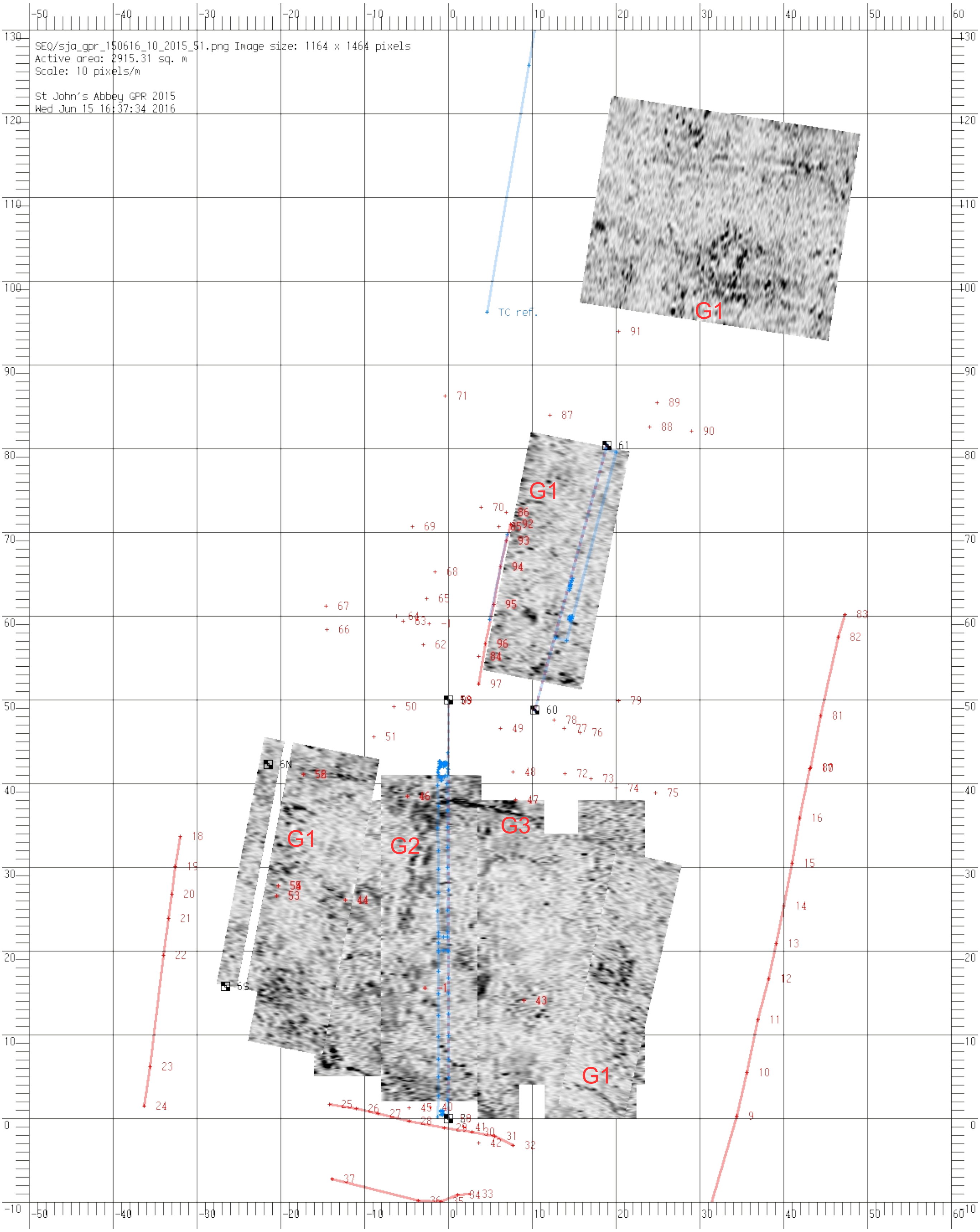


Figure 7a. GPR timeslice 51. Depth ≈ 0.4m. G1: tree roots; G2: 'tramlines' from former Abbey Gardens path; G3: residual feature from former tennis courts.

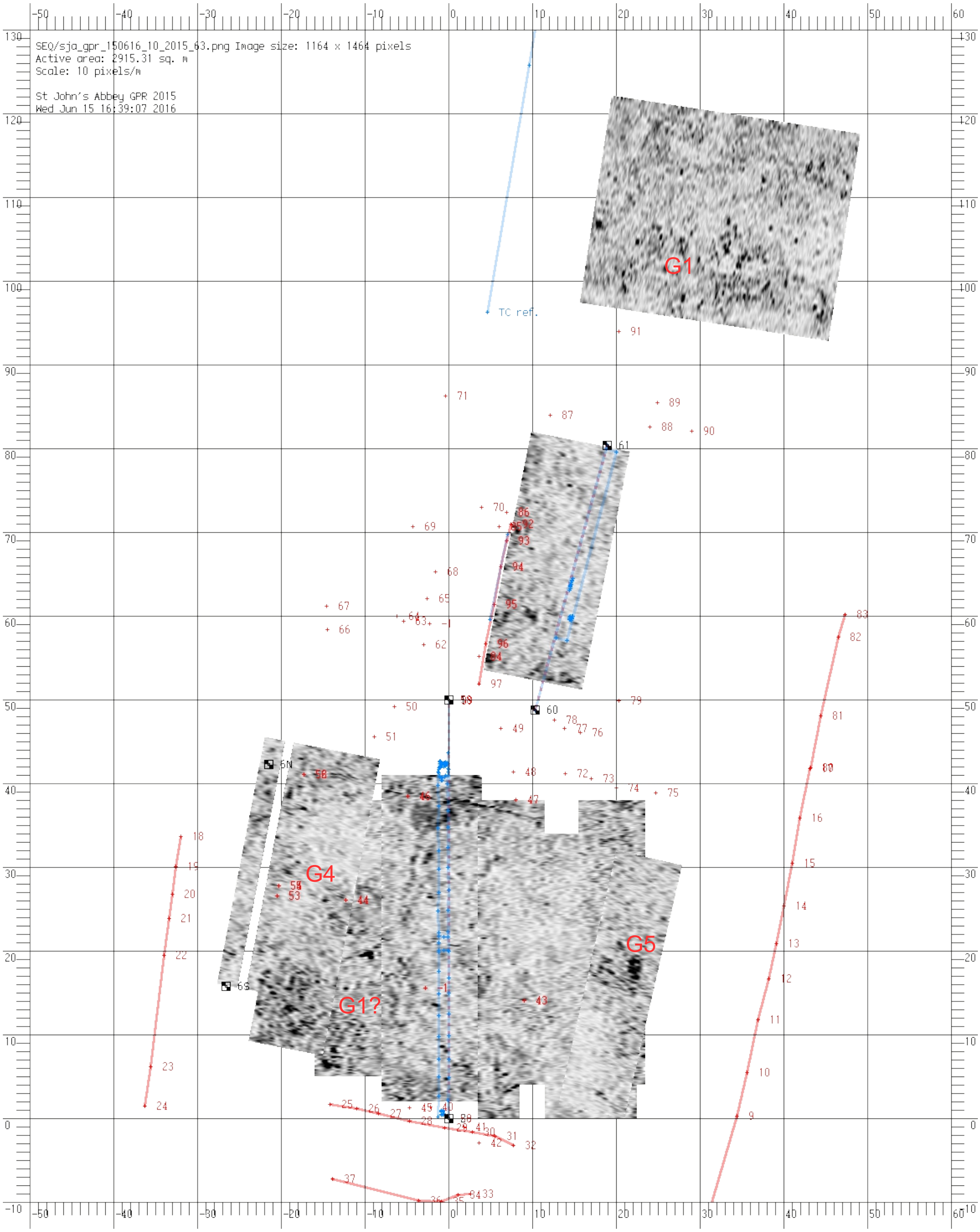


Figure 7b. GPR timeslice 60. Depth ≈ 0.47m. G1: tree roots; G4: parallel lines, possibly recent vehicle tracks; G5: solid reflecting surface, possibly brickwork.

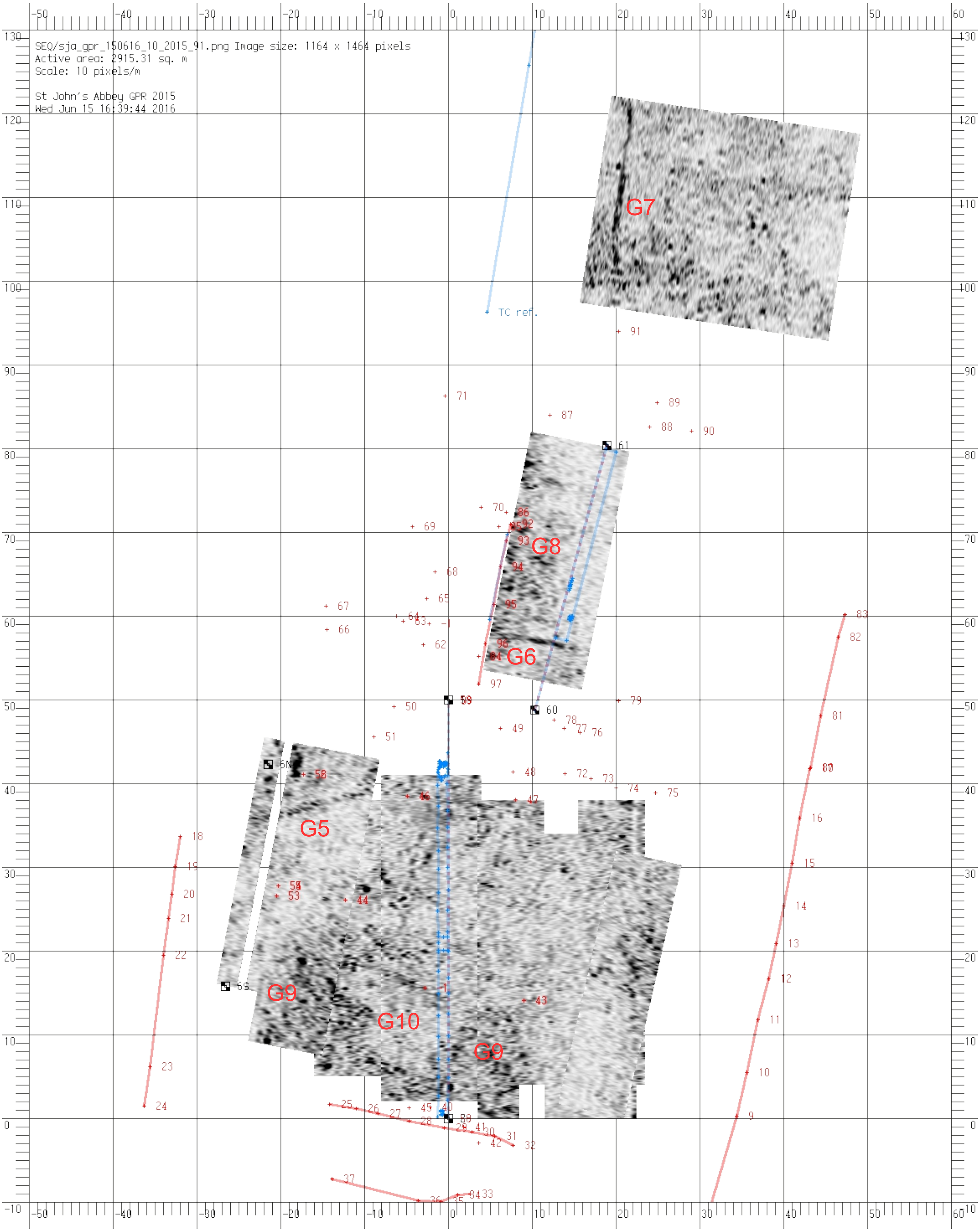


Figure 7c. GPR timeslice 91. Depth ≈ 0.71m. G5 – G7: typical pipeline responses. G8: possibly tree roots. G9: generally active areas. G10: significant L-shaped outline with 90° corners; within it the signal level is lower than outside.

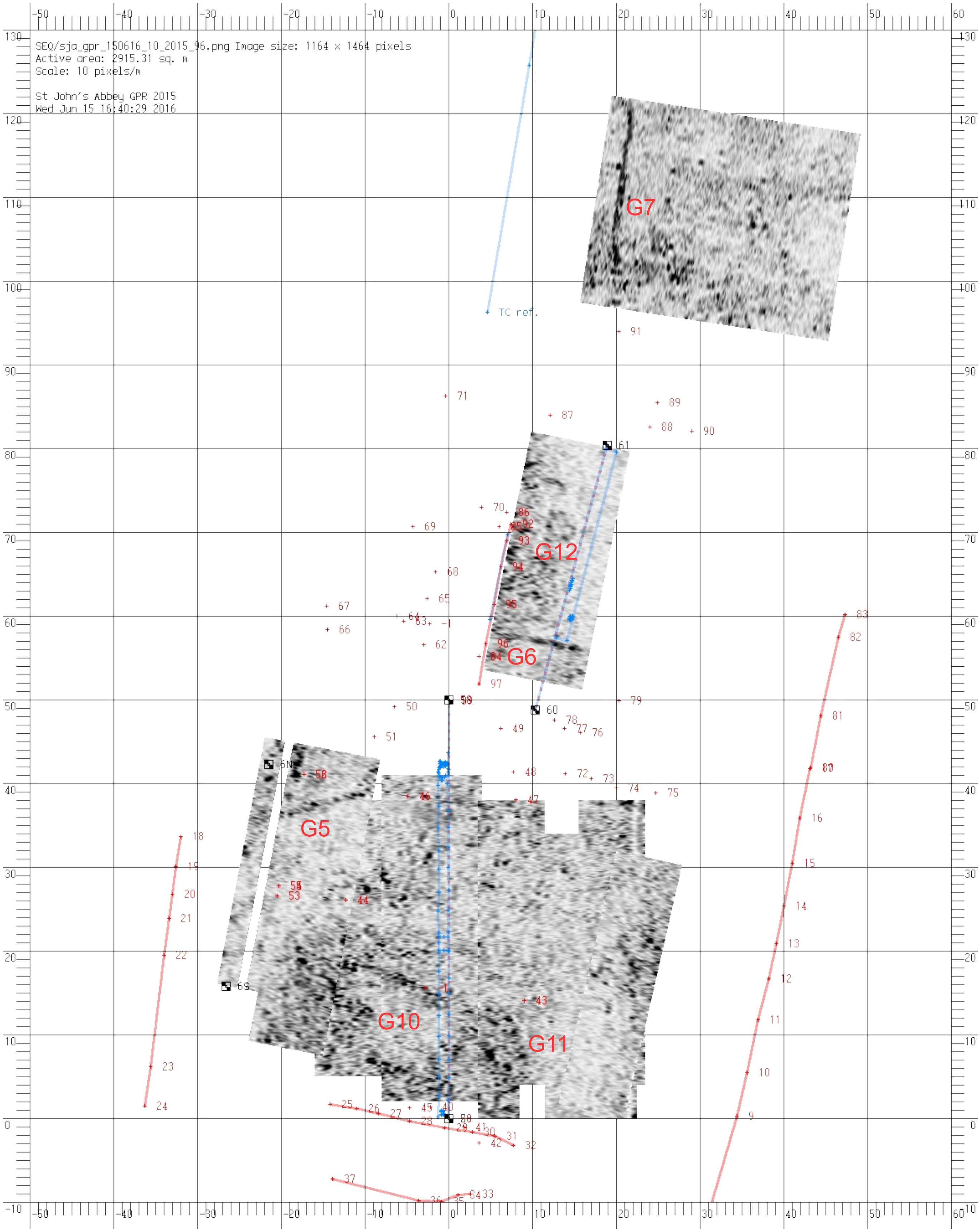


Figure 7d. GPR timeslice 96. Depth ≈ 0.75 m. G5-10: continuation of features from Fig. 7c. G10 has improved definition. G11: cluster of isolated responses, possibly structured and characteristic of solid remains. G12: increasingly coherent responses, including a linear suggesting a small-diameter pipeline, unidentified.

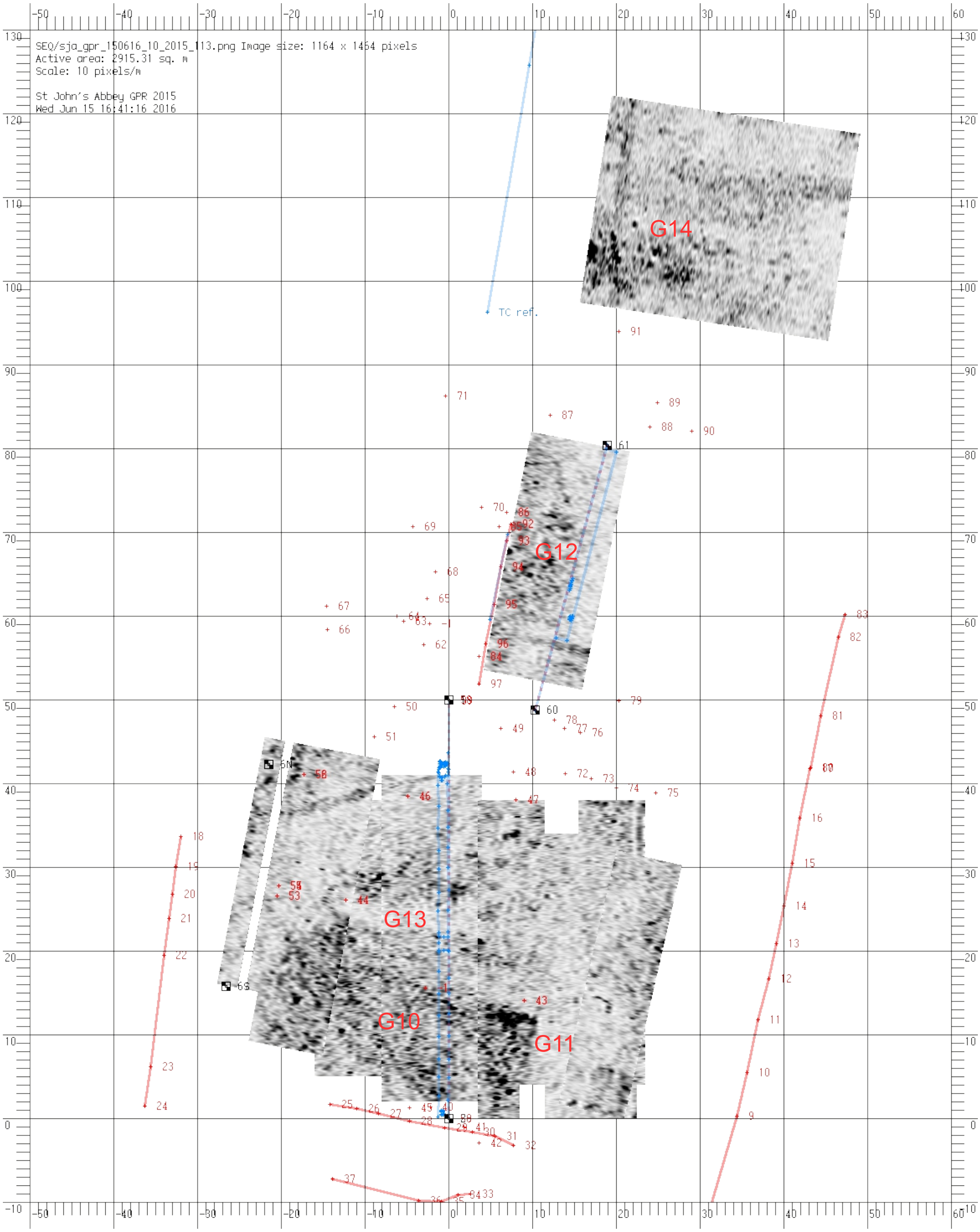


Figure 7e. GPR timeslice 113. Depth ≈ 0.88 m. G10: L-profile outline is less well-defined and has an active interior. G11: well-defined eastern edge, with strong reflections. G12 now has a low-contrast geometric outline. G13: linear void characteristic of a ditch backfilled with homogeneous material. Does not exactly match R6. G14: region of unstructured responses characteristic of a scatter of solid surfaces.

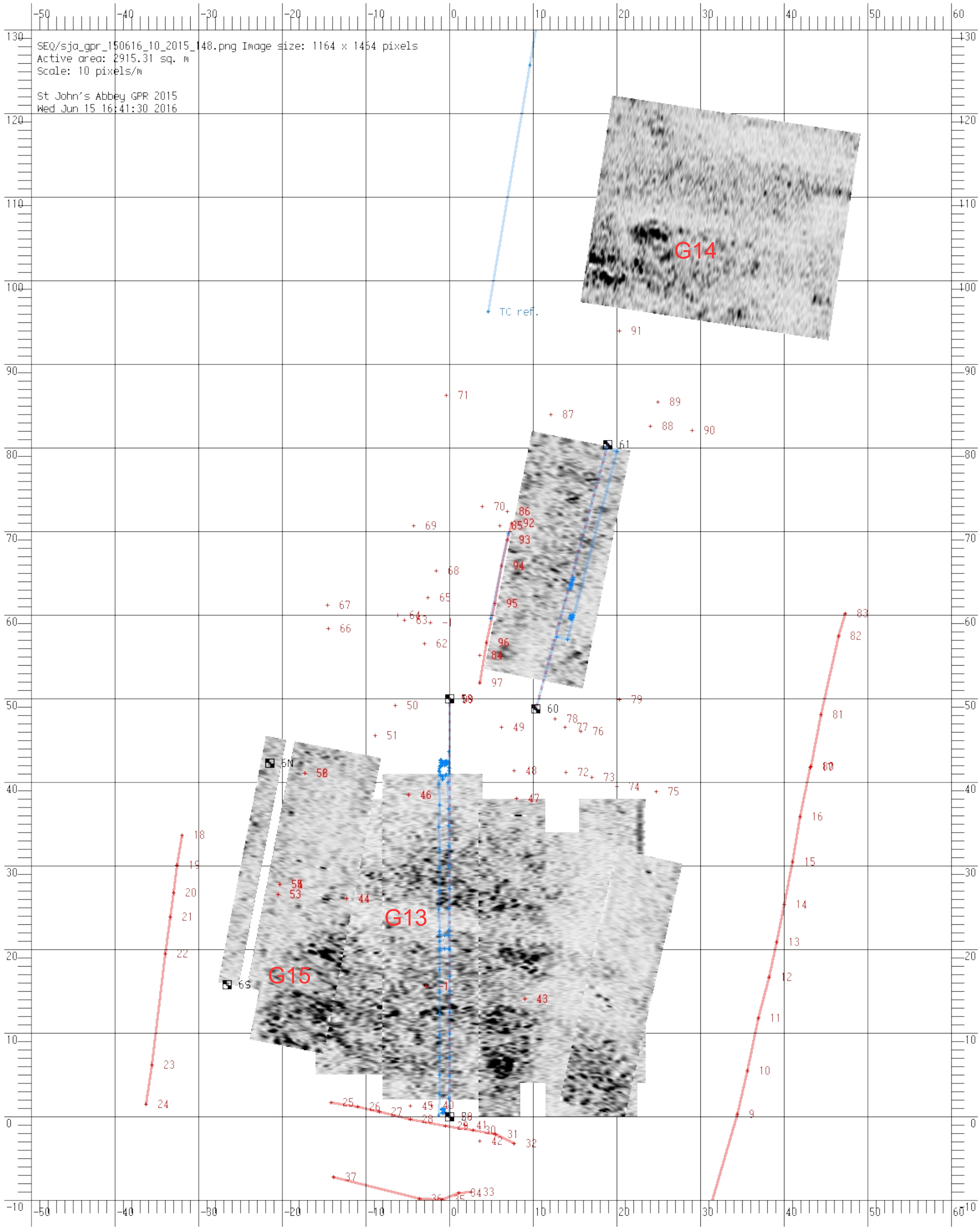


Figure 7f. GPR timeslice 148. Depth ≈ 1.16 m. G13: as previously. G14: more strongly defined. G15: striated region, with a directional trend that continues across this part of the site.

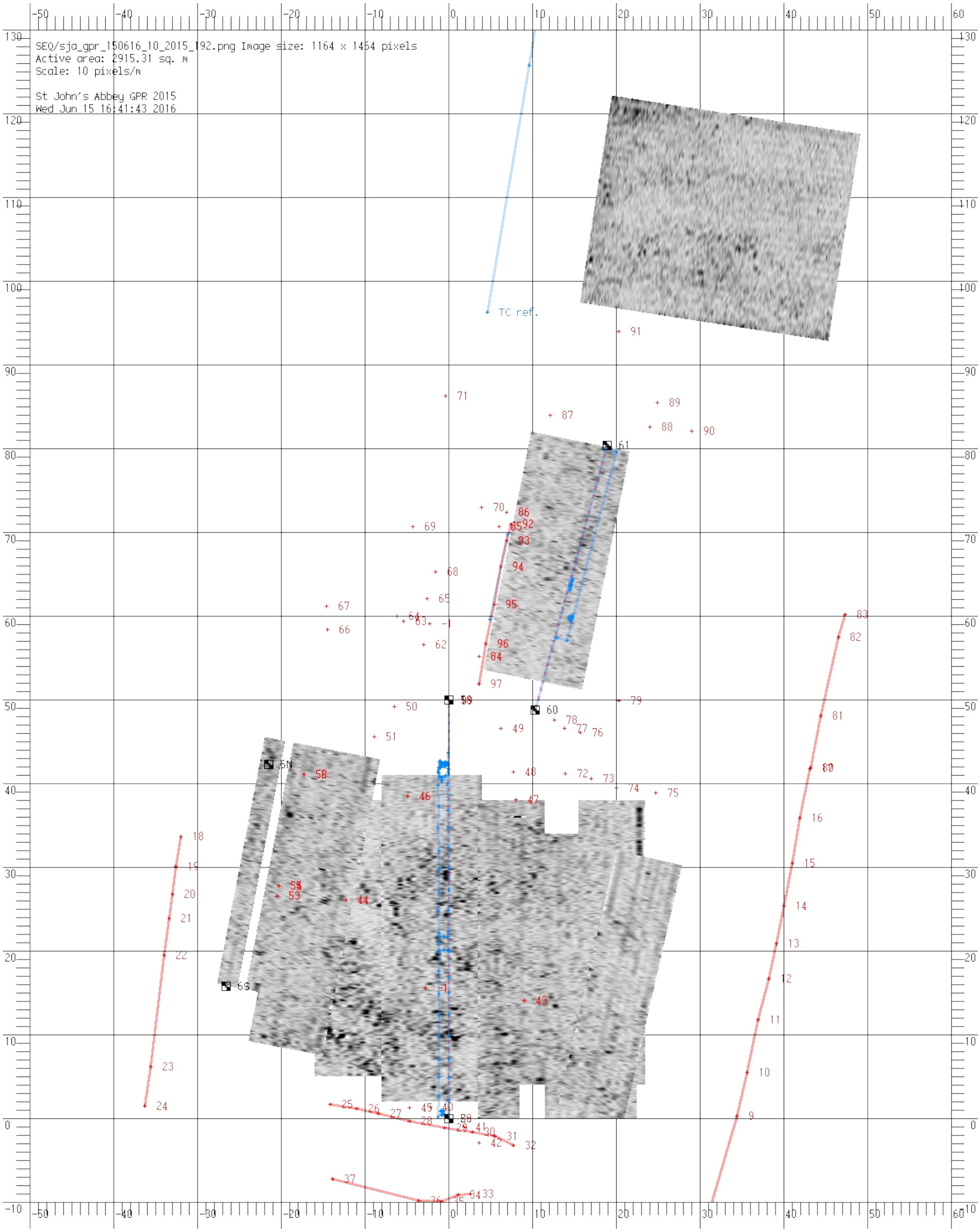


Figure 7g. GPR timeslice 192. Depth ≈ 1.5 m. Isolated point responses in the southern block, some possibly structured.

Appendix – site photographs

Figure A1. Ground resistance survey in progress.

Figure A2. GPR survey in progress.