Fearn Abbey
Resistivity Survey 2025

David Newman
With Bob and Rosemary Jones
and Anne Coombs

Front cover photo *– Aerial view looking south over Fearn Abbey and its churchyard and surrounding glebe. The canalised former mill lade can be seen to the right.*

Back cover photo *– Bob Jones taking resistivity readings at Fearn Abbey, August 2025.*

Fearn Abbey Resistivity Survey 2025

Survey Report

CONTENTS

Foreword by David Newman	2
Acknowledgements	2
A Brief History of Fearn Abbey	4
Fearn Geology	4
Resistivity Survey Proposals	6
The Survey	8
Survey Results: Glebe Fields	8
Survey Results: Churchyard	12
Survey Summary	15
References	15
Appendix 1: Resistivity Survey as an Archaeological Research Method	16

Figure 1: Fearn Abbey looking NE, winter 2024-5

FOREWORD BY DAVID NEWMAN

The decision by the Church of Scotland to sell Fearn Abbey in Easter Ross as part of its programme of church disposals was finalised in the Autumn of 2023, and, at a community meeting called to discuss that decision later that Autumn, I volunteered to prepare some basic drawings of the abbey church building and churchyard for the group of volunteers set up to acquire it for the local community. At that time, the only drawings available were a survey plan and the internal elevation of the presbytery south wall produced by RCAHMS in 1997.

As I carried out the necessary survey work on site, I noticed a number of features in the building's fabric and in the surrounding churchyard which are not immediately apparent to the casual visitor. As a result I decided to extend the survey work and also undertake some documentary research to gain a better understanding of the building's history and its context within the significant number of abbeys and priories founded in Scotland around the same time as Fearn in the late medieval period.

The outcome of that research is to be published separately (The Fearn Abbey Survey 2023-25 Report - due Easter 2026), but during a visit to Kinloss Abbey in the spring of 2025 as part of that research, NOSAS member and Kinloss Abbey Trust trustee, Steve Worth, explained that as part of the ongoing research there, they were going to be undertaking resistivity survey work looking for signs of the now removed former monastic range buildings in the fields surrounding the main abbey site. He suggested that this non-invasive survey technique might be one to consider trying at Fearn too, although he tempered expectations for any significant results by explaining the limitations of the method and its results – especially in graveyards.

The North of Scotland Archaeological Society (NOSAS), of which I became a member in 2022, has its own resistivity survey equipment which was acquired from an Edinburgh-based archaeological group several years ago, and its current keepers and lead users are NOSAS members Bob and Rosemary Jones.

After an initial approach to them raising the possibility of a resistivity survey at Fearn Abbey, they provisionally agreed to come to Fearn in August 2025 to undertake the work, and, in advance of that made a scoping visit to the site in July 2025 when the Friends of Fearn Abbey, as the community group acquiring the abbey buildings are now known, held its first public open day. We looked around the churchyard and the surrounding glebe fields and discussed the various possible survey locations in the context of areas of possible interest, the method's limitations, and best use of the survey time available.

Following that visit a draft survey proposal was prepared, and dates agreed at the beginning of August to carry out the work on site over two consecutive days.

With my knowledge of the resistivity survey technique starting from zero and my results expectations at a similar level, I had no real idea in advance how the survey process would either proceed or turn out so I was pleased to discover that not only was my 100% involvement encouraged, but I was also shown how to process the results.

I think these proved to be far better than anyone hoped, and provide a very useful basis for future detailed field survey work and possible archaeological excavation.

DN

ACKNOWLEDGEMENTS

My thanks are due to:

- NLS for use of the OS 1st edition mapping on P3;
- NRS for use of the James Shand sketch on P5;
- Steve Worth of Kinloss Abbey Trust who had the original idea;
- John Scott of Fearn Farms and Chair of the Friends of Fearn Abbey who supported the survey idea and facilitated access to the glebe fields during the survey;
- Anne Coombs who helped with the setting up on day 1;
- Jean Newman who provided refreshments for the surveyors;
- Bob and Rosemary Jones of NOSAS who led the project and ensured the optimum results were gained, and
- Special thanks to Bob Jones who provided training on the use of the Resistivity and Snuffler software used to process and display the survey results.

<u>David Newman, Hilton of Cadboll, September 2025</u>

Figure 2 (left): Extract from the Timothy Pont map of Easter Ross showing Fearn Abbey and its mills believed to have been surveyed in around 1590
(Note that all plan drawings in this paper are always orientated with north upwards unless shown otherwise – as in this case.)

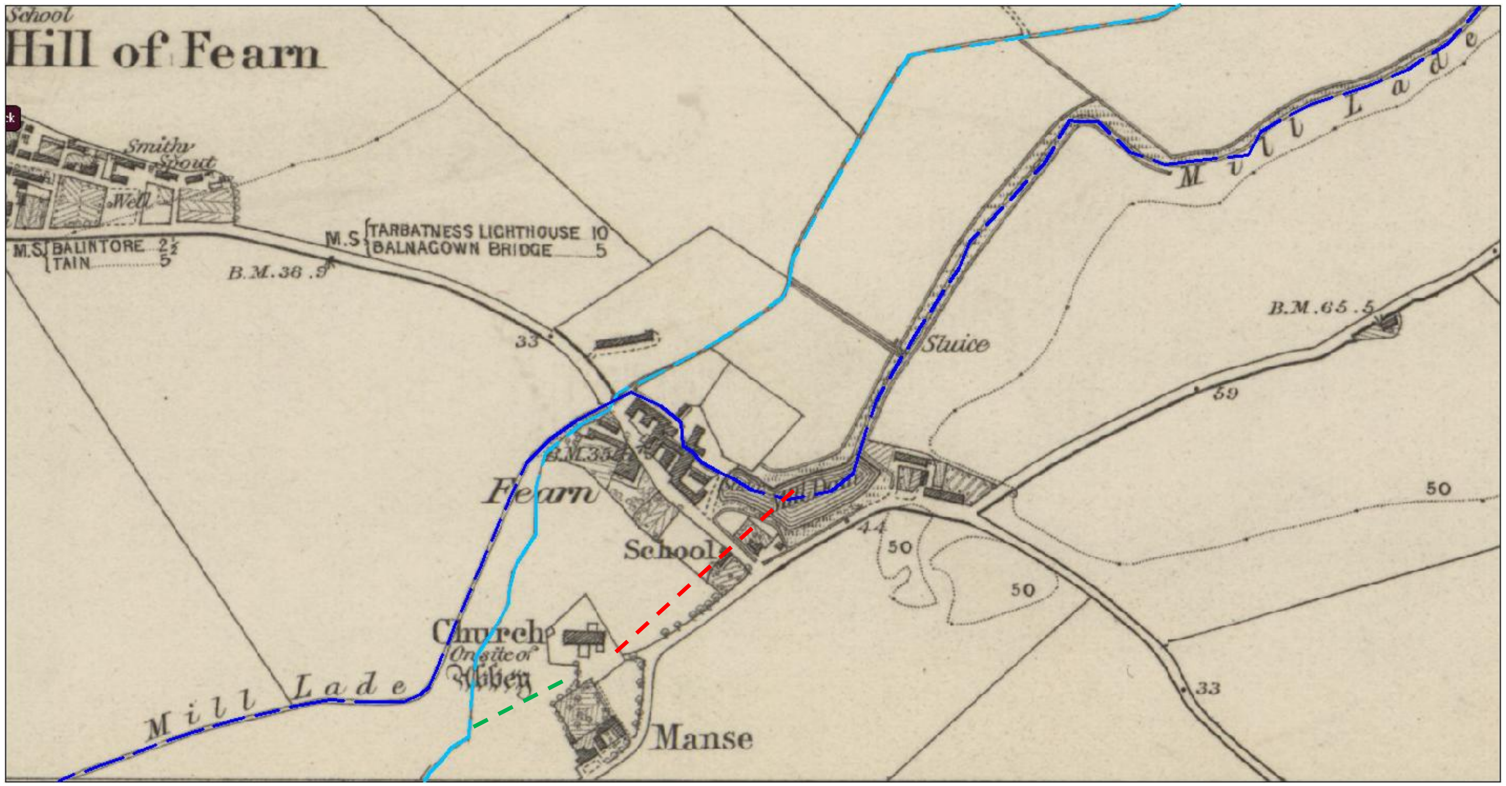


Figure 3: OS 6" 1st edition mapping surveyed in 1872 showing the routes of the mill lade and natural water course north and west of the abbey and possible water supply and drainage for the abbey

A BRIEF HISTORY OF FEARN ABBEY

A number of histories have been written about Fearn Abbey, but in truth few hard facts are known about its original foundation and early years as these are all derived from two manuscripts - 'The Kalendar of Fearne' which is believed to date to around 1470 and 'Ane Breve Cronicle of the Earlis of Ross' which was probably written in around 1600 - both of which significantly post-date the generally agreed foundation date of around 1225, the second by nearly four centuries.

Despite these uncertainties, the idea of an abbey being founded in this part of Scotland in the early 13th century fits well with the pattern of up to fifty abbey and priory foundations across Scotland in the post-Norman period which started at Coldingham in Berwickshire in 1100 and continued right through to St Monan's Priory in Fife in around 1360.

The first Fearn Abbey is believed to have been established by Premonstratensian canons from Whithorn in Galloway on the south coast of the Dornoch Firth at another place called Fearn near the northern end of the Struie road, but its actual location is unknown. The move to 'New Fearne' on the Tarbat peninsula took place around 25 years later for reasons unknown, but little if anything remains of the first buildings there either, as the main church that can be seen today dates from around 1350 when a major re-building programme took place. Since that time, not only have nearly all traces of the monastic range been removed, but the church itself has been the subject of several extensions, alterations and refurbishments, the most significant being after the roof collapsed in 1742.

Despite these changes, a good deal of the remaining 14th century sandstone ashlar fabric within the church's external walls can still be identified, and the building's architecture fits well with that late medieval gothic period including a now hidden double tier angled stone plinth located at the original floor level which was discovered during excavations for drainage works around the church in around 2000. Furthermore, because the layouts of nearly all late medieval abbeys and priories followed a relatively standard plan, and the number of resident canons at Fearn never appears to have been more than seven, the likely location, arrangement and scale of the monastic range here can be reasonably surmised.

In addition, as the Timothy Pont map of Easter Ross still exists (*fig 2*), which represents the first large scale mapping in this part of Scotland dating to around 1590, the general site arrangement of the abbey in the immediate Post-Reformation period can be seen. This includes the looping route of the mill lade - presumably built by the monks for the two grain mills shown by Pont - whose water supply came from Loch Eye (then known as Loch Slynn) around 2km to the north. This canalised water course deviated from the original natural water course route which followed a shallow valley and which was still shown on 1st edition mapping surveyed in 1872 (*fig 3*). Although in 1590 it seems likely that the abbey's water supply came from the mill lade to the north-east, its drainage must have discharged into the original natural water course to the south-east as the ground levels made a connection to the lade below the mills impossible.

After the Reformation the Abbey Church became the Parish Church, and apart from a brief interlude following the 1742 roof collapse, it has served as such until its closure by the Church of Scotland in 2023.

At the time of writing, funding has been awarded by the Scottish Government's Land Fund for the church to be acquired by local community group Friends of Fearn Abbey and it is hoped the process will be complete by the end of 2025.

Thereafter, the former church will become a community held asset and the hope is that before too long, the opportunity can be taken to undertake further research on the Abbey's history and original form.

<u>Fearn Geology</u>

The bedrock in the area is Devonian sandstone with overlying marine deposits of sand, gravel and silt. Agricultural soils are of good quality and used for growing a wide variety of arable crops including malting barley, wheat, rape, potatoes and carrots with some grass clover leys used for rearing beef cattle and sheep. Despite that, the glebe fields, which are rented from the Church of Scotland by Fearn Farms, are reported to have not been cultivated for many decades.

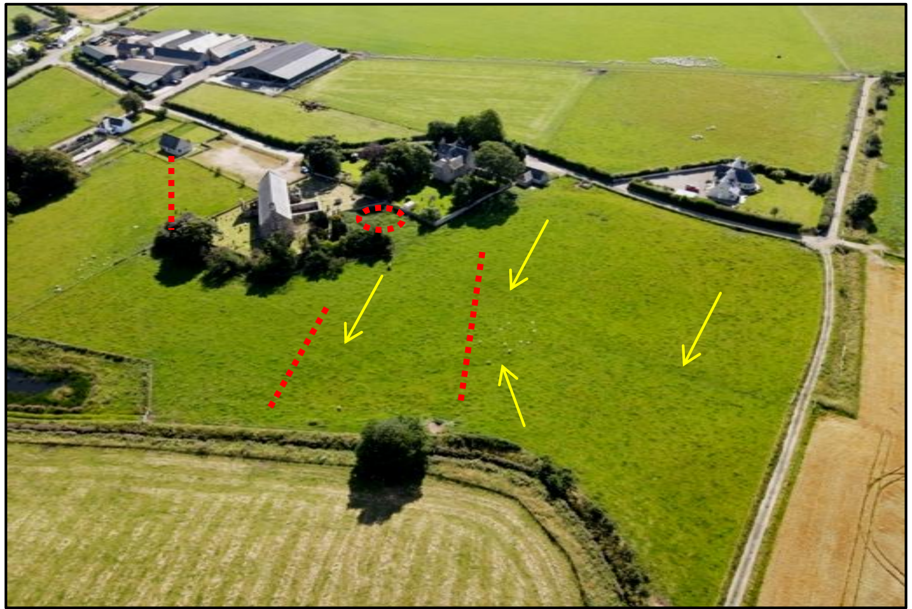


Figure 4: Discontinuity lines revealed by aerial imagery (yellow) and locations of proposed glebe resistivity survey areas (red)

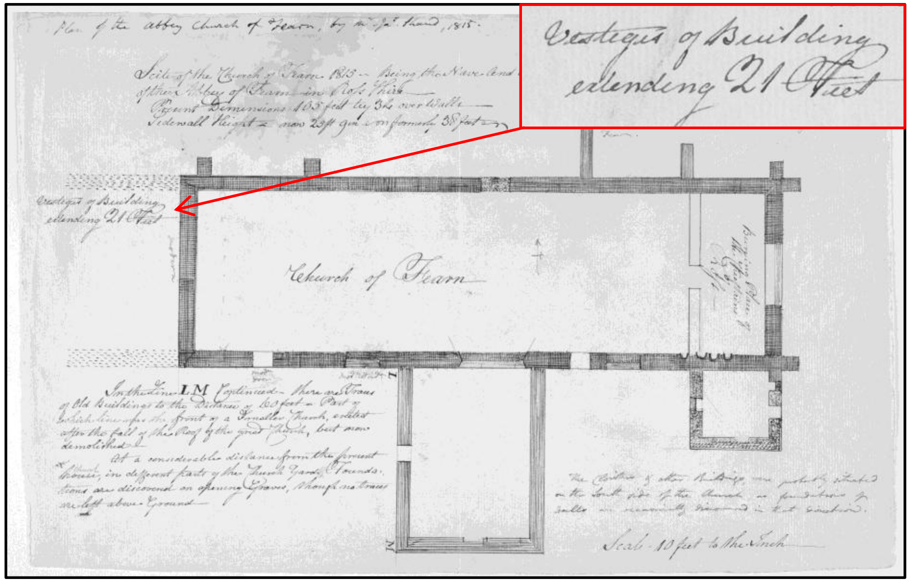


Figure 5: Extract and enlargement from James Shand sketch of 1815

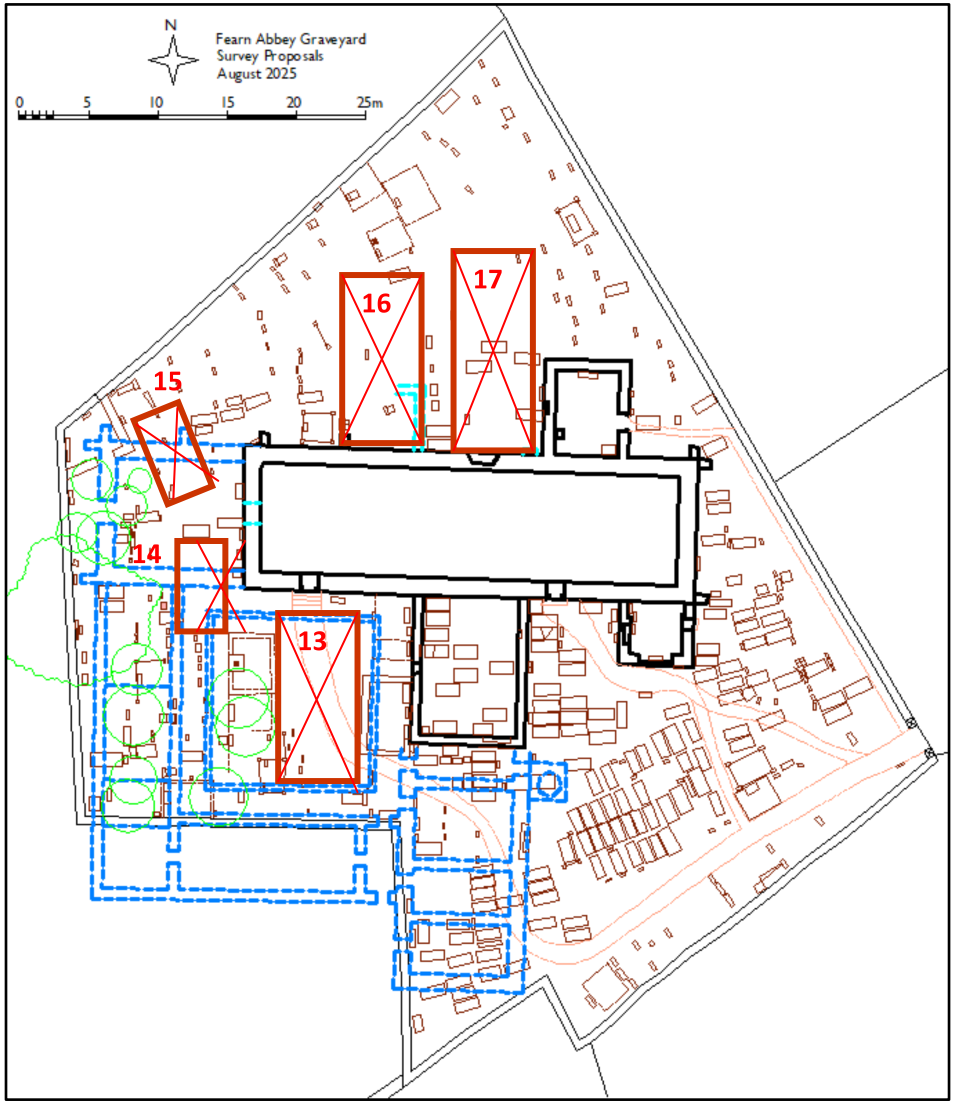


Figure 6: Proposed churchyard resistivity survey areas 13-17 with notional monastic range layout shown in blue.

RESISTIVITY SURVEY PROPOSALS

The initial aims of the survey were to seek answers to two questions:

1. How effective was the resistivity survey method in identifying below-surface features in the local geological conditions in the glebe meadows surrounding the churchyard enclosing wall; and

2. Could known below surface features in the churchyard be distinguished from the general 'noise' of seven centuries of buildings and burials?

Glebe

There are no known building remains in the glebe fields immediately surrounding the current churchyard walls, although the Highland Archaeological Research Framework speculates in its Medieval Ecclesiastical section that

These monastic sites have potential for archaeological work. ……………….at Fearn (MHG8451), where there is also significant opportunity to explore cloister and precinct arrangements. A second important consideration at the latter is the identified presence of anthrosols around the abbey site, which might be a legacy of monastic land-management on its home grange lands (Foster and Smout 1994). One rare archaeological opportunity that would be unique in Scotland is the locating and investigating the temporary site of the original Premonstratensian abbey at Mid Fearn (MHG8074) between Edderton and Kincardine. This was where the community was before it relocated to the site occupied by the surviving remains of the monastic church.

Closer to the church and churchyard, a superimposed 'standard' monastery range plan of modest size which is attached to the west end of the south elevation of the abbey church (*fig 6*), suggests that some of the likely buildings on the range on the south side of the cloister might extend into the curious inset in the churchyard's south-west sector and that this area had significant potential. The alignment of the W-E churchyard wall at this point may not be a coincidence.

Further out to the west, there was not only the line of the former burn to locate (this drained Loch Eye and was still shown on the OS 1st edition mapping surveyed in 1872), but also the monastery drain which is very likely to have been connected to it. Aerial imagery taken a few days before the survey itself had revealed faint discontinuity lines in this glebe area (*fig 4*) and survey transects across these areas appeared to have some potential.

Finally, it was decided to carry out another transect across the glebe to the north-east of the church to see if any features were visible – including the line of a possible water supply channel - which, looking at ground levels, may have connected to the mill lade above the mill buildings.

Churchyard

The density of grave slabs south and east of the church building (*fig 6*) makes these areas of the churchyard unsuitable for resistivity survey, but it was hoped that areas to the west and north where fewer slabs exist might produce results.

The first area targeted was in the area where the former cloister is likely to have existed, now crossed by the gravelled access path to the church's south-west door.

The second was the area west of the existing west gable of the church where the remains of foundations of longer north and south elevations were recorded by Tain surveyor James Shand in 1815 (*fig 5*).

Finally there are areas immediately north of the church's north elevation, which are unusually relatively free of grave slabs, one of which also contains a line of raised ground extending north. This lies roughly where a former buttress once stood which was not rebuilt after this section of wall reportedly collapsed in 1742 (*fig 6*).

Figure 7: Plan showing the locations of the resistivity survey areas in the Fearn glebe fields.

THE SURVEY

The resistivity survey work was carried out on Friday and Saturday the 8th and 9th of August 2025. The lead team for NOSAS were Bob and Rosemary Jones with Anne Coombs and David Newman assisting.

The weather during the survey was generally overcast and dry with strong W – NW winds both days which made the setting out work on the exposed glebe fields something of a challenge. Fortunately, there had been some rain in the previous few days which it was hoped would help improve the contrast of resistivity measurements in what are normally relatively dry, well-draining, sandy soils and sub-soils.

All survey grids were set out at 1m intervals with the exception of the cloister area in the churchyard (13) which was surveyed at 0.5m intervals.

David Newman carried out aerial pre-survey work using drone imagery and, having identified the locations of each survey site, set out one side of each of three proposed survey grids in the glebe fields (7, 8 and 9) (*fig 7*) and five in the churchyard (13, 14 and 15 + 2 on the north side)(*fig 6*). During the survey itself, two additional survey areas were added in the glebe fields (10 and 11) and two separate areas on the north side of the church in the churchyard were combined into one (16).

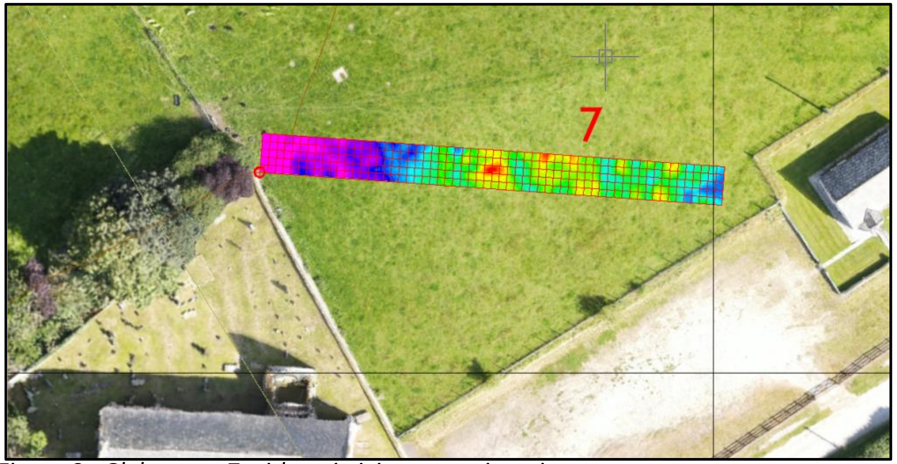


Figure 8: Glebe area 7 with resistivity survey imaging

SURVEY RESULTS

A full explanation of the ground resistivity survey technique and process is given in appendix 1 (pp. 16-19). In summary, this involves passing an electric current between two portable frame-mounted metal probes which are inserted into the ground surface.

A meter measures the resistance in ohms and this measurement is stored in a small memory chip in the meter. Measurements are taken at regular (usually 1m) intervals which are set out in a grid in advance of the survey using marked strings. As the meter does not record a position for a particular measurement – just its place in the sequentially numbered list of readings – the setting out work is an important part of the process, as are a record of the start and finish positions and the position of the survey grid on the ground.

For the Fearn survey the survey areas were identified in advance, the four corners marked with pegs, and then the position of the area recorded using drone imagery.

Appendix 1 gives an explanation as to how the multiple numerical resistance readings are converted into a graphical representation. In the results images that follow, the colours follow the ROYGBIV rainbow sequence with red-orange = high resistivity and blue-violet low. In general, a high resistivity reading (red) is seen in ground with a low moisture content which can equate to a wall or wall foundation, and blue-violet, a low resistivity reading in ground with a high moisture content which can equate to a marshy area or infilled ditch.

<u>Glebe Fields: Area no 7</u>

Survey area 7 in the glebe north-east of the churchyard measured 60 X 5m and extended west from the existing church hall towards the north corner of the graveyard.

Little of significance was revealed (*fig 8*) apart from an area of slightly wetter ground towards the west end which was reflected in both lower resistivity readings and an area of greener grass in aerial imagery. As a result the route of the abbey's water supply channel remains undetermined.

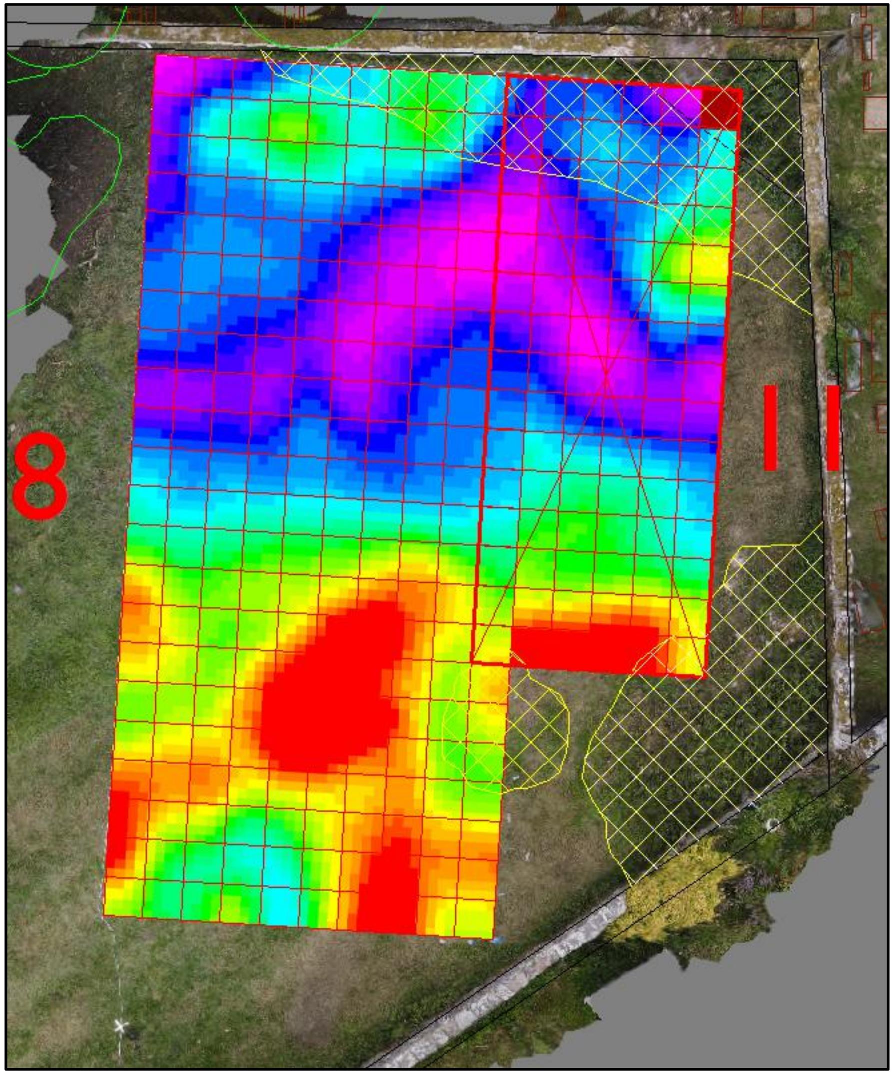


Figure 9: Glebe areas 8 and 11 with resistivity survey imaging. Yellow cross-hatched areas show areas of stone rubble

<u>Glebe Fields: Areas no 8 and 11</u>

As noted previously, the reasons for this curious inset in the churchyard boundary are not clear, but may be related to the position of the monastic range building(s) on the south side of the cloister (*fig 6*). Today this area – in contrast to the adjoining meadow – is usually thick with nettles suggesting high soil N – although these were kindly cleared by Fearn Farms to facilitate the survey. Their presence may be related to the area's sheltered aspect making it a sought after space for livestock in bad weather, or its reported previous occasional use as a boneyard for farm animals.

Towards its SE and NE corners are areas of stone rubble (*fig 9*), the latter presumably related to the collapse of the adjoining manse garden wall, although that to the NE has no obvious reason. Some dressed sandstone blocks were observed. There is a third low mound of rubble around 3m in diameter and 0.5m high west of, but separated from, the rubble from the collapsed manse boundary wall. Parts of these rubble piles were included in the resistivity survey areas.

Area 8 (22 X 10m) was surveyed on the first day, and because the processed and mapped data looked interesting, it was decided to survey an additional area (area 11) on the second day. Area 11 was 6m wide and overlapped area 8 by 1m for a length of 15m and the resistivity data outputs along the line of this overlap were usefully consistent. There was a single blank recording in the NE corner of area 11 as it was behind a stock fence.

Resistivity readings varied between 95 and 138 ohms around a base point of 96 - a range which compares well with the measurements west of the church where wall foundations are known to exist (see areas 14 and 15).

Whilst the Snuffler graphic plots from these survey areas (*fig 9*) need further interpretation, and it is likely that some of the high resistivity readings relate to the rubble piles, there appear to be a number of possible features in this area which make it one of interest for future excavation.

There is a chance that the west-east low resistivity (violet) feature represents a drainage channel of some kind – its position usefully coincides with the predicted track of the outflow from the monastery reredorter, which, based on a standard late medieval monastery range layout, would have lain to the east of the N-S churchyard wall visible to the right hand side in this image.

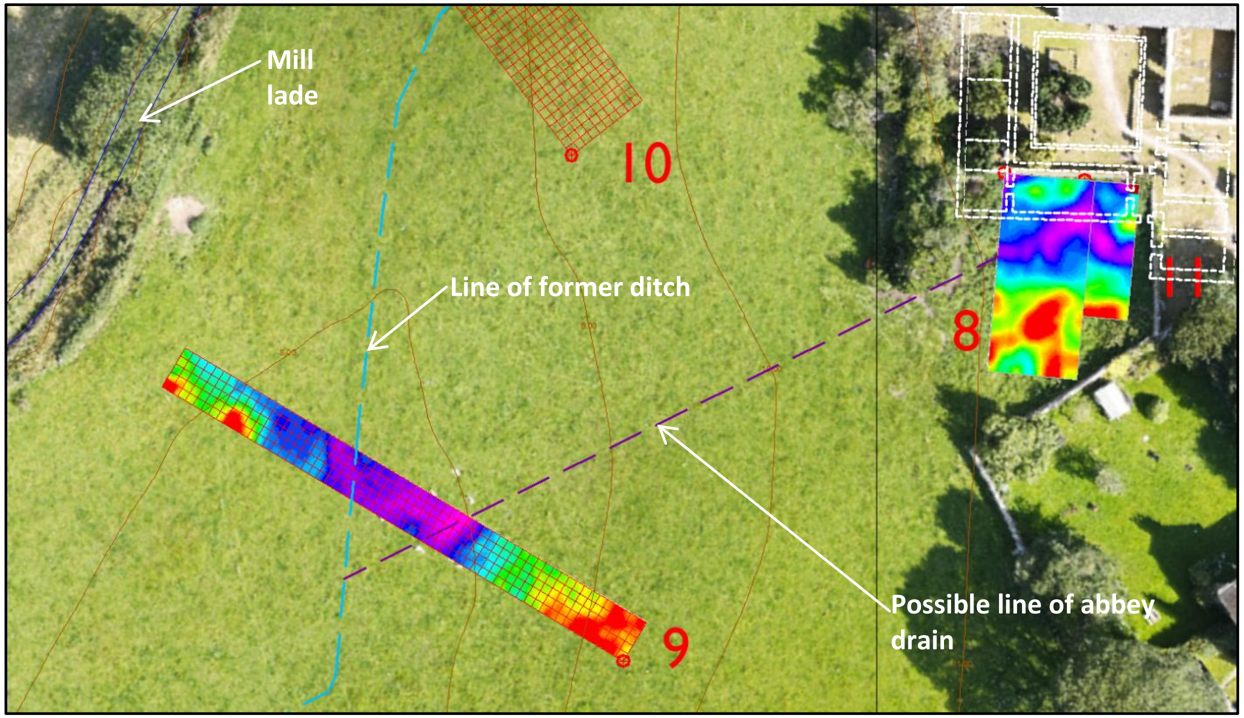


Figure 10: Glebe area 9 resistivity imaging. 1m contours shown.

Glebe Fields: Area no 9

Resistivity survey area 9 was specifically located to target two features – the line of the original outflow from Loch Eye which is still shown as a ditch feature on 1st edition 6" mapping surveyed in 1872 (*fig 3 page 3 and fig 10*), and the line of a possible drain connection from the former abbey range (*fig 10*). As the canalised mill lade lies to the west of the 19th C ditch, and at a higher level, it is clear that any abbey drain could never have been connected to this.

As this glebe field has not been cultivated within living memory (*John Scott pers. comm*.) it was also hoped to identify what could be described as 'normal' resistivity readings for the underlying surface and sub-surface geology.

For area 9, the resistivity readings varied between 56 and 109 ohms around a base point of 100 – a range of 53 compared with 43 ohms for areas 8 and 11. The larger range can probably be explained by the lower areas of the field around the former ditch line being particularly wet – they still flood in very wet weather (*John Scott pers comm*.) - which results in low resistivity readings.

The line of the former ditch shown on OS 1st edition mapping surveyed in 1872 which, being in the base of a shallow valley, follows the likely course of the original outflow from Loch Eye/Slynn, was identified by the survey in the location expected (*figure 10*).

However, the extension of this low resistivity area east higher up the valley side towards the church was not expected, especially as it was not reflected in a similar pattern on the west side, and this may possibly indicate the line of a former abbey drain connection also possibly visible in survey area 8.

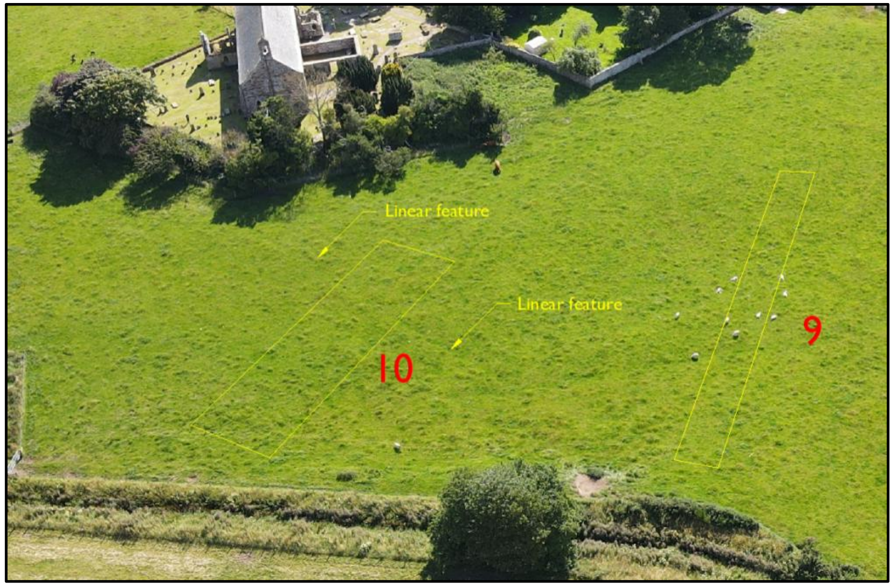
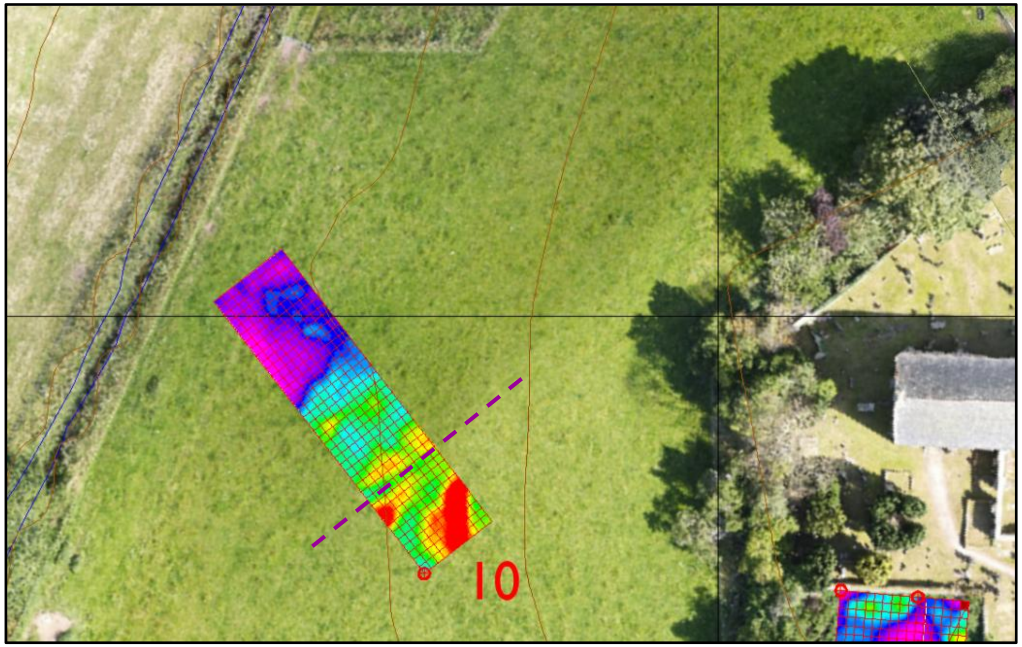


Figure 11: Aerial view of survey areas 9 and 10. (Note north to left in this image.)



Glebe Fields: Area no 10

If time permitted, a second survey transect across the glebe west and south of the church was always planned, but its final position was selected by the survey team on the day of the survey following a walkover and inspection of potential ground features including what appeared to be traces of a linear feature orientated SW – NE (*fig 11*).

It was also decided to survey a shorter, wider area of dimensions 10 X 40m rather than the 5 X 60m used for area 9 to better identify linear features that crossed the survey area

95% of resistivity readings in area 10 varied between 66 and 130 ohms around a base point of 92, which at 64 ohms, represents the biggest range of any of the Fearn glebe resistivity data sets. And, assuming that the low readings represent similar wet ground conditions in the base of the original Loch Eye outflow valley to those existing in neighbouring area 9, it is the very high readings recorded in a narrow curving band around 3m wide towards the upper, south-eastern end of the survey area which may identify a feature of possible interest (*fig 12*) – perhaps a boundary dyke?

The possible linear feature seen on the ground is revealed as a band of light green responses in the 95 ohm range between two bands of higher readings and again may represent another feature worthy of future investigation.

Figure 12: Survey area 10 showing resistivity survey grid, curved high resistance feature in red and another possible linear feature.

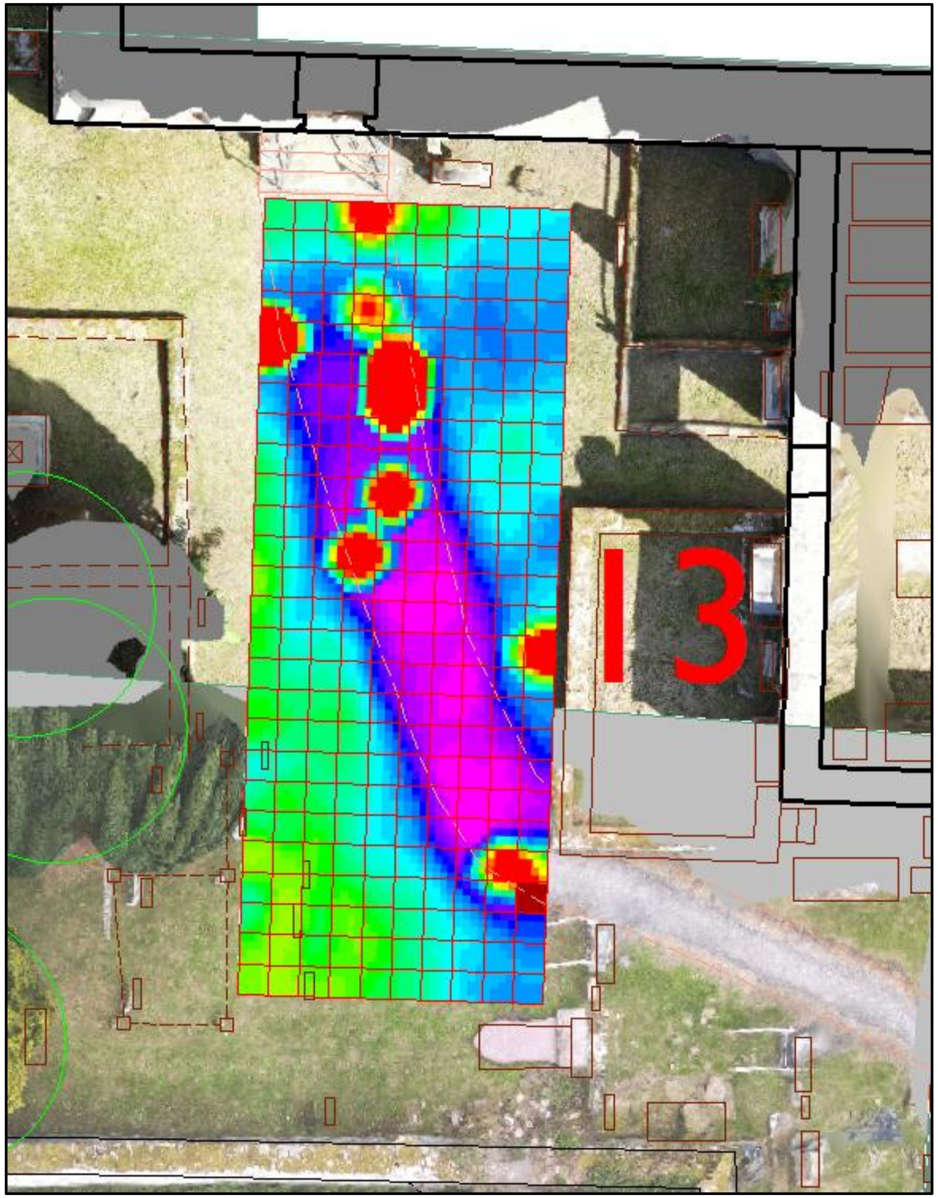


Figure 13: Churchyard area 13 resistivity imaging

Churchyard: Area no 13

Area 13 was surveyed at 0.5m centres rather than at the 1m used in every other case. Measuring 13 X 5m, it was positioned in an area relatively free of gravestones south of the current church SW entrance door in the area where the monastery cloister is believed to have existed (*fig 6 p.5*). The hope was that the lines of the cloister walkway might be identified. The resistivity range recorded was large being between 60 and 150 ohms.

Unfortunately the area is also crossed by the access path to the south-west entrance door and the imagery generated is dominated by this feature (*fig 13*). Although paved with a compacted, ‘type 1’ graded hardcore material, it appears in the resistivity imaging as showing generally low resistivity with occasional very high resistivity ‘hot spots’. The former is probably due to rainfall in the previous few days being held by the graded and compacted nature of the footpath finish, and the latter where the two probes each touched a larger stone. Otherwise nothing of interest can be identified.

It was useful however, to note that where the survey crossed burial sites in the SW part of this survey area, these did not produce notably different responses to areas where they did not exist.

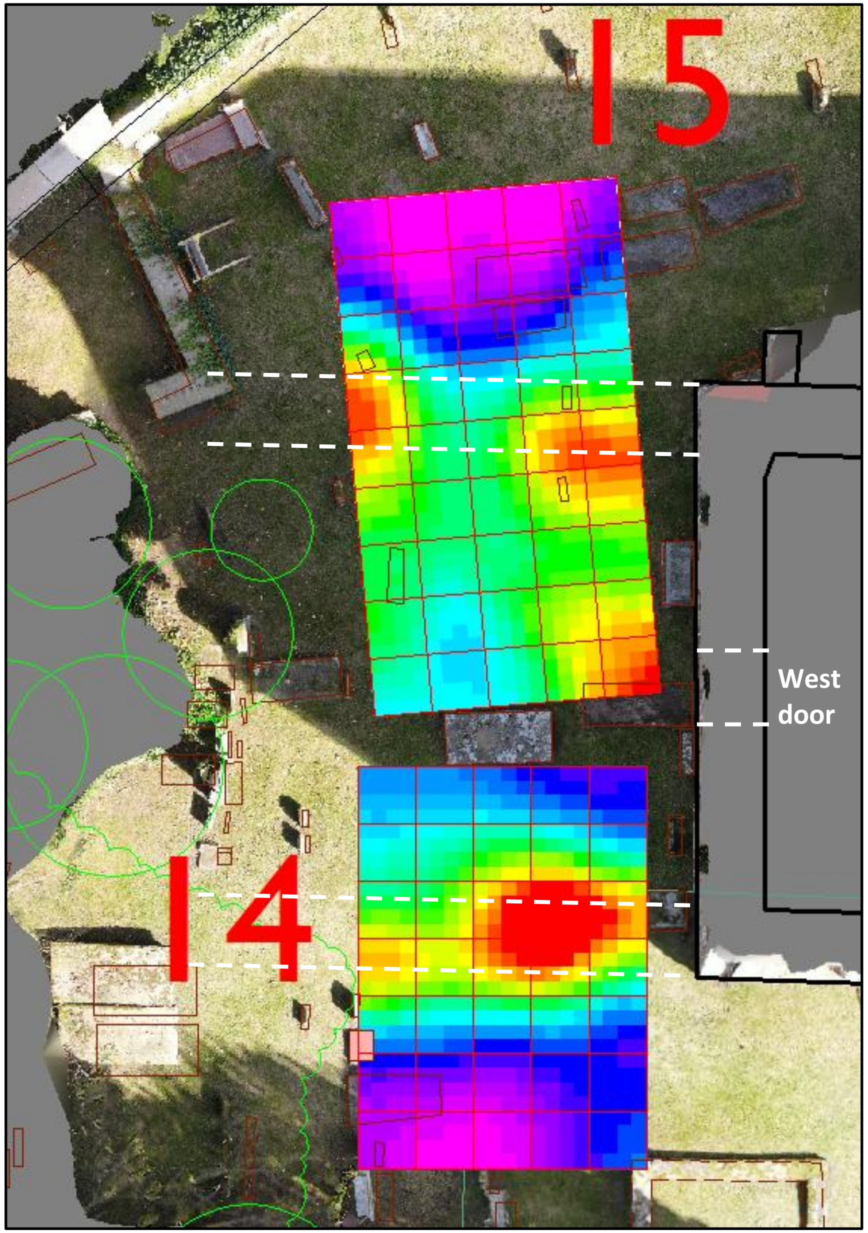


Figure 14: Churchyard areas 14 and 15 resistivity imaging

Churchyard: Areas no 14 and 15

As noted earlier, these two survey areas were specifically targeted to see if the known, but now hidden, foundations of the former western extensions to the north and south elevation walls of the church could be identified. These were revealed by the survey readings to reasonable effect in both cases (*figure 14*), although the low range of readings in these areas – between around 95 and 130 ohms indicates that the violet coloured areas are not 'wet' as noted in the glebe surveys.

A third higher resistivity area near the centre of the west facing gable wall was also recorded in area 15, and this may relate to some kind of hard surface outside the remains of a built up opening below ground level revealed during the drainage works carried out in 2000, which may well represent the cill of a west door into the church when the church was reduced in length at some unknown date in the past and a replacement west gable constructed.

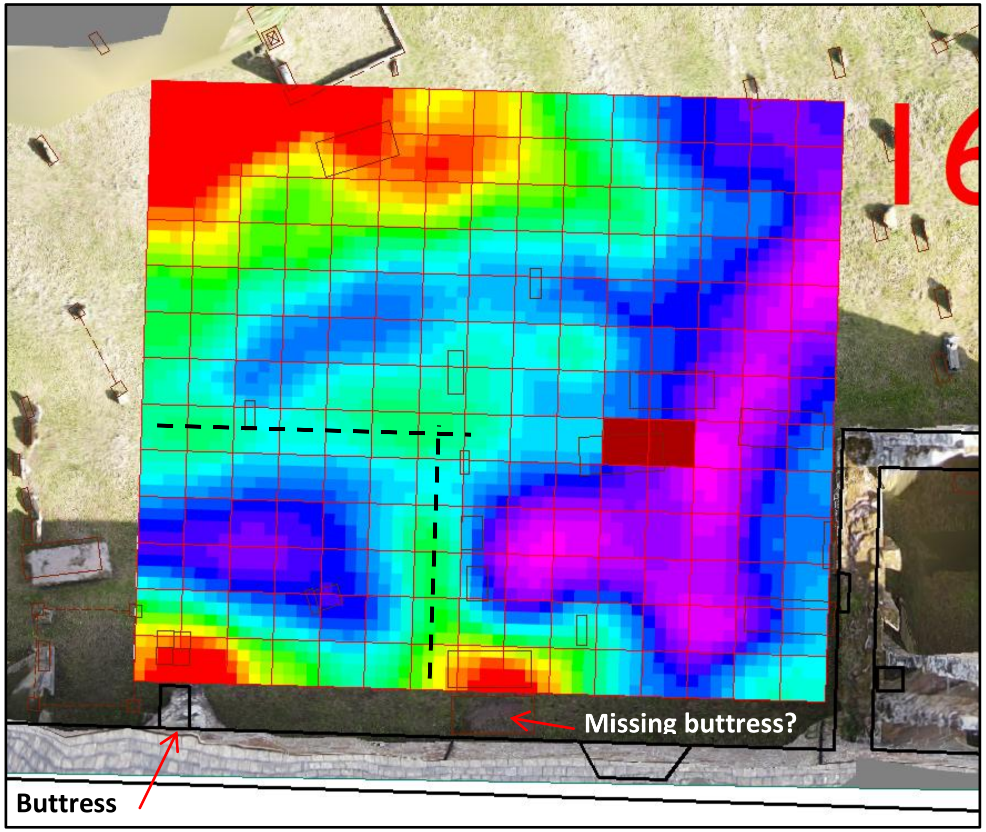


Figure 15: Churchyard area 16 resistivity imaging

Churchyard: Area no 16

Covering an area on the north side of the church measuring 15 X 13m, this was the largest continuous survey area within the churchyard, and one which unusually, contains relatively few gravestones. Resistivity readings ranged between 88 and 124 ohms around a base reading of 94, although one reading of over 600 ohms near the centre of the area was clearly anomalous and was substituted with a reading based on an average of surrounding square results.

The first high resistivity area that fits with a known structure is the buried projecting plinth and foundation surrounding the 14th century stone buttress in the SW corner of the survey area (*fig 15*). A second very similar result around 6m to the east may represent a similar set of buried structures which once supported a now missing buttress which is believed to have been demolished along with the adjoining nave wall in the 1742 roof collapse. Although this area also coincides with two grave slabs, the probes were inserted between these to take readings.

Immediately west of this possible structure lies a line of medium resistivity around 1.5m wide extending north from the church wall which matches the position of a slight embankment (black dotted line in *fig 15*). This feature meets another similar line of resistivity running E-W around 6m out and it may be that these represent the lines of foundations of another built structure once attached to the north elevation of the church – perhaps another burial aisle.

SURVEY SUMMARY

The survey set out to answer two main questions:

1. How effective was the resistivity survey method in identifying below-surface features in the local geological conditions in the glebe meadows surrounding the churchyard enclosing wall; and
2. Could known below surface features in the churchyard be distinguished from the general 'noise' of seven centuries of buildings and burials?

And looking at the results it is reasonably clear that answers have been gained.

As regards question 1, the resistivity images clearly distinguished between the lower wetter areas of the glebe where the outflow from Loch Eye (Slynn) formerly ran and the upper drier areas. The particularly low resistivity areas coloured violet in the imaging for area 9 are well matched in their locations for the mapped line of the former outflow, and it would be a very simple exercise to test this result by excavation. That method could also be used to look at the extension to that low resistivity feature extending NE up the hill towards the former monastic range, and the possible line of a similar feature in survey area 10 further north.

As regards question 2, results from area 13 south of the church were disappointing, but the survey areas west (14 and 15) and north (16) of the church prove that known below-ground features can be observed in the expected locations using the resistivity method. And that outcome suggests that the other results in area 16 may well indicate other structures lying below the ground surface in this area. Located within the churchyard, further investigation here is going to be more of a challenge, but at least the results provide good pointers, should that opportunity ever arise.

The results from areas 8 and 11 are difficult to interpret especially as they possibly represent a hybrid in terms of glebe/monastery location. But there is a good chance that they point to some feature or other existing there, and, because it lies outwith the churchyard, seeking permission for further exploration is going to be less of an issue. It can also be easily fenced off if a more extensive programme of excavation were to be considered.

Overall therefore, it seems reasonable to conclude that this two day resistivity survey by the NOSAS survey team at Fearn Abbey has been very worthwhile.

REFERENCES

Adam, R. J., 1991, *The Calendar of Fearn: text and additions 1471-1667*

British Geological Society, 2025, *Online Geology Viewer*

Fawcett R., 1994, *Scottish Abbeys and Priories*

Forde D., Munby J., Scott R. I., 2019, *Torre Abbey Devon, The Archaeology of a Premonstratensian Abbey*

MacFarlane, Rev.K., 1963, *History of Fearn Abbey*

Newman D. G. and J., 2025, *Fearn Abbey A Guide for Visitors*

Ordnance Survey, 1881, *Ross-shire and Cromartyshire, (Mainland) XLII*

Pont T. c. 1590, *Map of Tarbet Ness* (National Library of Scotland online maps)

RCAHMS, 1997, *Fearn Abbey, Piscina and Sedilia Elevation and Plan*

RCAHMS, 1997, *Fearn Abbey, Plan and Site Plan*

Soc. Antiq. Scot., 2025, *Highland Archaeological Research Framework (Online)*

'W. R. B.', (Iona Club) 1850, *Ane Breve Cronicle of the Earlis of Ross*

APPENDIX 1

Resistivity Survey as an Archaeological Research Method

Resistivity is a type of archaeological prospection that works by measuring the resistivity of the ground in a grid of points across a site (*fig 16*).

A section of ground to be measured has a set of probes pushed into the surface which pass an electrical current through the ground. As electricity conducts well through water, the amount of water in the soil will affect how much resistance there is to the current being passed through it. If there is little moisture, the electricity meets greater resistance in passing through the soil, which is then said to have a high resistance value. If there is a lot of moisture in the ground, the current passes through it easily and is said to have low resistance. A numerical value representing exactly how much resistance is met is calculated by the resistivity meter. Given a set of such measurements in a regular pattern across a site, a picture can be created using specialist software showing the contrasting readings.

The amount of moisture in the soil can be affected by a range of underground archaeological features. For example, if there is a pit cut into the bedrock, this pit may have a greater capacity for storing moisture than the surrounding rock, so the topsoil above will dry out slower as there is a supply of stored moisture, which will give a low resistance reading.

Alternatively, if you have the foundations of a wall underneath the topsoil, there is less room for stored moisture and the topsoil dries out more quickly, giving a high resistance reading. There are other factors that can affect this, such as soil type and density, but it is the differences in resistance across a site that can produce recognisable patterns on the images produced.

Equipment and Software Used

The NOSAS resistivity survey equipment comprises a wooden frame upon which are mounted the two ground probes and meter. Also connected to the meter by long cables is a set of two 'balancing' probes which are inserted in the ground around 1m apart as far from the survey area as possible. These are required because when measuring the current between just two probes, the problem arises that the contact resistance of the probes is higher than the lower resistance changes in the underlying soil which is the measurement of interest. This is because the probes' surface area is much smaller than the volume of ground through which the current is being passed, and is exacerbated by the fact that the soil's conductivity is generally poor near the surface where the probes are inserted.

This issue is overcome by using a four probe system, where two probes (the mobile probes) provide the current and another two (the remote probes), provide a background reading (measuring the voltage gradient) and is known as the twin electrode configuration. The separation of the probe pairs in the twin electrode configuration must conform to a strict ratio - a distance of at least 30 times the separation of the probes in the mobile pair, (i.e. a 50cm separation in the mobile probes means that the remote probes must be at least 15 metres away) - so that variations in the separation of the pairs will affect readings by less than 3 per cent. This is generally assumed to be a reasonable level of accuracy for archaeological surveying.

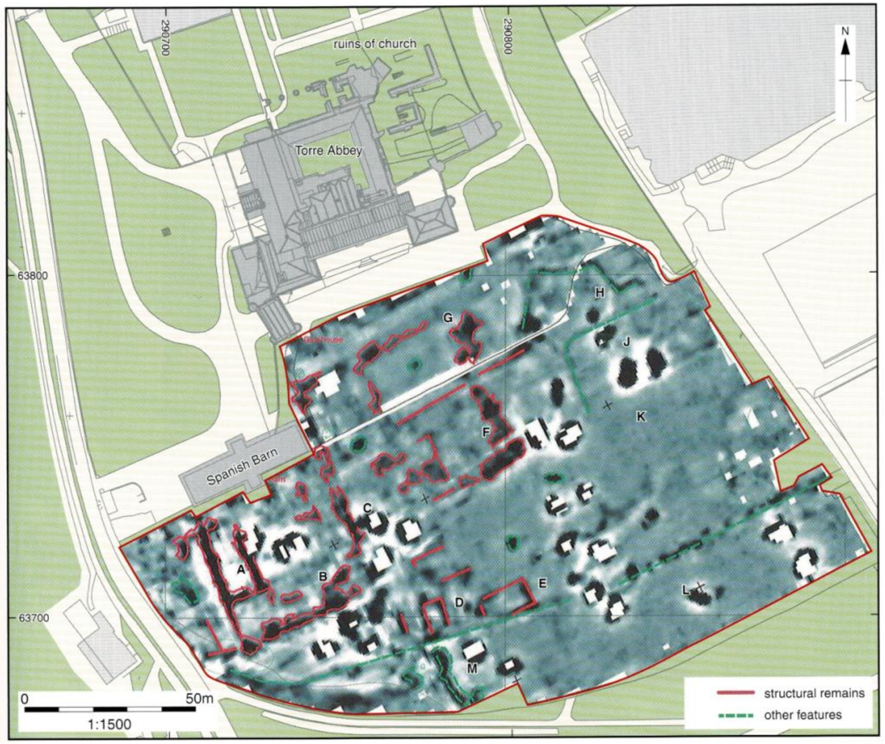
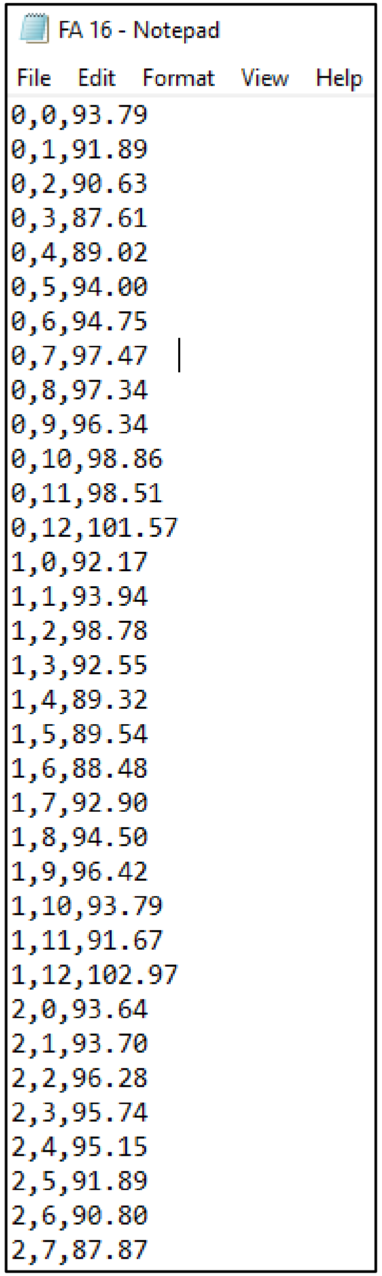


Figure 16: Image of a resistivity survey at Torre Abbey in Devon by English Heritage



FA 16 - Notepad

File Edit Format View Help

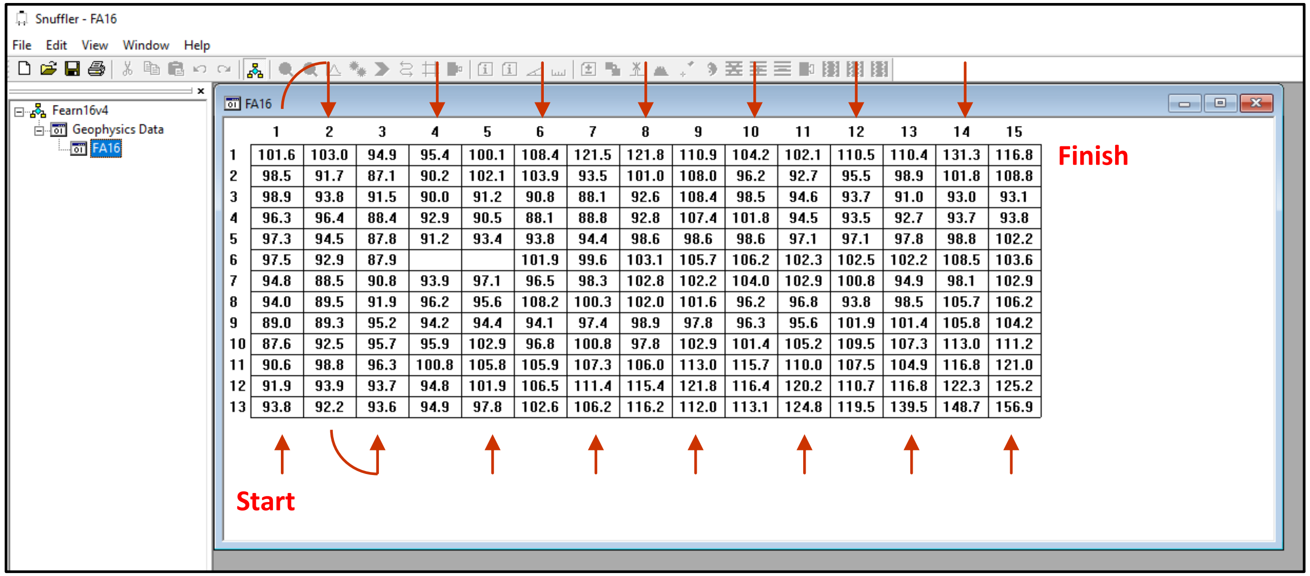
0,0,93.79
0,1,91.89
0,2,90.63
0,3,87.61
0,4,89.02
0,5,94.00
0,6,94.75
0,7,97.47
0,8,97.34
0,9,96.34
0,10,98.86
0,11,98.51
0,12,101.57
1,0,92.17
1,1,93.94
1,2,98.78
1,3,92.55
1,4,89.32
1,5,89.54
1,6,88.48
1,7,92.90
1,8,94.50
1,9,96.42
1,10,93.79
1,11,91.67
1,12,102.97
2,0,93.64
2,1,93.70
2,2,96.28
2,3,95.74
2,4,95.15
2,5,91.89
2,6,90.80
2,7,87.87

The survey data stored within the meter is downloaded into a piece of software called 'Resistivity' which converts the measurements into a simple text file, listing them line by line, beginning with the grid square X, Y co-ordinates, followed by a numerical reading in ohms (*fig 17*). Where readings have not been possible, in the case of this area of Fearn graveyard due to the presence of a large grave slab, the co-ordinate is recorded, but with no reading.

This data is then transferred to a second piece of software called 'Snuffler' which was developed by researchers at Brighton University. The readings are firstly transformed into a grid (*fig 18*) which matches the survey area in proportions (15 X 13m in this case) and inserts each measurement into its correct *relative* location on the grid depending on the order in which the readings were taken – in this case starting at the bottom left. Where readings are missed by the Resistivity software, a blank is inserted in the grid.

Figure 17 (left): Resistivity software text file giving an X, Y co-ordinate (eg 0,11,) followed by the resistivity reading in ohms to two decimal places (eg 98.51)

Figure 18 (below): Snuffler software grid of resistivity readings with sequence of survey shown by red arrows. The readings are reduced to one decimal place



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	101.6	103.0	94.9	95.4	100.1	108.4	121.5	121.8	110.9	104.2	102.1	110.5	110.4	131.3	116.8
2	98.5	91.7	87.1	90.2	102.1	103.9	93.5	101.0	108.0	96.2	92.7	95.5	98.9	101.8	108.8
3	98.9	93.8	91.5	90.0	91.2	90.8	88.1	92.6	108.4	98.5	94.6	93.7	91.0	93.0	93.1
4	96.3	96.4	88.4	92.9	90.5	88.1	88.8	92.8	107.4	101.8	94.5	93.5	92.7	93.7	93.8
5	97.3	94.5	87.8	91.2	93.4	93.8	94.4	98.6	98.6	98.6	97.1	97.1	97.8	98.8	102.2
6	97.5	92.9	87.9			101.9	99.6	103.1	105.7	106.2	102.3	102.5	102.2	108.5	103.6
7	94.8	88.5	90.8	93.9	97.1	96.5	98.3	102.8	102.2	104.0	102.9	100.8	94.9	98.1	102.9
8	94.0	89.5	91.9	96.2	95.6	108.2	100.3	102.0	101.6	96.2	96.8	93.8	98.5	105.7	106.2
9	89.0	89.3	95.2	94.2	94.4	94.1	97.4	98.9	97.8	96.3	95.6	101.9	101.4	105.8	104.2
10	87.6	92.5	95.7	95.9	102.9	96.8	100.8	97.8	102.9	101.4	105.2	109.5	107.3	113.0	111.2
11	90.6	98.8	96.3	100.8	105.8	105.9	107.3	106.0	113.0	115.7	110.0	107.5	104.9	116.8	121.0
12	91.9	93.9	93.7	94.8	101.9	106.5	111.4	115.4	121.8	116.4	120.2	110.7	116.8	122.3	125.2
13	93.8	92.2	93.6	94.9	97.8	102.6	106.2	116.2	112.0	113.1	124.8	119.5	139.5	148.7	156.9

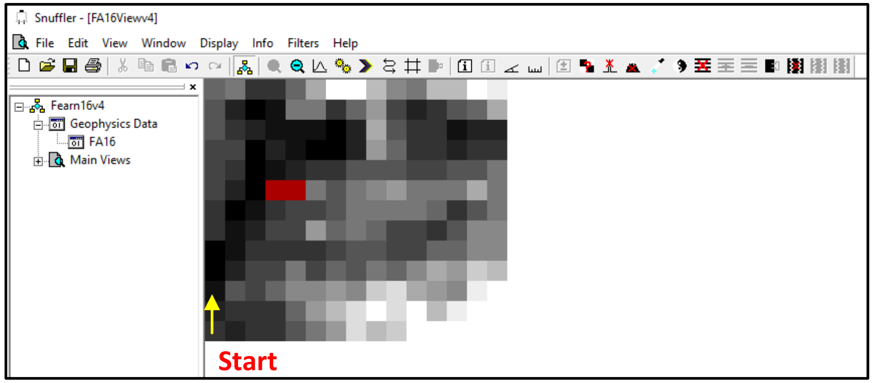


Figure 19: Stage 1 monochrome image. Missed readings are shown red

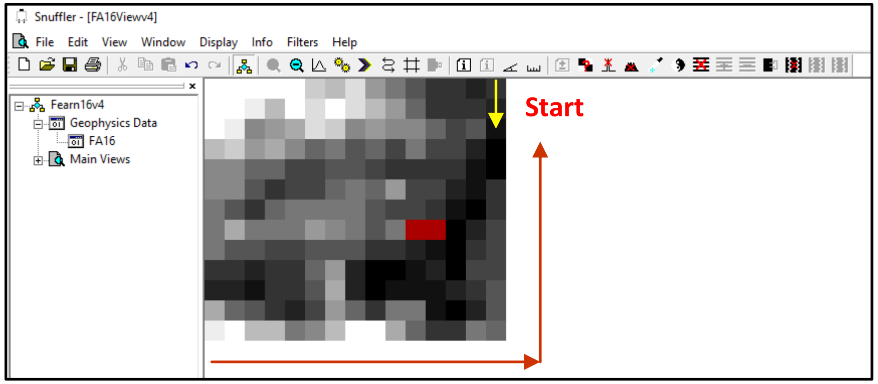


Figure 20: Stage 1 image rotated 180° to match survey start position on site

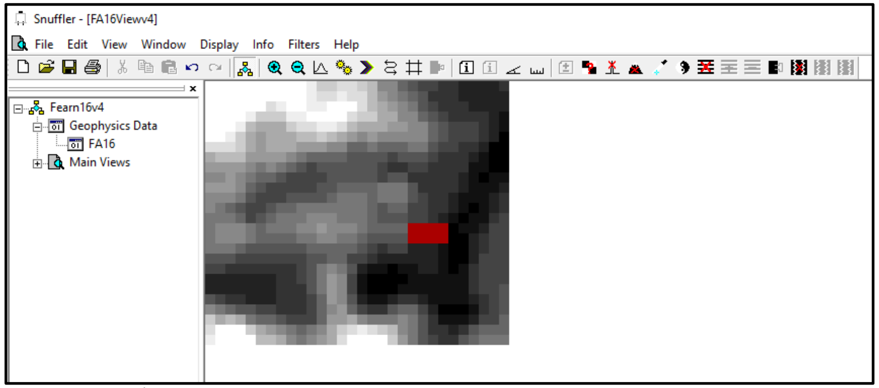


Figure 21: 1st Interpolation – 1 no 1x1m square becomes 4 no 0.5x0.5m squares

Snuffler then has a second stage of processing which transforms the grid of readings into a grid of graded monochrome shades from white (high resistivity) through shades of grey to black (low resistivity) (*fig 19*). A square with no reading is shaded red.

In this particular case, the grid image was then rotated through 180° (*fig 20*) to orientate it correctly with its relationship to the church, because the start point for the readings on site was in the north-east corner not the south-west as shown in *fig 19*.

Then there are a series of steps called filters which allow the data image to be further processed. The first to be used is a two step interpolation process. This calculates an interpolated reading between neighbouring grid squares and in the first step divides each 1m square into 4 no 0.5 X 0.5m squares (*fig 21*), and in the second, each of those quarter squares by four again to give 16 no 0.25 X 0.25m squares (*fig 22*). The end result is a much more graded image which provides more detail.

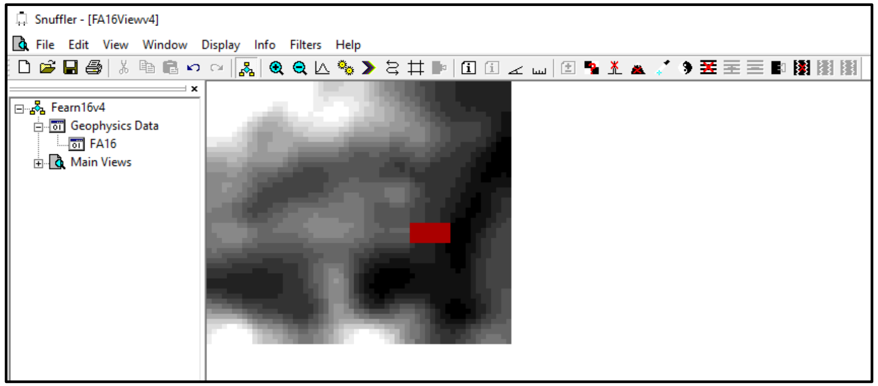


Figure 22: 2nd Interpolation – 4 no 0.5x0.5m squares become 16 no 0.25x0.25m squares

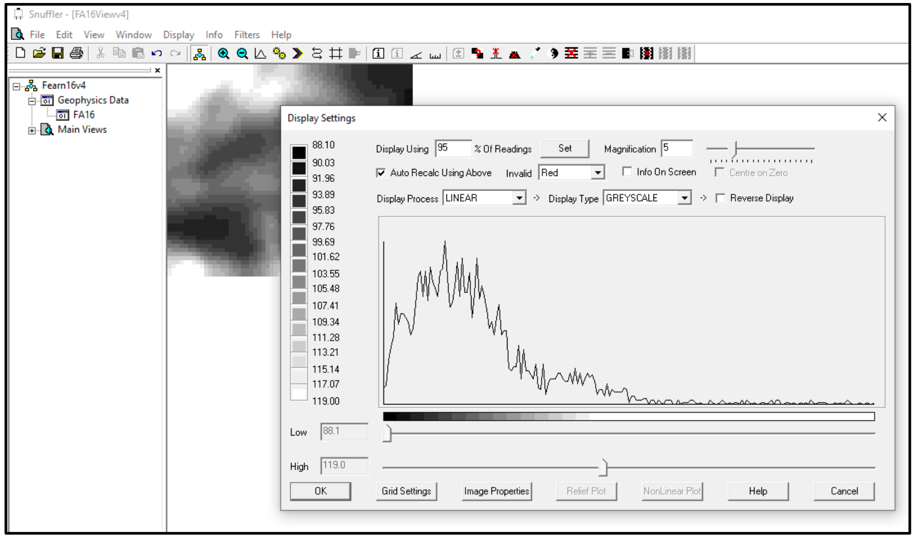


Figure 23: Graph showing range of resistivity readings against their frequency

It is possible to also view the range and relative proportions of resistivity readings as a graph and alter the percentage of all readings displayed. This is usually set at 95% and ensures that a small number of unusually high or low resistivity readings don't skew the grey scale imaging and thus hide interesting features (*fig 23*).

The same menu can be used to use a colour range of shading rather than greyscale in three different colour formats including RGB, RGB graded and rainbow. It is the 'rainbow' version used to present the results at Fearn Abbey (*fig 24*).

The software then allows a *.png file of the image to be created and downloaded for presentation use.

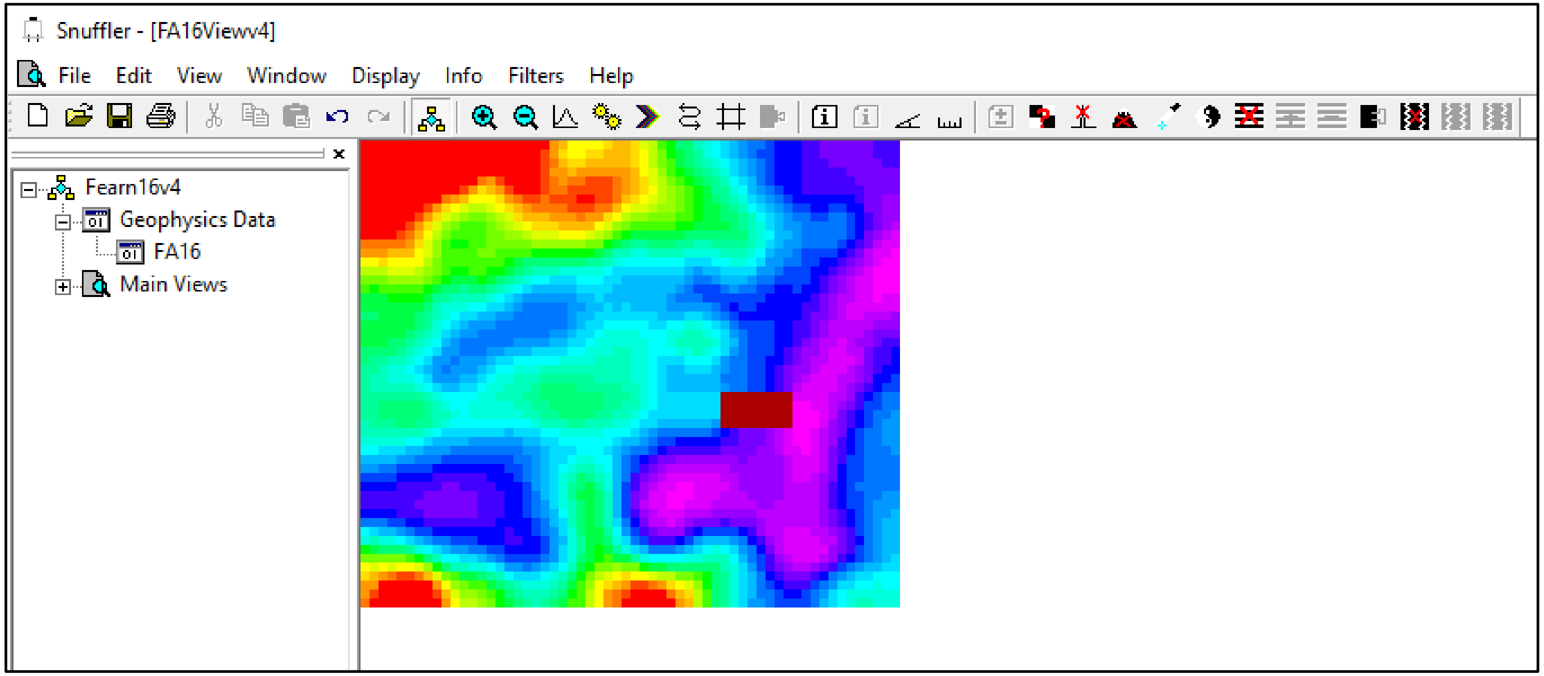


Figure 24: Snuffler rainbow image of churchyard area 16 ready for use.