STRATASCAN

Geophysical Survey Report

Torre Abbey, Torquay

MOLAS

March 2005

J1996

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REGISTERED ORGANISATION IFA

Document Title:	**Geophysical Survey Report** **Torre Abbey, Torquay**
Client:	**MOLAS**
Stratascan Job No:	**J1996**
Techniques:	**Ground Probing Radar, Detailed Magnetometry**
National Grid Ref:	**SX 908 638**

Viewed from Area 1 through separating wall into Area 2.

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1 SUMMARY OF RESULTS

Several strong linear discrete responses have been picked up running through Areas 1 and 2. These are probably of archaeological origin and are possibly caused by structural remains.

Linear arrangements of broad crested and point diffractions can be seen running through both Areas 1 and 3, these are probably be caused by modern services but there is a possibility that they are of archaeological origin.

A large planar anomaly can be seen running from Area 1 into Area 2. This may be caused by structural remains such as a path or a wall foundation and so may be of archaeological significance. However, there is a possibility that this is caused by a modern service.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned to undertake a geophysical survey of an area outlined for development. This survey forms part of an archaeological investigation being undertaken by MOLAS.

2.2 Site location

The site is located at Torre Abbey, Torquay, at OS NGR ref. SX 908 638

2.3 Description of site

The site consists of three separate lawned areas, interspersed with exposed structural remains of the Abbey and obstructions such as ornamental flowerbeds and a large oval pond as shown in the photographs below.

Area 1, viewed from the north west corner of the area.

Area 2, viewed from the east side of the area.

Area 3, viewed from the north east corner of the area.

The underlying geology is limestone (British Geological Survey South Sheet, Third Edition Solid, 1979). The overlying soils have not been surveyed as the site is within an urban area however the nearby soils are Crediton soils which consist of well drained gritty reddish loamy soils (Soil Survey of England and Wales, Sheet 5, South West England).

2.4 Site history and archaeological potential

The site is an area of intense historical interest as it is located within the Torre Abbey site. Torre Abbey was a Premonstratensian Abbey and was founded in 1196. The Abbey was then suppressed in 1540 and after the Dissolution parts of the Abbey's domestic ranges were retained and converted into a private mansion.
Part of the area has been trenched prior to our survey, this investigation revealed several features which are thought to be medieval and also helped to define the extent of the late 18th century demolition and landscaping works *(Borough of Torbay, An Post-excavation report on the evaluation, May 2002, MOLAS).*

2.5 Survey objectives

The objective of the survey was to locate any anomalies that may be of archaeological significance prior to trenching.

2.6 Survey methods

The survey was conducted using Ground Penetrating Radar with a 400MHz antenna.

More information regarding these techniques is included in the Methodology section below.

3 METHODOLOGY

3.1 Date of fieldwork

The fieldwork was carried out on 23rd March 2005 when the weather was fine.

3.2 Grid locations

The location of the survey grids has been plotted in Figure 2.

3.3 Description of techniques and equipment configurations

Two of the main advantages of radar are its ability to give information of depth as well as work through a variety of surfaces, even in cluttered environments and which normally prevent other geophysical techniques being used.

A short pulse of energy is emitted into the ground and echoes are returned from the interfaces between different materials in the ground. The amplitude of these returns depends on the change in velocity of the radar wave as it crosses these interfaces. A measure of these velocities is given by the dielectric constant of that material. The travel times are recorded for each return on the radargram and an approximate conversion made to depth by calculating or assuming an average dielectric constant (see below).

Drier materials such as sand, gravel and rocks, i.e. materials which are less conductive (or more resistant), will permit the survey of deeper sections than wetter materials such as clays which are more conductive (or less resistant). Penetration can be increased by using longer wavelengths (lower frequencies) but at the expense of resolution (see 3.4.2 below).

As the antennae emit a "cone" shaped pulse of energy an offset target showing a perpendicular face to the radar wave will be "seen" before the antenna passes over it. A resultant characteristic *diffraction* pattern is thus built up in the shape of a hyperbola. A classic target generating such a diffraction is a pipeline when the antenna is travelling across the line of the pipe. However it should be pointed out that if the interface between the target and its surrounds does not result in a marked change in velocity then only a weak hyperbola will be seen, if at all.

The Ground Probing Impulse Radar used was a SIR2000 system manufactured by Geophysical Survey Systems Inc. (GSSI).

The radar surveys were carried out with a 400MHz antenna. This mid-range frequency offers a good combination of depth of penetration and resolution.

3.4 Sampling interval, depth of scan, resolution and data capture

3.4.1 Sampling interval

Radar scans were carried out along traverses 0.5m apart on a parallel grid as shown in Figure 3. Data was collected at 60 scans/metre. A measuring wheel was used to put markers into the recorded radargram at 1m centres.

3.4.2 Depth of scan and resolution

The average velocity of the radar pulse is calculated to be 0.07m/nsec which is typical for the type of sub-soils on the site. With a range setting of 60nsec this equates to a maximum depth of scan of 2.2m but it must be remembered that this figure could vary by ± 10% or more. A further point worth making is that very shallow features are lost in the strong surface response experienced with this technique.

Under ideal circumstances the minimum size of a vertical feature seen by a 200MHz (relatively low frequency) antenna in a damp soil would be 0.1m (i.e. this antenna has a wavelength in damp soil of about 0.4m and the vertical resolution is one quarter of this wavelength). It is interesting to compare this with the 400MHz antenna, which has a wavelength in the same material of 0.2m giving a theoretical resolution of 0.05m. A 900MHz antenna would give 0.09m and 0.02m respectively.

3.4.3 Data capture

Data is displayed on a monitor as well as being recorded onto an internal hard disk. The data is later downloaded into a computer for processing.

3.5 Processing, presentation of results and interpretation

3.5.1 Processing

The radar plots included in this report have been produced from the recorded data using Radan software. No processing was undertaken.

3.5.2 Presentation of results and interpretation

Manual abstraction
Each radargram has been studied and those anomalies thought to be significant were noted and classified as detailed below. Inevitably some simplification has been made to classify the diversity of responses found in radargrams.

i. Strong and weak discrete reflector.
These may be a mix of different types of reflectors but their limits can be clearly defined. Their inclusion as a separate category has been considered justified in order to emphasise anomalous returns which may be from archaeological targets and would not otherwise be highlighted in the analysis.

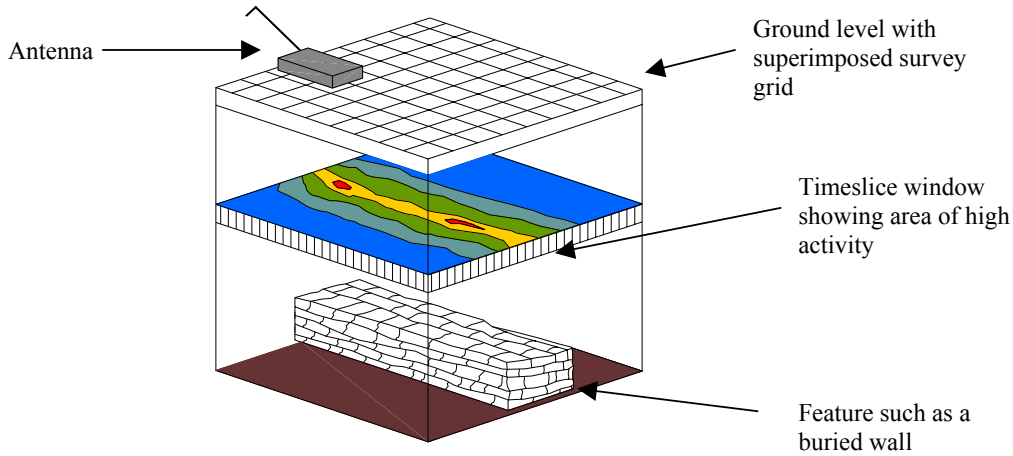
ii. Complex reflectors.
These would generally indicate a confused or complex structure to the subsurface. An occurrence of such returns, particularly where the natural soils or rocks are homogeneous, would suggest artificial disturbances. These are subdivided into both strong and weak giving an indication of the extent of change of velocity across the interface, which in turn may be associated with a marked change in material or moisture content.

iii. Point diffractions.
These may be formed by a discrete object such as a stone or a linear feature such as a small diameter pipeline being crossed by the radar traverse (see also the second sentence in 4. below).

iv. Convex reflectors and broad crested diffractions.
A convex reflector can be formed by a convex shaped buried interface such as a vault or very large diameter pipeline or culvert. A broad crested diffraction as opposed to a point diffraction can be formed by (for example) a large diameter pipe or a narrow wall generating a hybrid of a point diffraction and convex reflector where the central section is a reflection off the top of the target and the edges/sides forming diffractions.

v. Planar returns.
These may be formed by a floor or some other interface parallel with the surface. These are subdivided into both strong and weak giving an indication of the extent of change of velocity across the interface which in turn may be associated with a marked change in material or moisture content.

Timeslice plots
In addition to a manual abstraction from the radargrams, a computer analysis was also carried out. The radar data is interrogated for areas of high activity and the results presented in a plan format known as timeslice plots (Figures 6-14). In this way it is easy to see if the high activity areas form recognisable patterns.



The GPR data is compiled to create a 3D file. This 3D file can be manipulated to view the data from any angle and at any depth within range. The data was then modelled to produce activity plots at various depths. As the radar is actually measuring the time for each of the reflections found, these are called "time slice windows". Plots for various time slices have been included in the report. Based on an average velocity calculations have been made to show the equivalent depth into the ground. The data was sampled between different time intervals effectively producing plans at different depths into the ground.

The weaker reflections in the time slice windows are shown as dark colours namely blues and greens. The stronger reflections are represented by brighter colours such as light green, yellow, orange, red and white (see key provided in Figures 6-14).

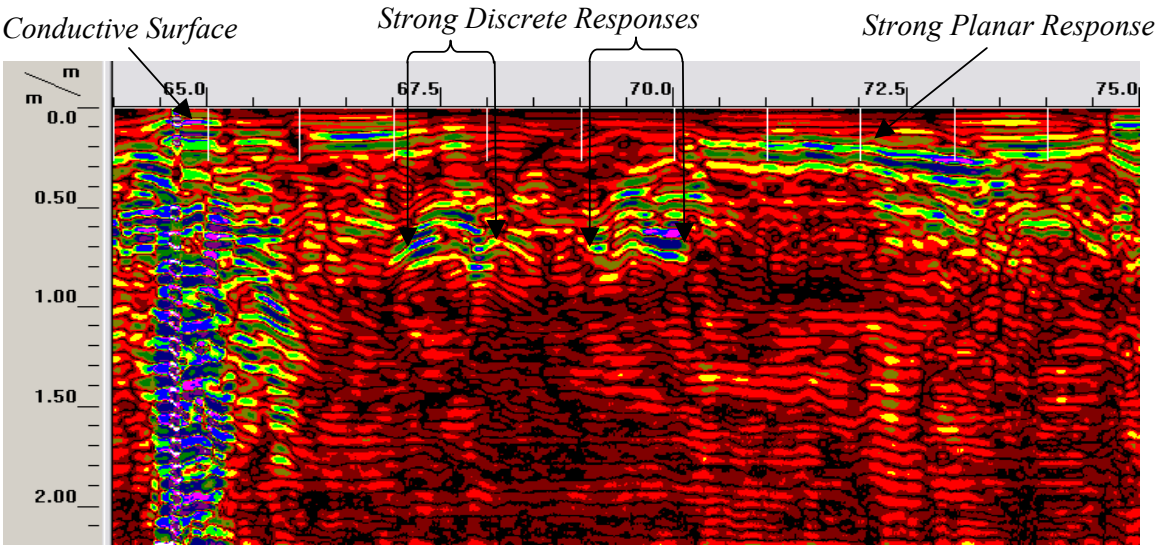
Reflections within the radar image are generated by a change in velocity of the radar from one medium to another. It is not unreasonable to assume that the higher activity anomalies are related to marked changes in materials within the ground such as foundations or surfaces within the soil matrix.

4 RESULTS

4.1 Area 1

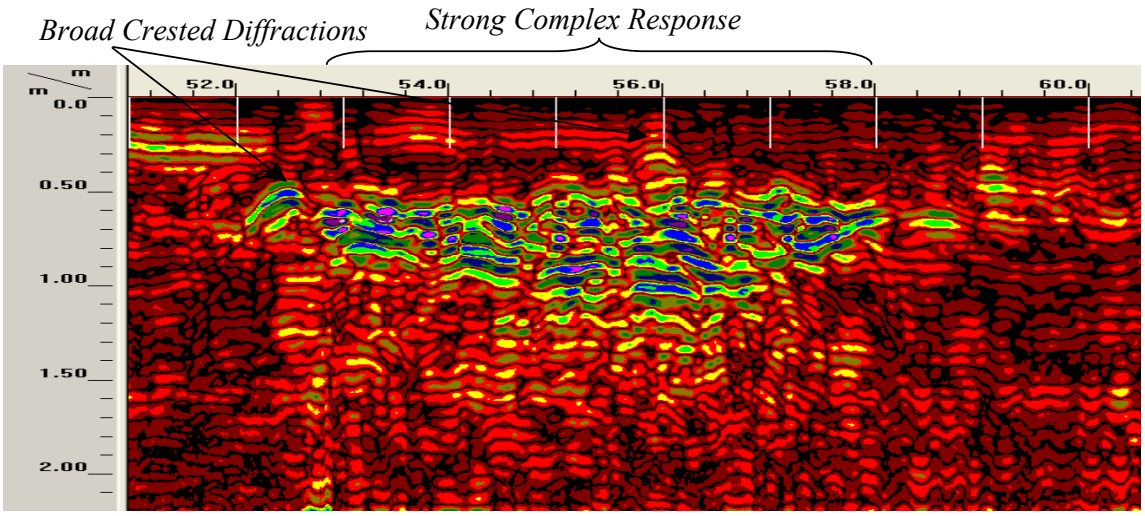
Area 1 is the largest of the three areas and also contains the most interesting anomalies. Several linear arrangements of strong and weak discrete responses can be seen throughout the area, all running perpendicular to the traverse direction (hatched in blue in Figure 15). An example of two such an anomalies are shown in Example Radargram 1 (below). It is probable that these anomalies are caused by structural remains, such as masonry wall foundations. Any structures running parallel to the traverse direction would more difficult to identify, perhaps explaining why they are all of the same orientation. While the majority of these anomalies are to the east of the area, only one can be seen on the western side. This anomaly is of particular significance as it coincides with one of the excavation trenches that took place prior to the geophysical survey. The discrete response occurs over the known location of a land drain channel

that was unearthed during the excavation *(Torre Abbey,Torquay, Archaeological field evaluation of the west walk of the cloister, Report 105, November 1999, Paul Gibbons Associates)*.

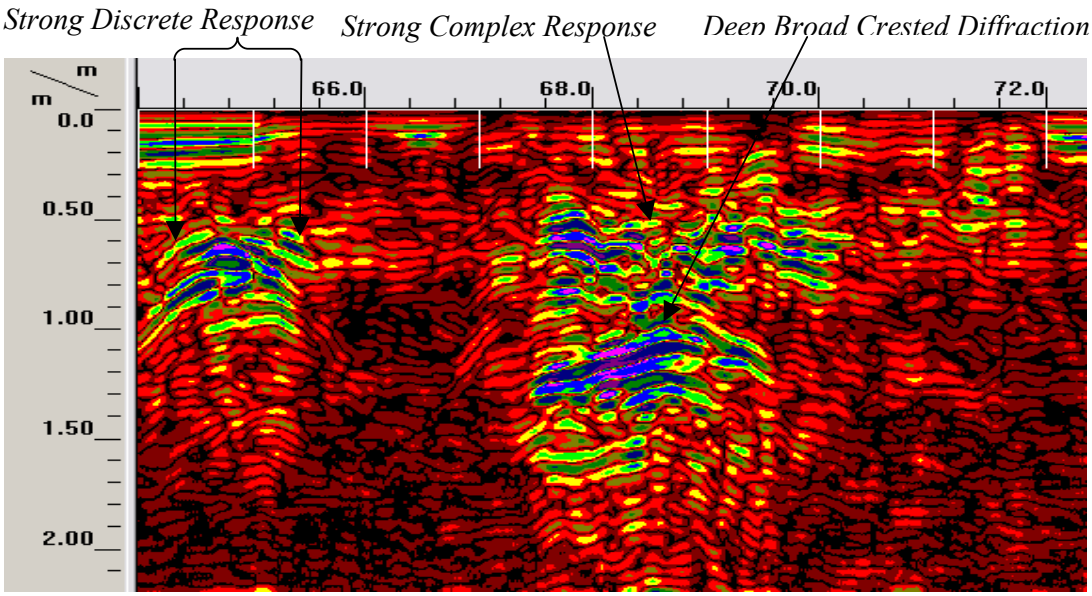


Example radargram 1: along transect at 16.5N from 64E to 75E

There are three distinct linear anomalies hatched in red in Figure 15. The two thinner anomalies are a series of point diffractions and small broad crested diffractions and these are likely to be caused by a service. Again they are aligned perpendicular to the traverse direction. The larger linear anomaly in the southeast corner of Area 1 shows up in the radargrams as broad-crested diffractions. Due to its orientation in relation to the GPR traverse lines this anomaly is probably also caused by a smaller service but its width has been exaggerated due to the relative orientation of the service and the traverse. An example of diffractions from each linear anomaly can be seen in Example Radargrams 2 and 3.



Example Radargram 2: along transect at 22.5N from 51E to 60E



Example Radargram 3: along transect at 12N from 64E to 72E

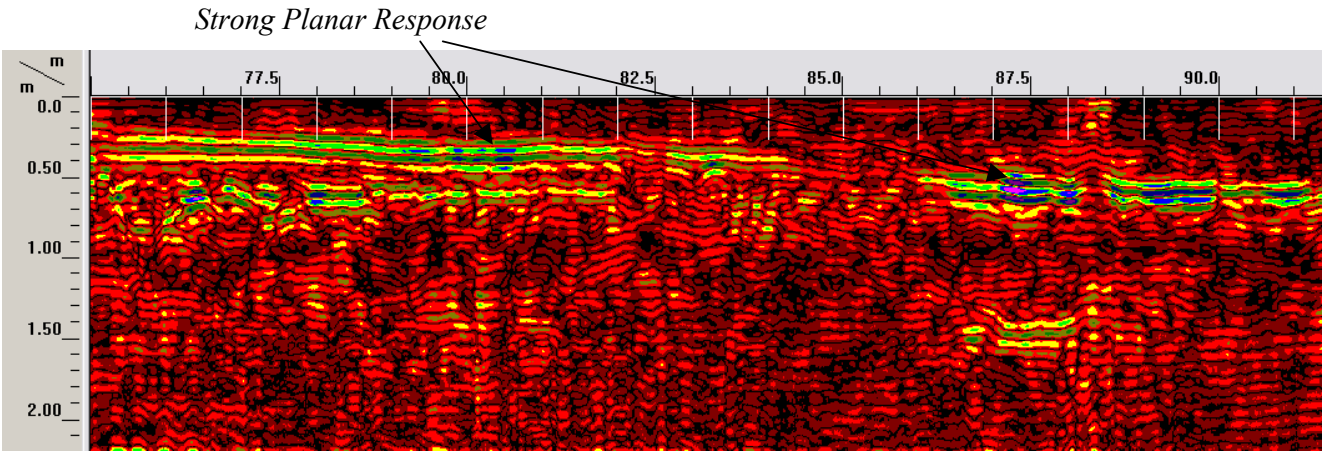
Several areas with strong complex responses can be seen in Area 1, these are shaded in dark brown in Figure 15. These are likely to mark areas of disturbed ground. This is probably the case for the large complex anomaly highlighted in the northwest corner of the area, which coincides with the location of an earlier excavation trench. Examples of complex responses are shown in Example Radargrams 2 and 3.

There are two strong linear planar responses highlighted in green in Figure 15. Unlike the other linear anomalies they run parallel to the traverse lines. One of these anomalies continues into Area 2 getting steadily deeper to the east. This anomaly crosses above two of the deeper discrete linear anomalies and blocks their response. An example of this anomaly can be seen in Example Radargrams 1 and 4. It is probable that a structural feature such as a path or possibly a service causes this planar response.

4.2 Area 2

The main feature in this area is the continuation of the strong planar response that extends into Area 1. Example Radargram 4 (below) shows the extent of this planar feature.

There is another planar feature in the north west of this area. This feature has well defined extents and may be caused by a buried surface of archaeological origin.



Example Radargram 4: along transect at 15.5N from 75E to 91E

There are some small linear discrete features highlighted in blue in Figure 16 although these are not as well defined as those in Area 1. As in Area 1 some of these linear features stop at the edge of the strong planar feature and reappear on the other side. This suggests that they pass under the planar feature, which may have masked their response. It is probable that these are structural remains of archaeological origin.

There are several large complex anomalies highlighted in the north of the survey area. Again these are possibly caused by disturbed ground.

A series of weak planar responses run down the centre of this area. These are caused by a concrete kerb that is visible on the surface.

4.3 Area 3

Area 3 is fairly quiet in comparison with the other two areas. The two most prominent features within this area are linear broad crested diffractions that are probably caused by services, or possibly a buried structural feature.

There are a number of anomalies bounding the west and east sides of the survey area, mostly weak planar and complex anomalies. It is probable that these are responses from the existing pathway.

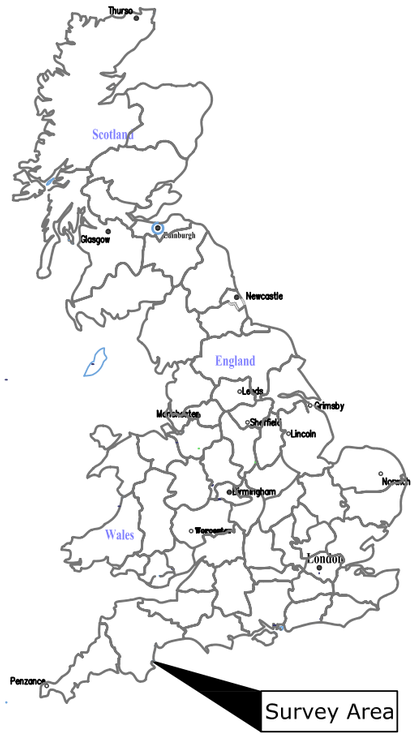
5 CONCLUSION

Area 1 revealed the most promising responses with several strong linear discrete anomalies running through the area, it is probable that these are of archaeological significance and are possibly caused by structural remains.

Several linear arrangements of broad crested and point diffractions can be traced through the radargrams in both Areas 1 and 3. These are probably caused by modern services although the possibility that they may be of archaeological origin should not be ruled out.

There is one large linear arrangement of strong planar responses running from Area 1 into Area 2. This feature may well be structural such as a path or a wall foundation but could possibly be a service.

OS 100km square = SZ



Amendments		
Issue No.	Date	Description
-	-	
		-

Site centred on NGR: SX 908 638

Client: MOLAS

Project Title: TORRE ABBEY TORQUAY

Job No. J1996

Subject: LOCATION PLAN OF SURVEY AREA

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Scale: 1:25 000 (0m 500 1000m)

Plot	Checked by	Issue No.
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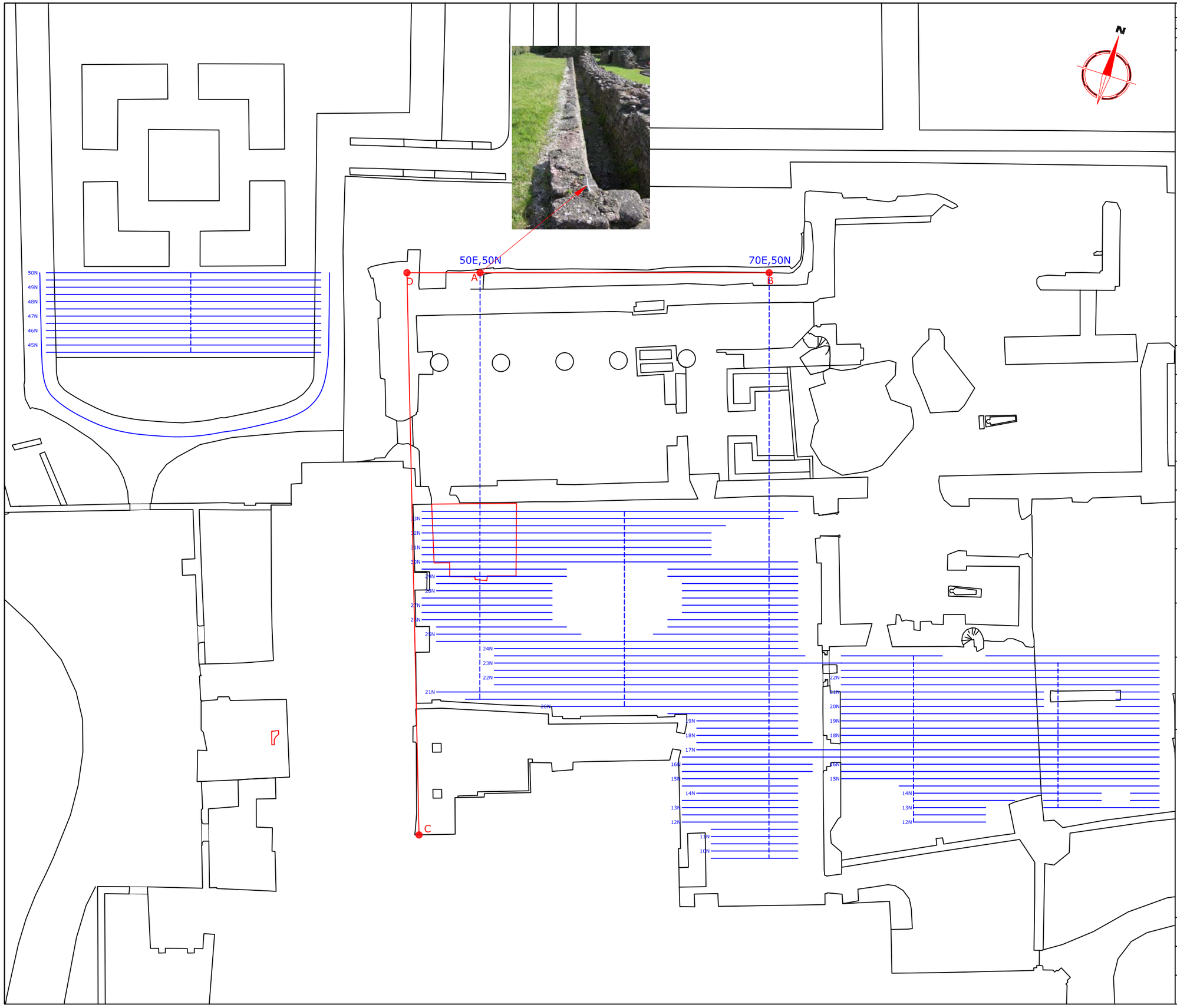
Survey date	**Drawn by**	**Figure No.**
23/03/05	AHC	01



Amendments		
Issue No.	Date	Description
-	-	
		-

Referencing information

A-B	20.0m	A-D	5.06m	B-D	25.06m

A-B	Baseline
A	50E,50N (Point on north side of open drain)
B	70E,50N (Extension of north side of open drain)
C	point on building line
D	Extension of building line
——	Radar Transects

Client

MOLAS

Project Title — Job No. J1996

TORRE ABBEY TORQUAY

Subject

SITE PLAN SHOWING LOCATION OF SURVEY GRIDS AND REFERENCING

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Scale 1:250 — 0m 5 10m

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Survey date	**Drawn by**	**Figure No.**
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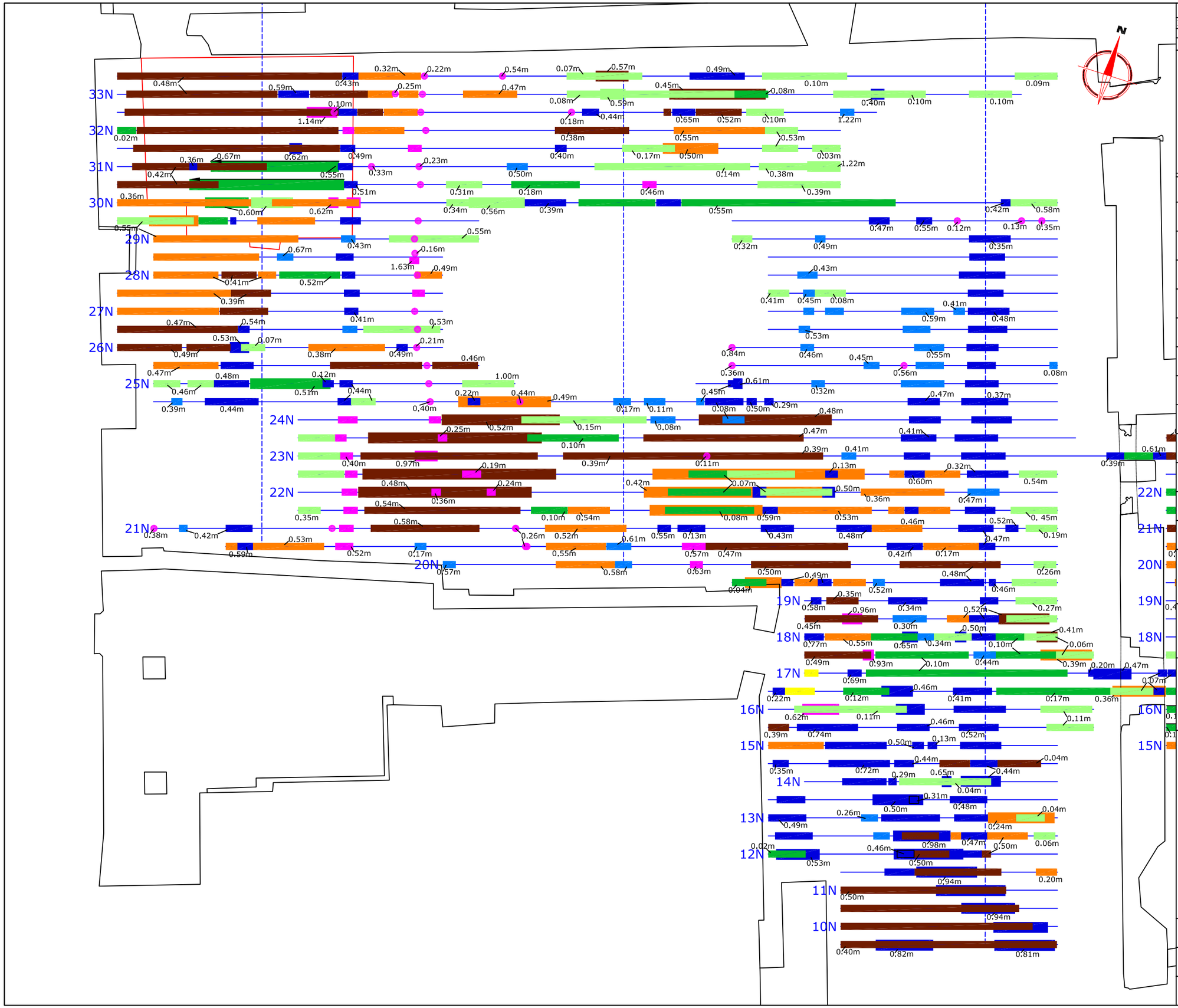

Amendments

Issue No.	Date	Description
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RADAR ABSTRACTION KEY

	Strong Discrete
	Weak Discrete
	Strong Complex
	Weak Complex
	Point Diffraction
	Broad Crested
	Strong Planar
	Weak Planar
	Focused Ringing
	Conductive Surface
	Inclined Event
0.25	Depth to top of feature [m]

Client
MOLAS

Project Title — Job No. J1996
TORRE ABBEY TORQUAY

Subject
ABSTRACTION OF GROUND PENETRATING RADAR DATA-400MHz AREA 1

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Scale 1:100 — 0m 1 2 3 4 5m

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Survey date	**Drawn by**	**Figure No.**
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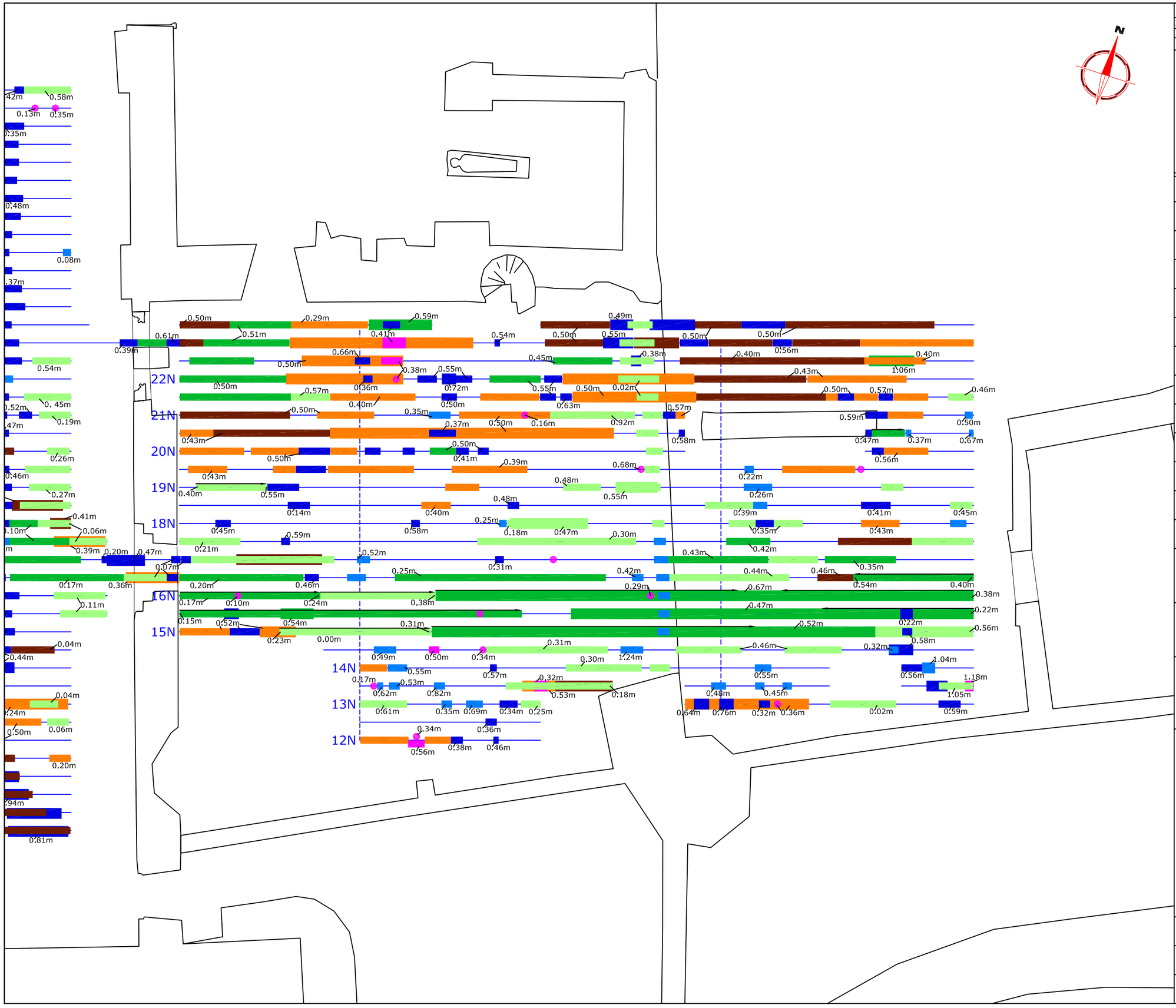

Amendments		
Issue No.	Date	Description
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RADAR ABSTRACTION KEY

	Strong Discrete
	Weak Discrete
	Strong Complex
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	Point Diffraction
	Broad Crested
	Strong Planar
	Weak Planar
	Focused Ringing
	Conductive Surface
	Inclined Event
0.25	Depth to top of feature [m]

Client
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Project Title — Job No. J1996
TORRE ABBEY TORQUAY

Subject
ABSTRACTION OF GROUND PENETRATING RADAR DATA-400MHz AREA 2

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Scale 1:100 (0m 1 2 3 4 5m)

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Survey date	**Drawn by**	**Figure No.**
24/03/05	AHC	04

Amendments

Issue No.	Date	Description
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RADAR ABSTRACTION KEY

	Strong Discrete
	Weak Discrete
	Strong Complex
	Weak Complex
	Point Diffraction
	Broad Crested
	Strong Planar
	Weak Planar
	Focused Ringing
	Conductive Surface
	Inclined Event
0.25	Depth to top of feature [m]

Client
MOLAS

Project Title — Job No. J1996
TORRE ABBEY TORQUAY

Subject
ABSTRACTION OF GROUND PENETRATING RADAR DATA-400MHz AREA 3

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Scale 1:100 — 0m 1 2 3 4 5m

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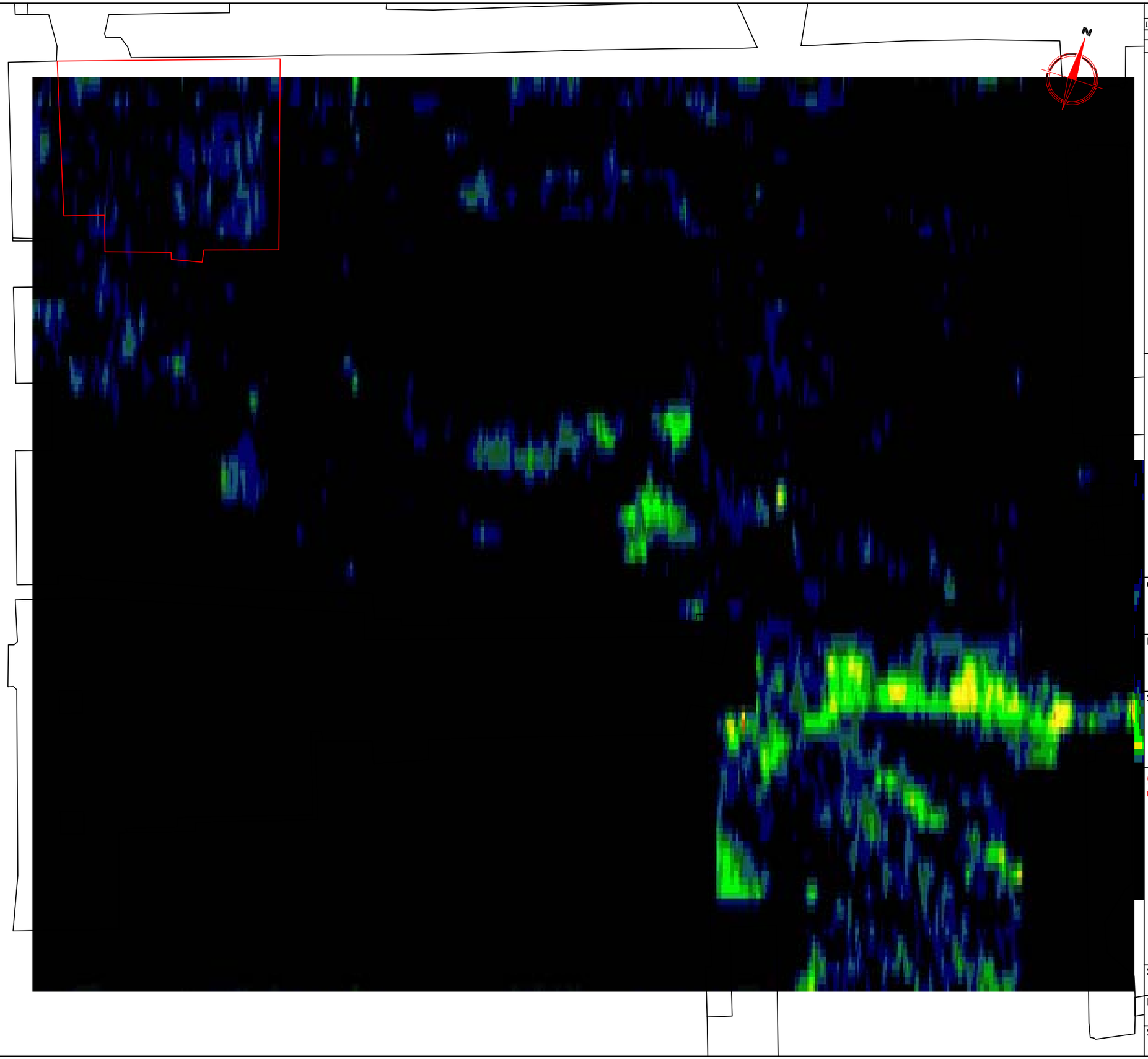

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Issue No.	Date	Description
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Colour Scale for Timeslice 'Activity' Plots and Simplified Key

INCREASING
ENERGY LEVEL
DECREASING

High Energy Return
-Possible Archaeological Target

Medium Energy Return
-Mixed Ground

Low Energy Return
-Homogenous Ground

Client
MOLAS

Project Title
Job No. J1996
TORRE ABBEY TORQUAY

Subject
GPR TIMESLICE PLOT AT 0.2m DEPTH - AREA 1

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Scale 1:100 — 0m 1 2 3 4 5m

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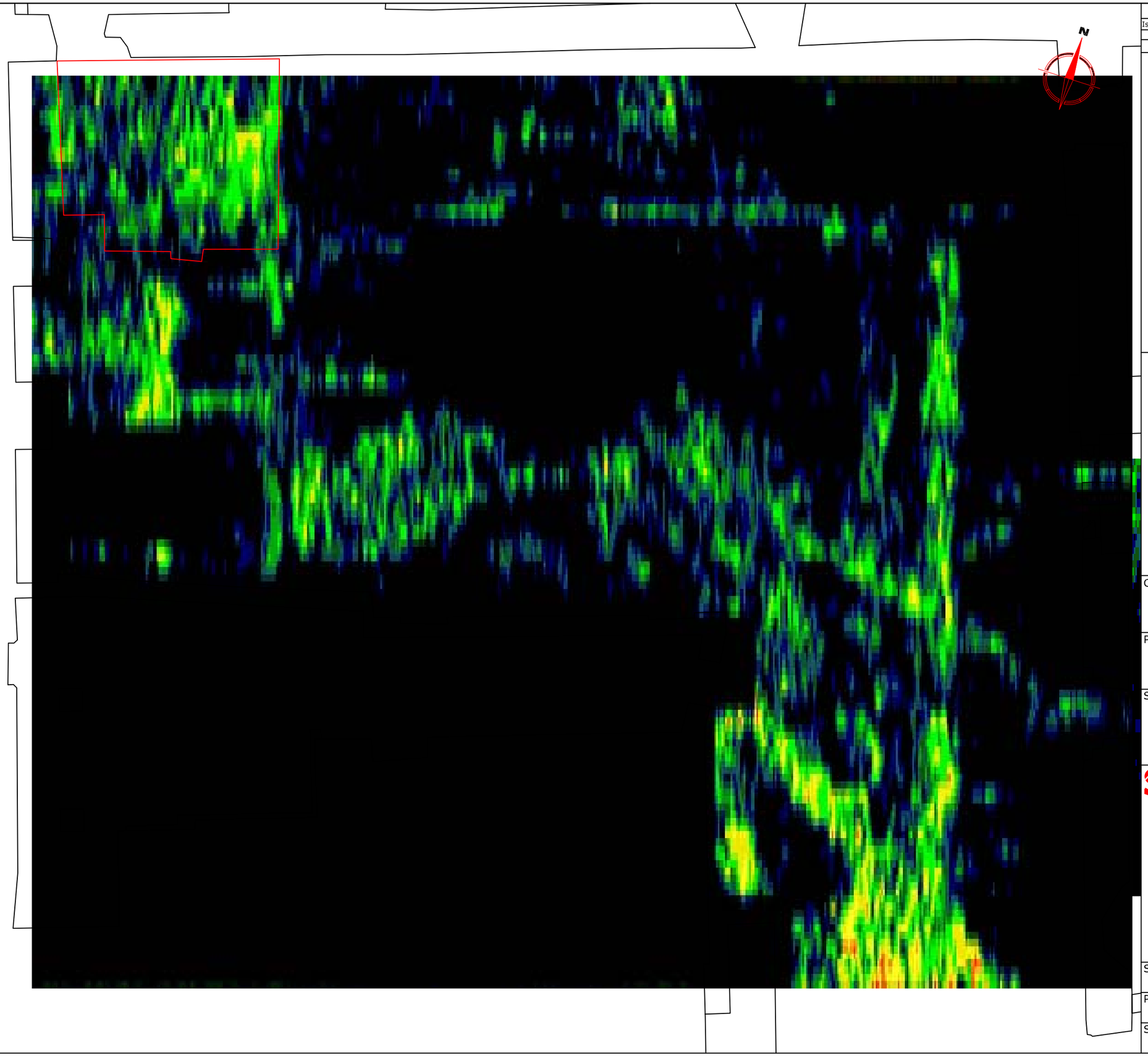

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Colour Scale for Timeslice 'Activity' Plots and Simplified Key

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High Energy Return
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Client

MOLAS

Project Title — Job No. J1996

TORRE ABBEY TORQUAY

Subject

GPR TIMESLICE PLOT AT 0.6m DEPTH - AREA 1

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Scale 1:100 — 0m 1 2 3 4 5m

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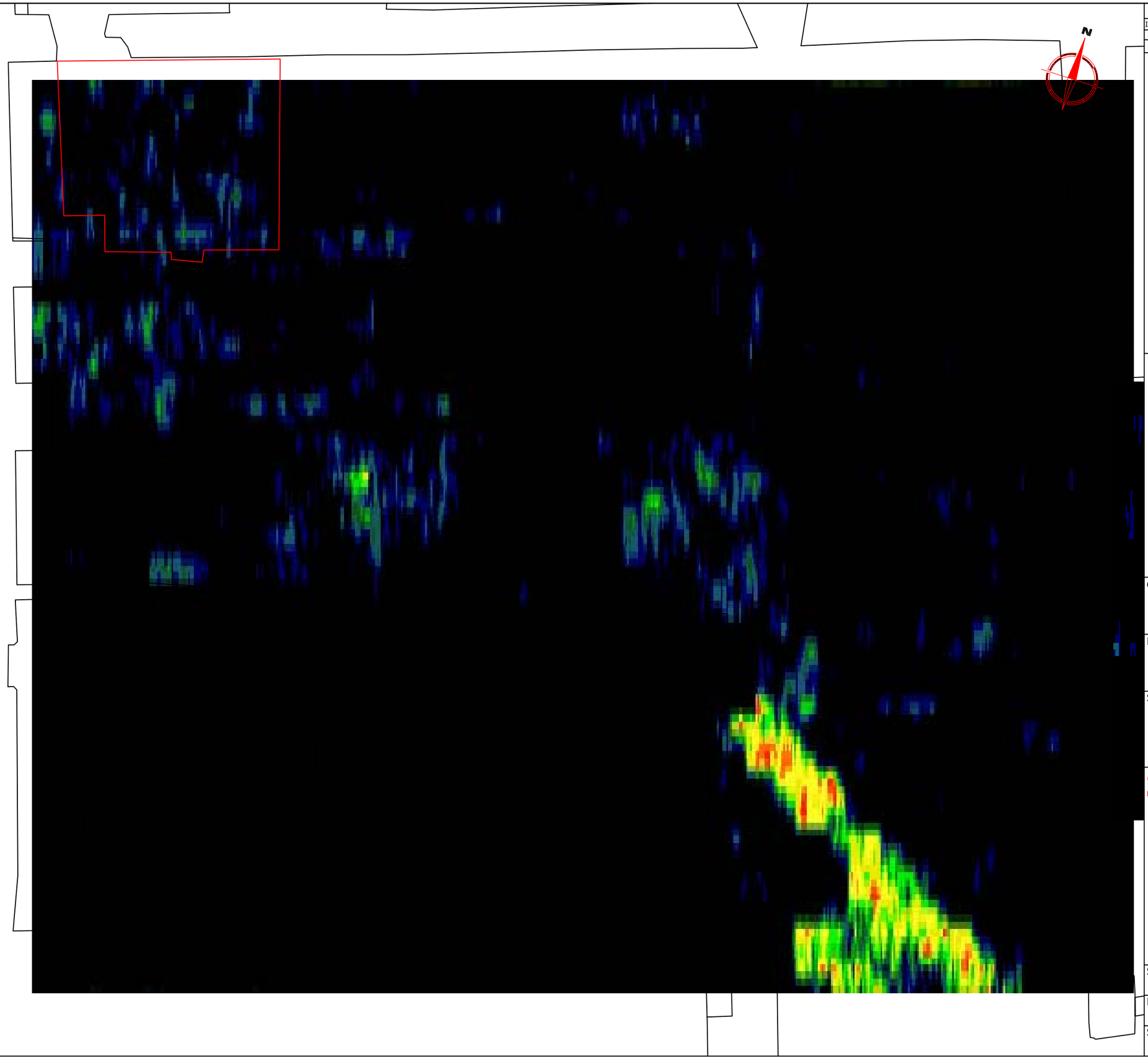

Amendments

Issue No.	Date	Description
-	-	
		-

Colour Scale for Timeslice 'Activity' Plots and Simplified Key

INCREASING
ENERGY LEVEL
DECREASING

High Energy Return
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Medium Energy Return
-Mixed Ground

Low Energy Return
-Homogenous Ground

Client

MOLAS

Project Title — Job No. J1996

TORRE ABBEY TORQUAY

Subject

GPR TIMESLICE PLOT AT 1.2m DEPTH - AREA 1

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GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
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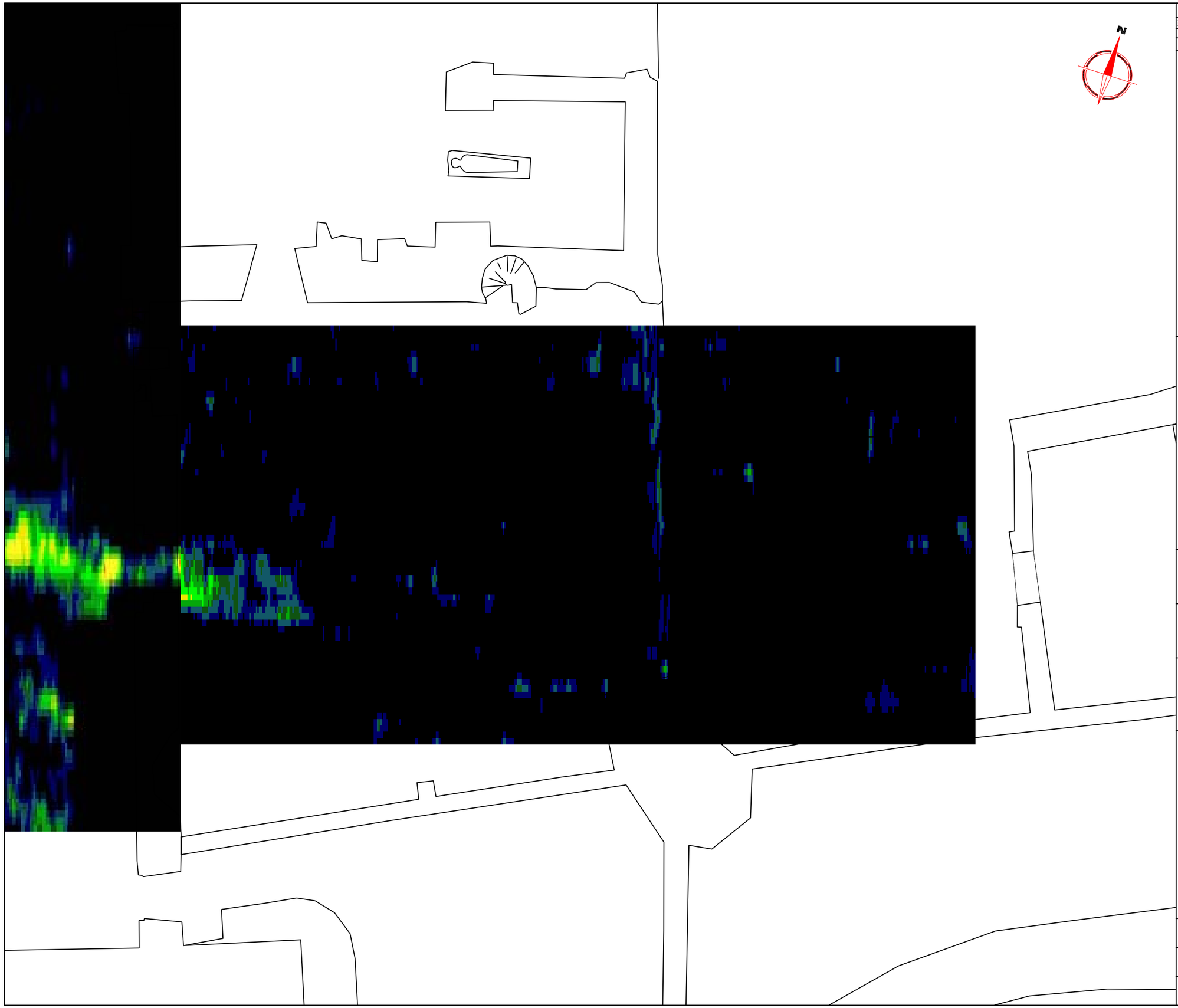
Scale 1:100 — 0m 1 2 3 4 5m

Plot	Checked by	Issue No.
A3	SAS	01
Survey date	**Drawn by**	**Figure No.**
24/03/05	AHC	08



Amendments		
Issue No.	Date	Description
-	-	
		-

Colour Scale for Timeslice 'Activity' Plots and Simplified Key

INCREASING

ENERGY LEVEL

DECREASING

High Energy Return
-Possible Archaeological Target

Medium Energy Return
-Mixed Ground

Low Energy Return
-Homogenous Ground

Client

MOLAS

Project Title — Job No. J1996

TORRE ABBEY TORQUAY

Subject

GPR TIMESLICE PLOT AT 0.2m DEPTH - AREA 2

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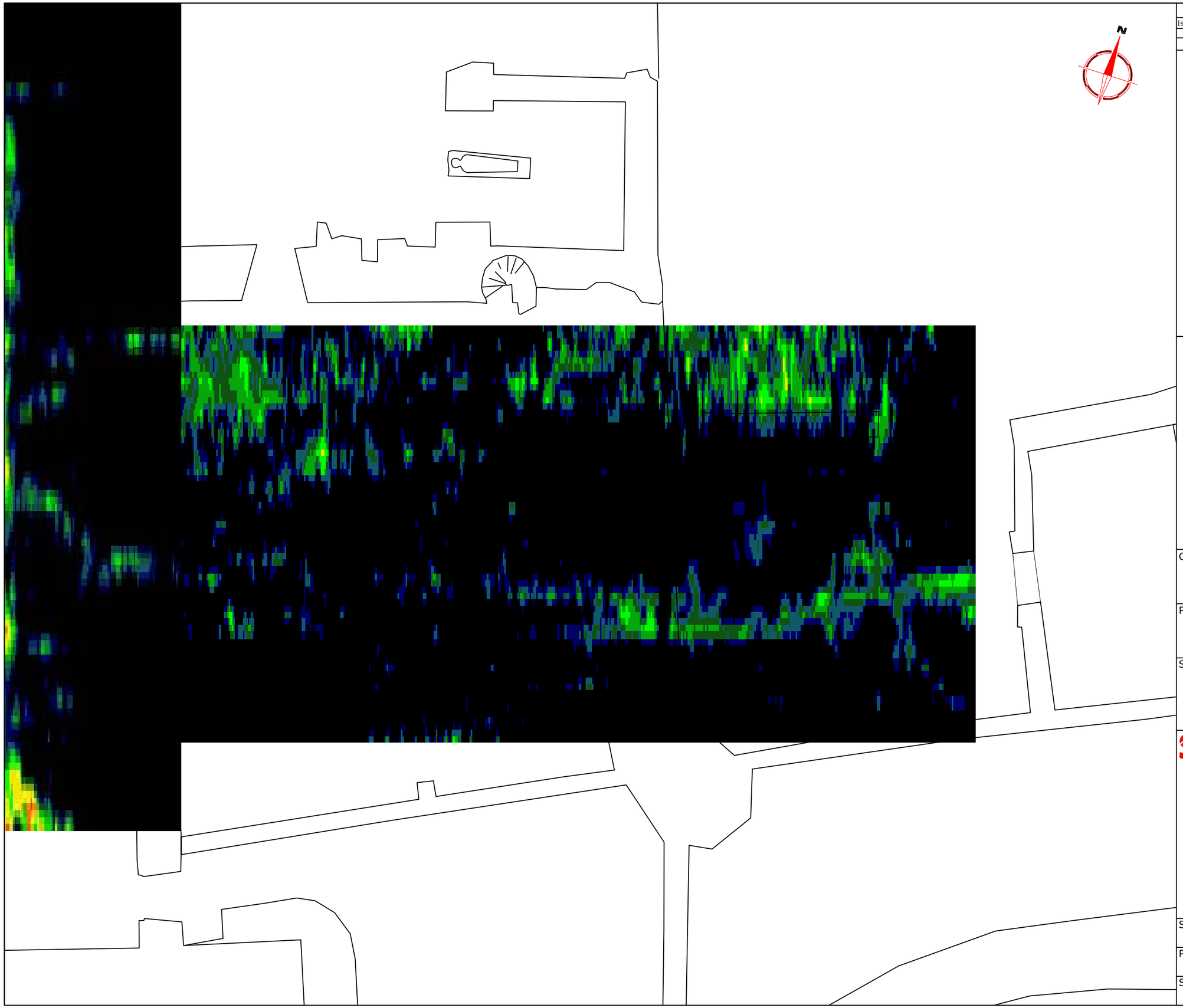
Scale 1:100 — 0m 1 2 3 4 5m

Plot	Checked by	Issue No.
A3	SAS	01
Survey date	**Drawn by**	**Figure No.**
24/03/05	AHC	09



Amendments		
Issue No.	Date	Description
-	-	
		-

Colour Scale for Timeslice 'Activity' Plots and Simplified Key

INCREASING

ENERGY LEVEL

DECREASING

High Energy Return
-Possible Archaeological Target

Medium Energy Return
-Mixed Ground

Low Energy Return
-Homogenous Ground

Client

MOLAS

Project Title — Job No. J1996

TORRE ABBEY TORQUAY

Subject

GPR TIMESLICE PLOT AT 0.6m DEPTH - AREA 2

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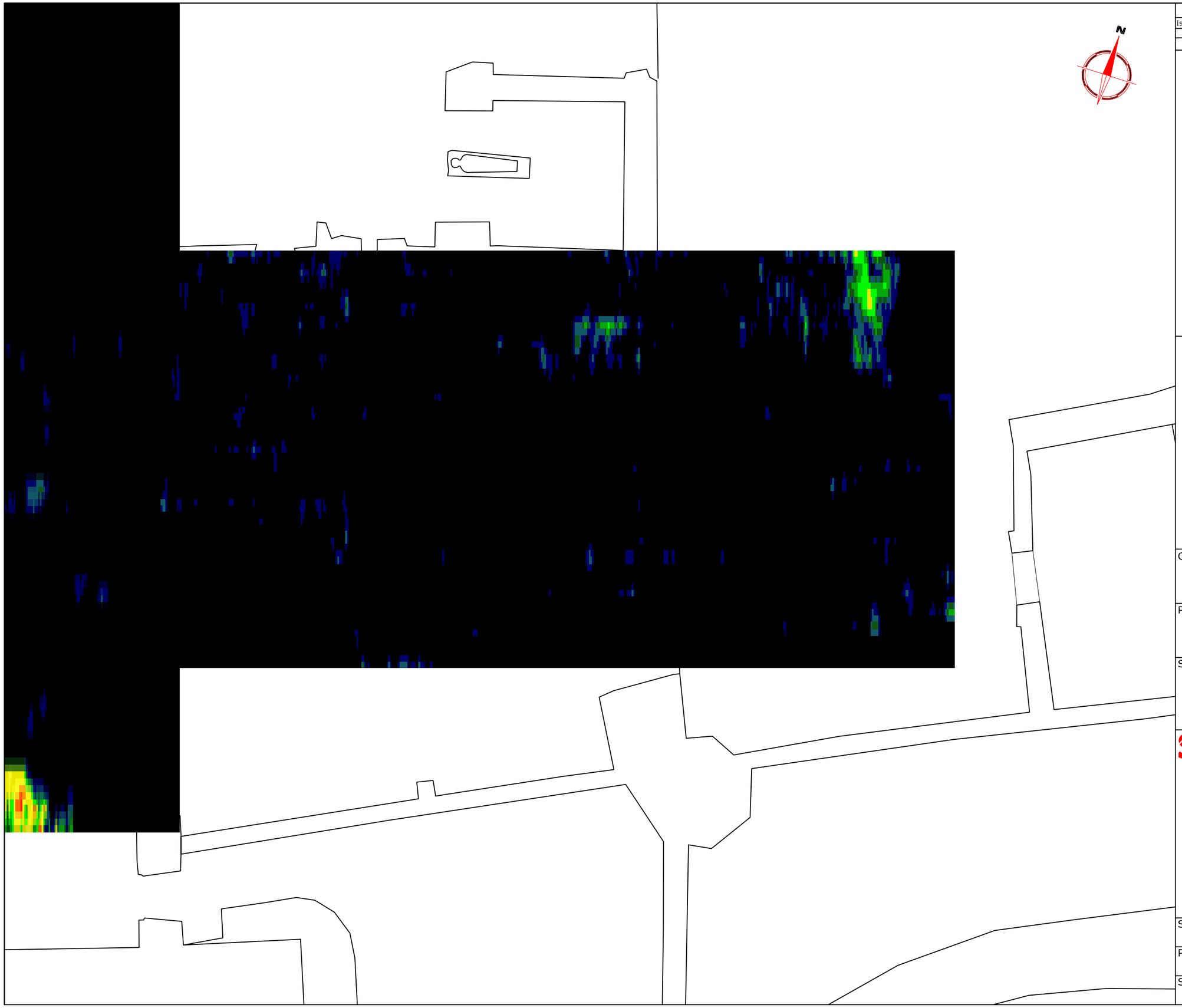
Scale 1:100 — 0m 1 2 3 4 5m

Plot	Checked by	Issue No.
A3	SAS	01
Survey date	**Drawn by**	**Figure No.**
24/03/05	AHC	10



Amendments		
Issue No.	Date	Description
-	-	
		-

Colour Scale for Timeslice 'Activity' Plots and Simplified Key

INCREASING
ENERGY LEVEL
DECREASING

High Energy Return
-Possible Archaeological Target

Medium Energy Return
-Mixed Ground

Low Energy Return
-Homogenous Ground

Client

MOLAS

Project Title — Job No. J1996

TORRE ABBEY TORQUAY

Subject

GPR TIMESLICE PLOT AT 1.2m DEPTH - AREA 2

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Scale 1:100 — 0m 1 2 3 4 5m

Plot	Checked by	Issue No.
A3	SAS	01
Survey date	**Drawn by**	**Figure No.**
24/03/05	AHC	11

Amendments		
Issue No.	Date	Description
-	-	
		-

Colour Scale for Timeslice 'Activity' Plots and Simplified Key

INCREASING
ENERGY LEVEL
DECREASING

High Energy Return
-Possible Archaeological Target

Medium Energy Return
-Mixed Ground

Low Energy Return
-Homogenous Ground

Client
MOLAS

Project Title — Job No. J1996
TORRE ABBEY TORQUAY

Subject
GPR TIMESLICE PLOT AT 0.2m DEPTH - AREA 3

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Scale 1:100 — 0m 1 2 3 4 5m

Plot	Checked by	Issue No.
A3	SAS	01
Survey date	**Drawn by**	**Figure No.**
24/03/05	AHC	12

Amendments		
Issue No.	Date	Description
-	-	
		-

Colour Scale for Timeslice 'Activity' Plots and Simplified Key

INCREASING

ENERGY LEVEL

DECREASING

High Energy Return
-Possible Archaeological Target

Medium Energy Return
-Mixed Ground

Low Energy Return
-Homogenous Ground

Client

MOLAS

Project Title — Job No. J1996

TORRE ABBEY TORQUAY

Subject

GPR TIMESLICE PLOT AT 0.6m DEPTH - AREA 3

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Scale 1:100 — 0m 1 2 3 4 5m

Plot	Checked by	Issue No.
A3	SAS	01
Survey date	**Drawn by**	**Figure No.**
24/03/05	AHC	13

Amendments		
Issue No.	Date	Description
-	-	
		-

Colour Scale for Timeslice 'Activity' Plots and Simplified Key

INCREASING
ENERGY LEVEL
DECREASING

High Energy Return
-Possible Archaeological Target

Medium Energy Return
-Mixed Ground

Low Energy Return
-Homogenous Ground

Client
MOLAS

Project Title
TORRE ABBEY TORQUAY

Job No. J1996

Subject
GPR TIMESLICE PLOT AT 1.2m DEPTH - AREA 3

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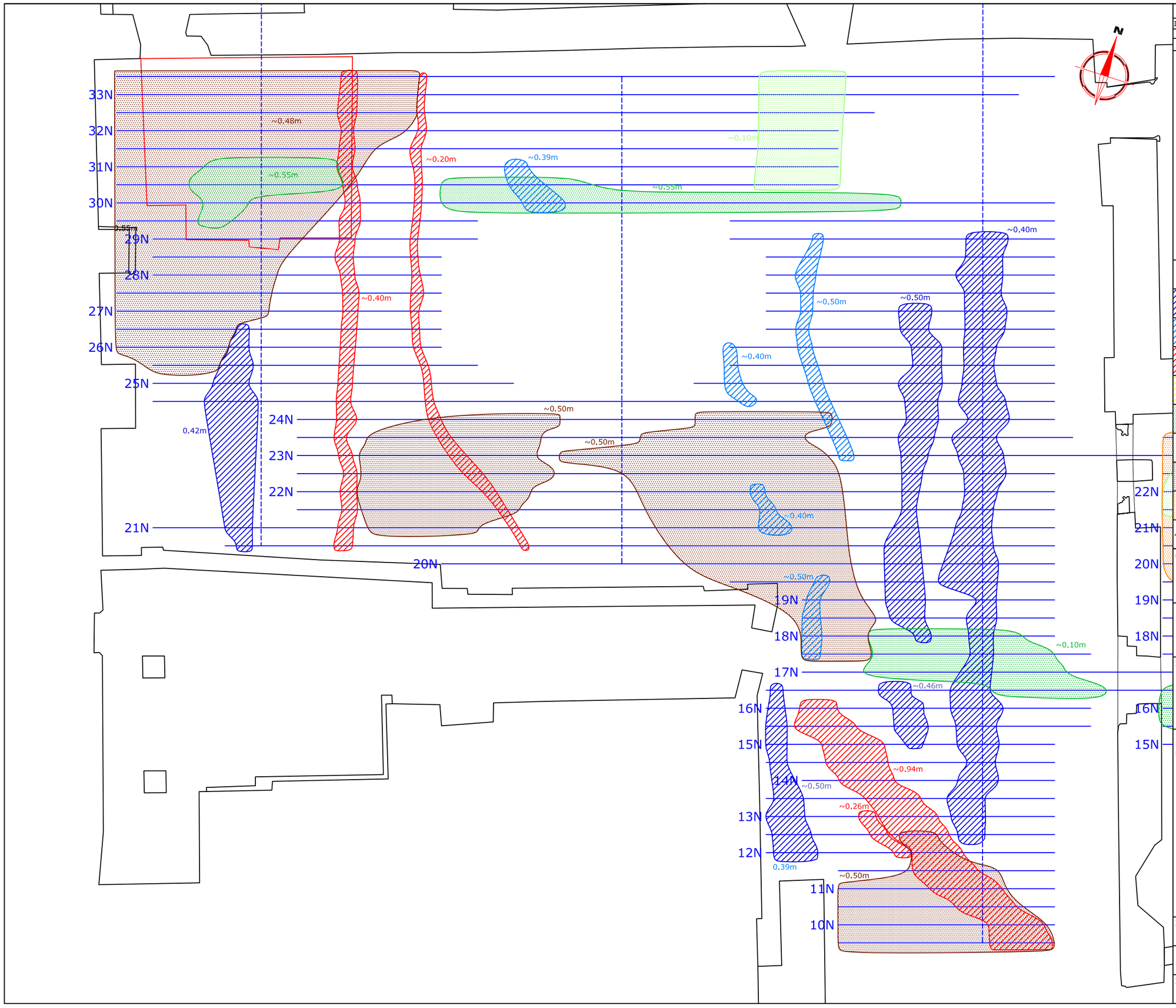
Scale 1:100 — 0m 1 2 3 4 5m

Plot	Checked by	Issue No.
A3	SAS	01
Survey date	**Drawn by**	**Figure No.**
24/03/05	AHC	14



Amendments

Issue No.	Date	Description
-	-	
		-

KEY

	Strong discrete responses probably caused by buried structural remains of archaeological origin
	Weak discrete responses possibly caused by buried structural remains of archaeological origin
	Linear arrangement of point and/or broad crested diffractions - possibly caused by a service
	Shallow planar and/or discrete anomalies - probably caused by surface features (paths etc)
	Strong planar anomalies probably caused by buried structural remains running parallel to the traverses
	Planar anomailes possibly caused by a buried surface or a former pathway
	Complex responses - possibly due to structural remains or disturbed ground such as trenches.
	Weak complex responses - possibly due to structural remains or disturbed ground such as trenches.
~0.00m	Approximate depth to top of feature

Client

MOLAS

Project Title — Job No. J1996

TORRE ABBEY TORQUAY

Subject

INTERPRETATION OF GPR DATA
AREA 1

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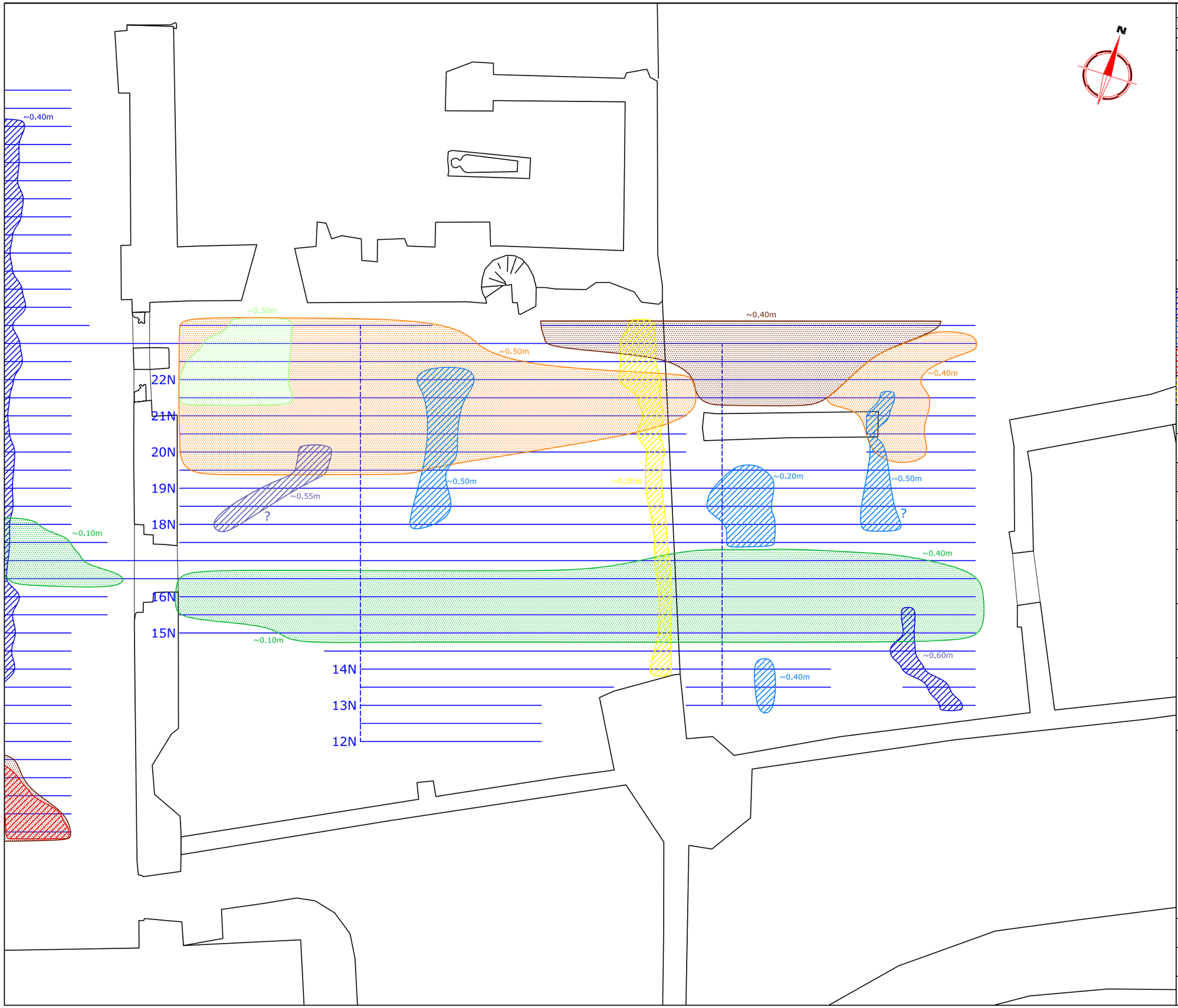
Scale 1:100 — 0m 1 2 3 4 5m

Plot	Checked by	Issue No.
A3	SAS	01
Survey date	**Drawn by**	**Figure No.**
24/03/05	AHC	15



Amendments

Issue No.	Date	Description
-	-	
		-

KEY

	Strong discrete responses probably caused by buried structural remains of archaeological origin
	Weak discrete responses possibly caused by buried structural remains of archaeological origin
	Linear arrangement of point and/or broad crested diffractions - possibly caused by a service
	Shallow planar and/or discrete anomalies - probably caused by surface features (paths etc)
	Strong planar anomalies probably caused by buried structural remains running parallel to the traverses
	Planar anomalies possibly caused by a buried surface or a former pathway
	Complex responses - possibly due to structural remains or disturbed ground such as trenches.
	Weak complex responses - possibly due to structural remains or disturbed ground such as trenches.
~0.00m	Approximate depth to top of feature

Client

MOLAS

Project Title — Job No. J1996

TORRE ABBEY TORQUAY

Subject

INTERPRETATION OF GPR DATA
AREA 2

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Scale 1:100 — 0m 1 2 3 4 5m

Plot	Checked by	Issue No.
A3	SAS	01
Survey date	**Drawn by**	**Figure No.**
24/03/05	AHC	16

Amendments

Issue No.	Date	Description
-	-	
		-

KEY

	Strong discrete responses probably caused by buried structural remains of archaeological origin
	Weak discrete responses possibly caused by buried structural remains of archaeological origin
	Linear arrangement of point and/or broad crested diffractions - possibly caused by a service
	Shallow planar and/or discrete anomalies - probably caused by surface features (paths etc)
	Strong planar anomalies probably caused by buried structural remains running parallel to the traverses
	Planar anomailes possibly caused by a buried surface or a former pathway
	Complex responses - possibly due to structural remains or disturbed ground such as trenches.
	Weak complex responses - possibly due to structural remains or disturbed ground such as trenches.
~0.00m	Approximate depth to top of feature

Client

MOLAS

Project Title — Job No. J1996

TORRE ABBEY TORQUAY

Subject

INTERPRETATION OF GPR DATA
AREA 3

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Scale 1:100 — 0m 1 2 3 4 5m

Plot	Checked by	Issue No.
A3	SAS	01
Survey date	**Drawn by**	**Figure No.**
24/03/05	AHC	17