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Hopwood Academy, Rochdale

Geophysical Report



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***This proposal and the contents detailed herein are strictly.
intended for the recipient as set out on the cover page.***

This report is commercial in confidence.

1. Introduction

SEP Geophysical Ltd were instructed by Tier Consult Group Ltd, to undertake a Ground Penetrating Radar (GPR) survey, to map possible voiding and obstructions within the car park at Hopwood academy, Rochdale.

2. Project Overview

2.1. Site Details

The site is located at Hopwood College, Rochdale and comprises of a hard standing car park. A historic ground investigation has been carried out at the site recording made ground between 1.50 – 6.80 metres below ground level. This is underlain by clays and silt.



Map 1 – Site location and area of interest.

3. Scope & Survey Design

It is understood the site is to be developed. The site has had multiple historical uses over the years with industrial mills and other buildings present. The former River Rothe and a weir are also recorded in the middle of the car park according to historical imagery (**Image 1**). Previous Ground Investigations (GI) have encountered multiple obstructions within the ground. The next phase of GI is being planned with the aim to characterise the site further and target buried obstructions.

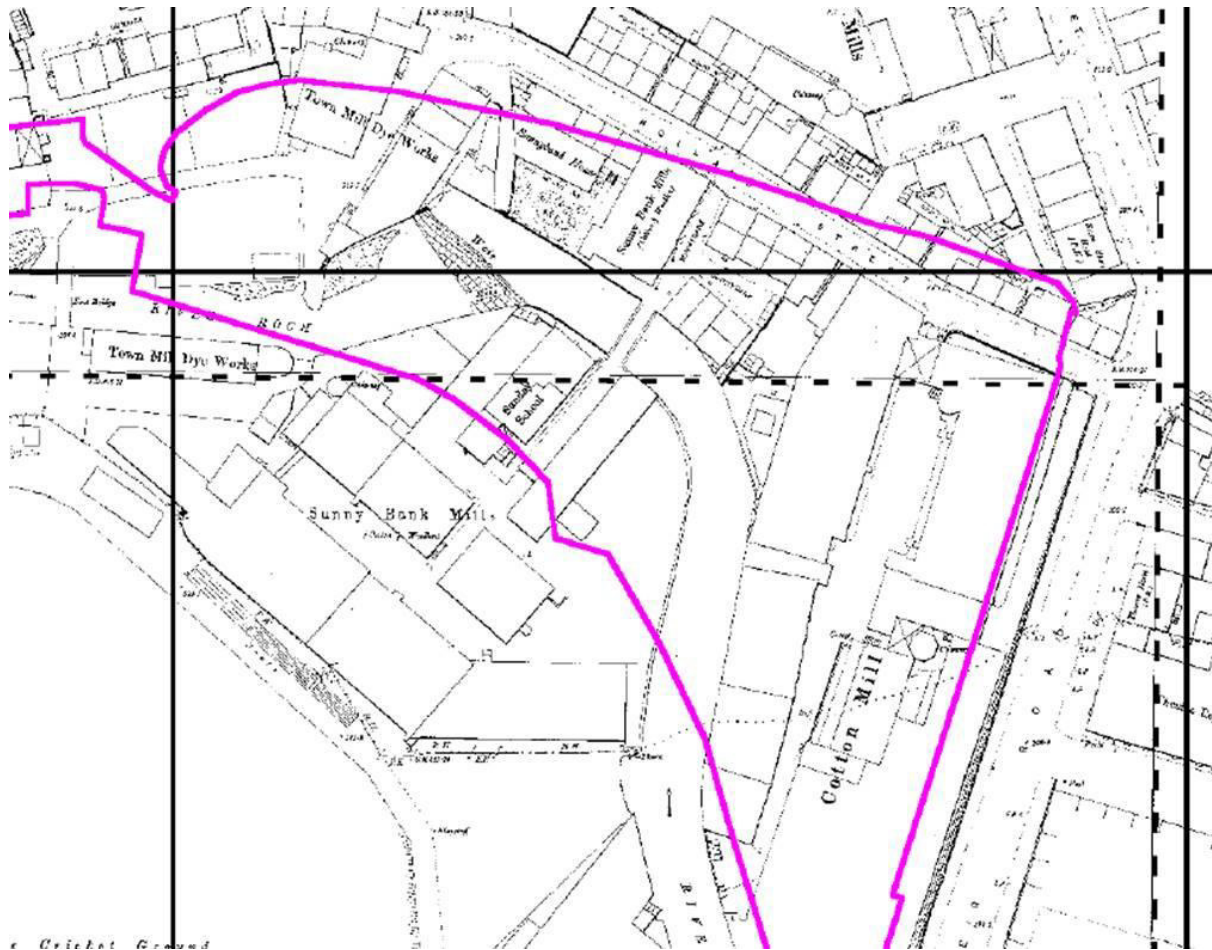


Image 2 – Historical Imagery.

A geophysical survey has been requested to map the extents of buried obstructions as a result of the historic site usage. This includes, compositional changes from the river, possible voids, foundations and other insitu structures.

SEP Geophysical suggested a multi-technique geophysical approach including;

- Time-Domain Electromagnetic Mapping (TDEM) - To attempt to map buried metallic objects (ferrous or non-ferrous), such as the buried foundations and other remnant structures.
- Ground Penetrating Radar (GPR) survey – to map contrasts in electrical properties which could relate to compositional variations or anthropogenic structures within the subsurface

Following discussions with the client, the concerns were raised about the potential for reinforcement below the car park, this would saturate the sensors and reduce the effectiveness of the method. It was decided to still collect the data and preliminarily process it to assess the impact of the reinforcement.

4. Ground Penetrating Radar

The GPR system is an electromagnetic (EM) technique which consists of a transmitter and receiver attached to a console for data visualisation and recording. The transmitter emits electromagnetic waves which propagate through the subsurface at a velocity determined by the permittivity of the material. When encountering a material/object of contrasting dielectric properties the waves become scattered with some energy reflected back to the receiver at the surface. The depth of this

feature is then calculated by the two-way travel time and the velocity of the electromagnetic pulse through the material.

In order to confidently identify features within a GPR dataset, a detectable contrast in dielectric properties between the object of interest and the surrounding ground is required. For example, metallic features offer the strongest contrast with other materials such as concrete and brick offering low amplitude reflections.

It is anticipated that poorly consolidated material which would typically manifest as chaotic and/or high amplitude reflections within the GPR radargram. Furthermore, the presence of a void, within an otherwise homogeneous medium should offer as a reversal in polarity of the GPR signal and/or reverberations (“ring down effect”) within the radargram. Large voids can also manifest themselves with a “pull-up” effect due to the radar wave velocity in air being approximately 3 times faster than in solid materials.

Buried linear features such as services or historic walls should be identifiable due to a hyperbolic response in the GPR radargram in combination with the linear nature of the anomaly. Broad obstructions such as foundations or large fill bodies such as broken up concrete can also be mapped, with responses varying dependent on the obstruction.

4.1. Equipment

The GPR equipment selected for the survey was the Proceq GS8000 which operates a stepped frequency continuous wave (SFCW) system. This emits a sequential sinusoidal signal across a predetermined range of frequencies and measures the resulting responses, allowing for variable depth penetration dependent on the frequency range selected. This system was chosen because it offered the unique ability to be able to deploy only one antenna but image a variety of depths to a higher resolution than if a single channel, pulse GPR system had been applied.

The Proceq GS8000 was deployed across the site, in a 4 wheeled cart configuration. The survey was undertaken by pushing the GPR, with the antenna flush to the ground surface, in a series of parallel transects, centred at 1.0 metre intervals covering the area as access allowed.

4.2. Data Quality

Data were constantly reviewed on site to ensure the best quality were collected. The settings applied allowed for a possible depth penetration of 4 metres below ground level (mbgl), however despite various filtering and gain corrections it was not possible to image below 1.0 – 1.5 mbgl. This is likely attributed to the conductive made ground material, absorbing some of the energy and attenuating the return signal.

4.3. Data Processing

The GPR data were post-processed and analysed within the specialist GPR software Geolix. **Table 1**, below, presents the processing workflow applied to each GPR transect.

A dielectric factor of 7.0 was applied during the depth calculations, based on our experience, this is a typical value for this environment. Using this depth calibration, we would anticipate depth measurements accuracies to be within 15 - 20%.

Processing Step	Application
Time-Zero Correction	Correcting the GPR signal to the ground surface
Constant Scale	Applying a constant gain to each profile.
Background Subtraction	This function performs a subtracting average in order to remove horizontal reflections.
Frequency Filtering	Application of different filtering mechanisms i.e. band-pass, low pass etc, to allow for greater imaging and increasing the signal to noise ratio.
Manual Gain	A gain application, that can be used to improve the image quality, amplifying relative amplitude dependent on depth, as defined by the user.

Table 1 - GPR processing workflow.

The processed data profiles were individually analysed to identify anomalous responses which have the characteristics of features of interest. These would be categorised and picked with their size, shape and depth transposed onto a CAD drawing for visualisation.

5. Time-Domain Electromagnetic Mapping (TDEM)

Electromagnetic mapping is a geophysical technique which involves inducing electric currents into the ground via a transmitter. The induced eddy currents within the subsurface in turn create secondary magnetic fields. These are measured by the receiver at the surface. Time-Domain Electromagnetic Mapping (TDEM) uses a transmitter to emit a transient pulse of electric currents during the “time on” phase of recording. During the “time off” stage the receivers measure the secondary magnetic fields as a millivolt (mV) response. The presence of a buried obstruction with a high ferrous content should manifest as an anomalously high area of EM response.

4.1. Equipment & Deployment

The EM instrument which was selected for this site was the Geonics EM-61 MK2A. This highly sensitive TDEM sensor can be likened to a metal detector. The EM-61 MK2A consists of two rectangular coils, separated by 40 cm, mounted within a non-metallic cart. A transmitter and one receiver are located in the bottom coil with a secondary receiver located in the top coil. The EM-61 operates with three incrementing “time off” stages to measure the rate of decay of magnetic fields generated by foreign bodies to a maximum depth of 2 – 3 m.

The EM-61 was deployed as a 2 wheeled cart. Data was monitored in real time, to ensure quality, and collected at a 1 metre centred line spacing using an odometer on the wheel. Readings were taken every 0.1 m. The EM data is positioned using a Real-time Kinematic (RTK) global positioning system (GPS) to allow for accurate location any recorded features.

4.2. Data Quality & Preliminary Processing

Data values were observed throughout the survey acquisition to monitor data quality. The line path could also be reviewed in order to ensure full data coverage. All accessible areas were covered with the EM-61.

The EM data set was initially imported into the specialist software Trackmaker, which compiles and combines the EM responses across each channel and the GPS readings. These datasets are then imported into Geosoft’s Oasis Montaj for analysis and interpretation. Once in Oasis Montaj, data is filtered in an iterative approach to highlight features and trends in the data. At this point it was apparent that the dataset had been severely affected by the presence of reinforcement which masked the detection of other features (**Image 2**) hence it was not processed further.

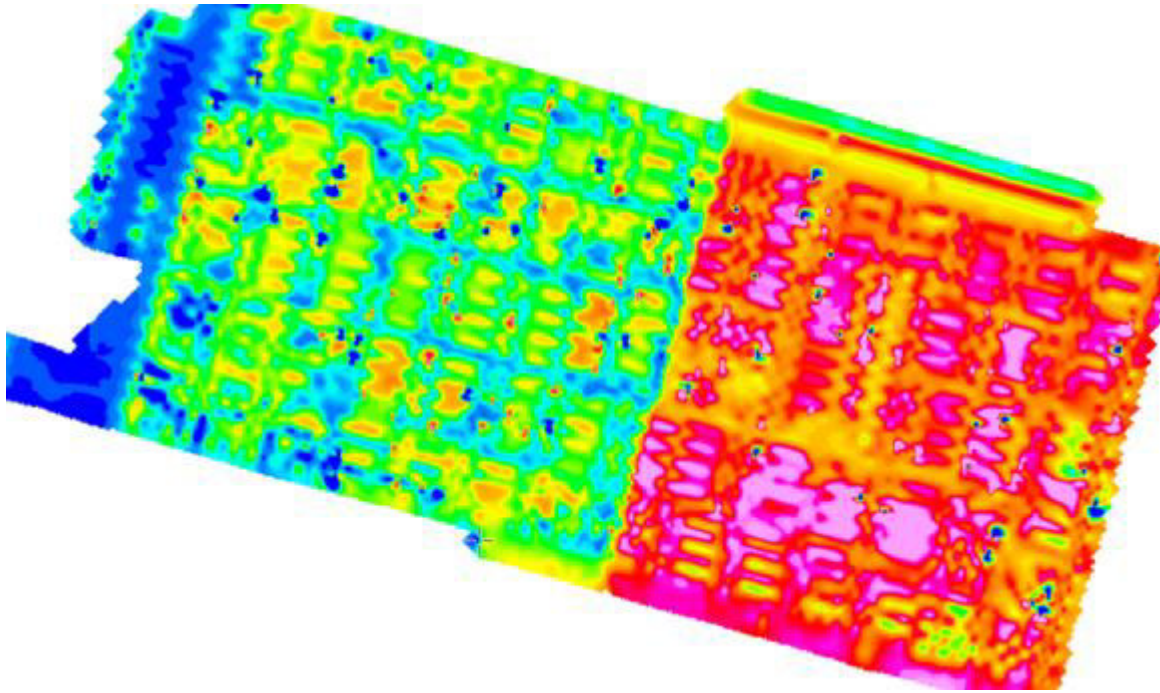


Image 2 – Preliminary EM-61 dataset

5. Results

Figure 1 presents the interpreted features from the GPR survey, displaying the anomalies A - F which are detailed below, overlain onto a topographic survey. In the final interpretation all depths / depth ranges are to the top of features and are given in metres (m).

GPR Detection Line – Linear Feature (brown)

These features were identified in profile view during analysis of the data and display as a high amplitude, broad hyperbola which were detected across a series of parallel transects. These features are interpreted to relate to buried services or other linear structures. These features are displayed as brown linework in **Figure 1**.

GPR Detection Line – Linear Feature (purple)

These features were identified at regular intervals in profile view during analysis of the data. They generally manifested as a high amplitude, sometimes hyperbolic in shape, across a series of parallel transects below the interpreted reinforcement. Due to their concentric pattern these features are interpreted to relate reinforced concrete slab joins. These features are displayed as light purple linework in **Figure 1**.

Anomaly A – Area of reworked/disturbed material

This anomalous group is defined by discrete areas of discontinuous and changeable reflectors which vary in amplitude. They are interpreted to likely relate to a compositional change such as more granular or saturated material. This could be attributed to localised areas of poorly consolidated or reworked ground after the installation or removal of services/infrastructure. These were commonly observed in the vicinity of the interpreted slab joins or as part of other interpreted anomalies.

The possibility that the anomaly type A features are related to voiding cannot be fully discounted, however, the response observed in the data is more indicative of poor consolidation/disturbance rather than air-filled voiding. This anomaly type is denoted with a red hatch in **Figure 1**.

Anomaly B – Discrete buried obstruction or large body of fill

These features are characterised by high amplitude anomalous reflections, either sub-horizontal or broadly hyperbolic in nature. These features are considered likely to relate to buried obstructions, remanent historic structures or large bodies of fill. A number of these are observed throughout the site with some correlating with the position of buildings on the historic imagery. One feature to draw attention to is in the centre of the site where window sample 1 is located. This shows good correlation with the position of the historic weir. It is also noted the configuration of the slab joins deviates from the general arrangement. This anomaly type is denoted with an orange hatch in **Figure 1**.

Anomaly C – Change in concrete slab construction

This identified geophysical anomaly is characterised by regularly spaced, hyperbolic reflections which differ from the general arrangement throughout the site. These are interpreted as broadly spaced reinforcing bars within a concrete slab. This change in the reinforcement could be highlighting either change in slab construction or the potential for structures buried beneath. This anomaly is denoted with green shading in **Figure 1**.

Anomaly D – Interpreted as a discrete strong change in ground conditions or buried manhole

Anomaly D is characterised by shallow high amplitude responses, with strong ringing down the radargram. This signifies a strong change in ground conditions and shares a similar response to when traversing over a manhole lid. No manhole topographically mapped in so this could suggest a buried manhole. Although, it is possible that these features could be attributed to air filled voids however they are only observed in one or two profiles and do not offer a reversal in polarity, hence this is a low confidence detection. This anomaly is denoted with blue shading in **Figure 1**.

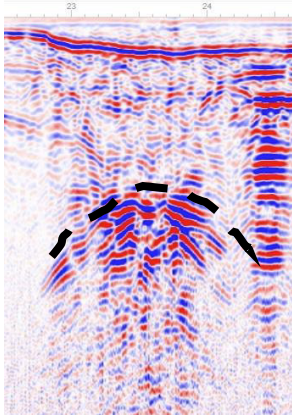
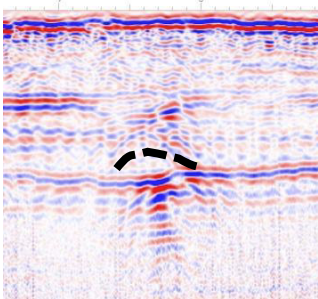
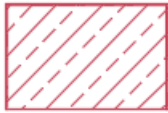
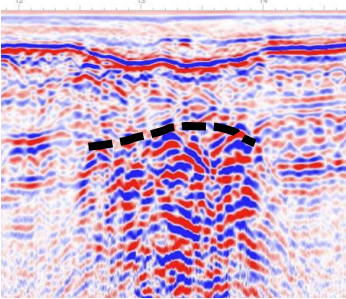
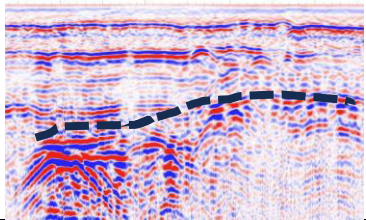
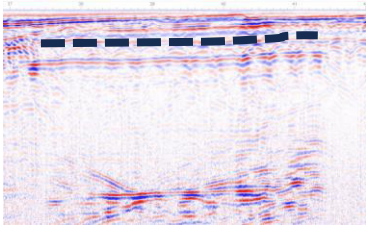
Anomaly E – Closely spaced hyperbolic reflections indicative of reinforcing bars.

This identified geophysical anomaly is characterised by regularly spaced, shallow hyperbolic reflections. Typically, they are indicative of reinforcing bars within a concrete slab. It should be appreciated the presence of reinforcing may have limited the detection of other features below. This anomaly is denoted with teal shading which has bordered the extents of the reinforcement observed in **Figure 1**.

Anomaly F – Variable response below anomaly type C

High amplitude and variable response observed at depth. Anomaly F is positioned beneath a change in slab construction where the reinforcement is observed to change in arrangement. This could be showing the presence of a buried structure or object. From our experience it has similar characteristics to a buried basement however this is a low confidence interpretation. This anomaly is denoted with purple dashed line in **Figure 1**.

Table 2 presents a summary of the GPR interpretations and indicative responses observed in the radargrams.

Anomaly Reference (Figure 1)	Anomaly Reference (Figure 1)	Data Example in Profile View	GPR Response	Geophysical Interpretation
GPR Linear Feature			Hyperbolic response observed in multiple adjacent transects	These features are likely to relate to buried services or other linear features such as buried walls.
GPR Detection Line			Concentrically patterned hyperbolic reflections observed below the interpreted reinforcement	Interpreted as concrete slab join.
Anomaly A			An area of discontinuous and changeable reflectors which vary in amplitude.	Generally indicative of an area of poorly consolidated or saturated material. Likely relating to areas of more disturbed heterogeneous fill material (The possibility of a small-scale voiding cannot be discounted).
Anomaly B			Broad, sub-horizontal, and high amplitude response.	This could relate to a possible buried obstruction such as a remanent structure, foundation, or a large body of fill.
Anomaly C			Widely spaced hyperbolic reflections. Different to the general trend of reinforcement.	Interpreted as a change in slab construction. Possibly indicating the presence of buried obstructions below.

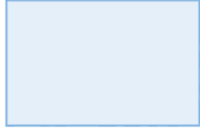
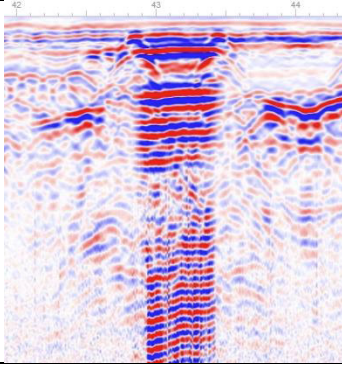
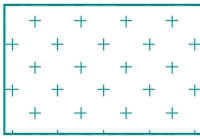
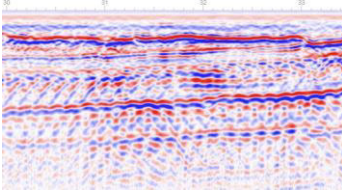
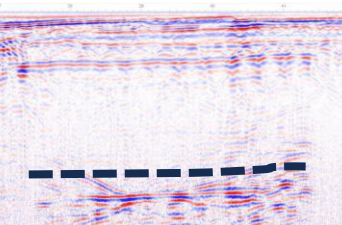
Anomaly Reference (Figure 1)	Anomaly Reference (Figure 1)	Data Example in Profile View	GPR Response	Geophysical Interpretation
Anomaly D			High amplitude response with ringing down the radargram	Possible strong change in ground conditions. Interpreted as a possible buried manhole or air filled void (low confidence)
Anomaly E			Closely spaced hyperbolic reflections	Likely related to reinforcing bars.
Anomaly F			High amplitude variable response below a anomaly type C	Interpreted as a buried obstruction. Some characteristics shared with a possible basement (low confidence detection)

Table 2 - GPR anomalies summary.

6. Conclusion

A GPR and TDEM survey was conducted across the car park at Hopwood academy. The TDEM data was heavily affected by the reinforcement present and was only preliminarily processed.

The GPR method has identified several anomalies of interest which likely relate to compositional changes and buried obstructions/structures below the ground. There were multiple areas of poorly consolidated/disturbed ground, these likely relate to the reworked ground, from installation/removal of infrastructure or services. The potential for small-scale voiding cannot be ruled out in these areas.

Several discrete and shallow anomalies indicative of buried obstructions were also identified, one such feature in the centre of the site shows very good correlation with the historic position of the weir.

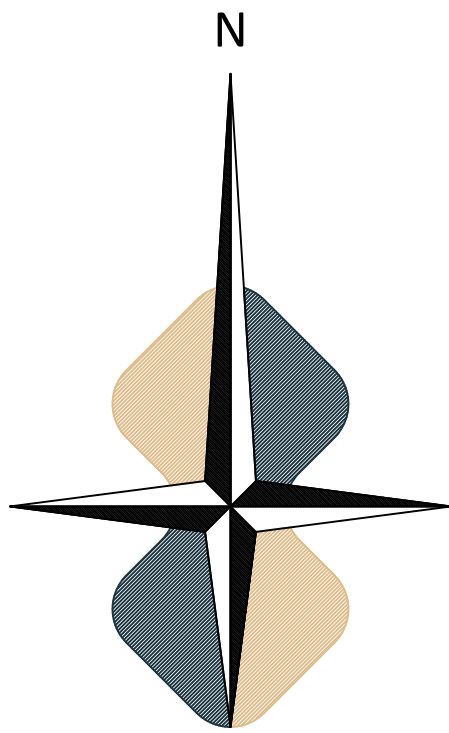
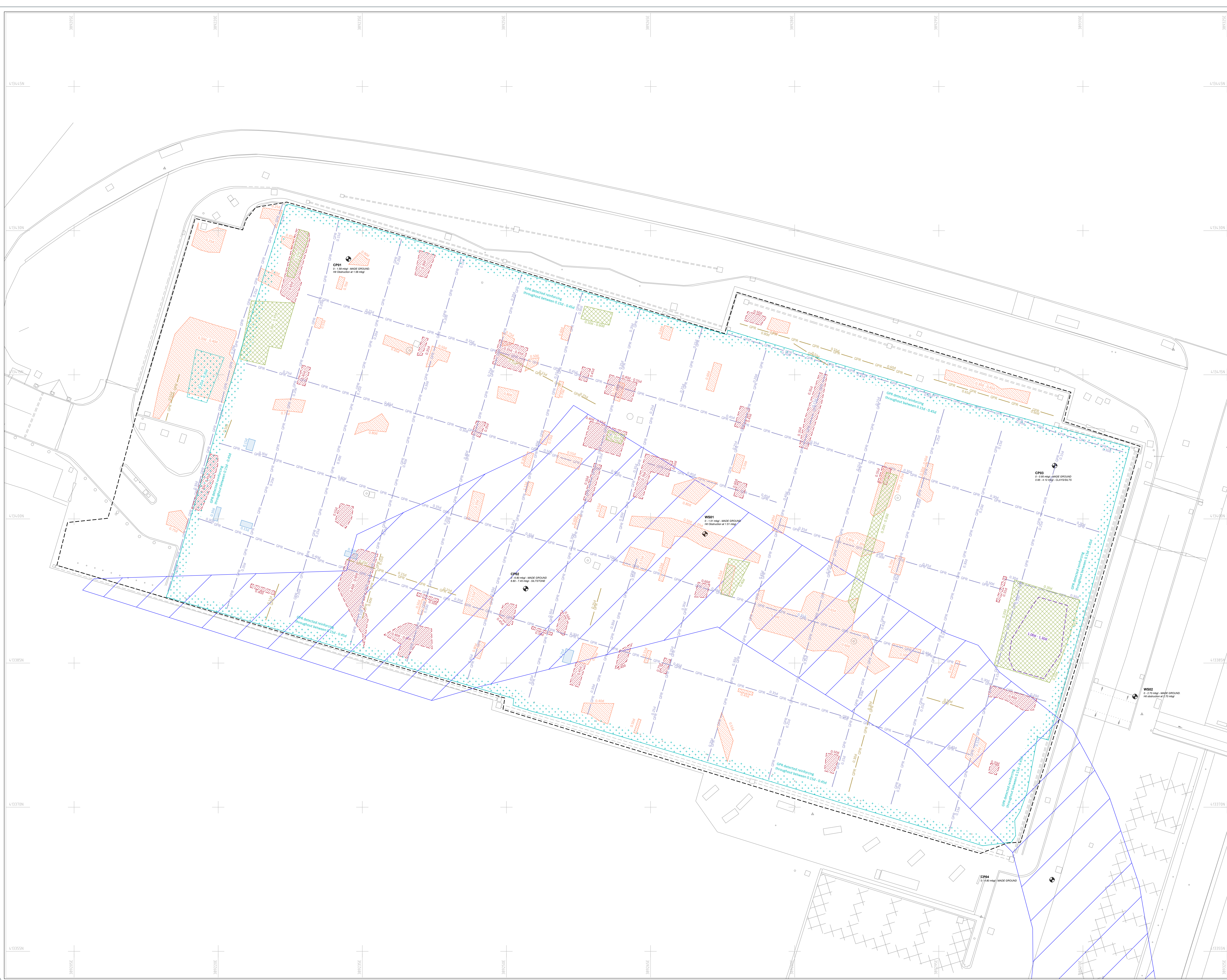
Other features include linear features which have been interpreted as possible buried services and concrete slab joins. The extents of the reinforcement has been identified with areas where broad variation in the reinforcement arrangement highlighted as possible changes in slab construction.

Five discrete anomalies were identified which display the characteristics of a possible buried manhole. Although this could also be highlighting strong change in ground conditions such as air filled voiding.

Finally, variable and anomalous responses were observed under a change in slab conditions where the observed reinforcing arrangement is wider. From our experience this displays the characteristics of a buried basement, however this is a low confidence interpretation.

It is recommended a selection of features are targeted with an intrusive investigation to determine their causative effect. SEP Geophysical, with discussions with the client, can put together an anomaly list prioritising the strongest and most confidently observed responses, to assist with an intrusive investigation plan. Safe digging practises should be observed during any targeted anomaly intrusive investigations.

GPR is a remote sensing technique which record changes in electrical properties within the ground. If there is insufficient contrast between the features of interest and the surrounding ground, then it may not be possible to resolve the object of the survey. The inability to measure a change in physical response does not necessarily suggest the lack of an anomaly but rather it is suggestive there is not a measurable physical contrast between the materials and the subsurface medium.



NOTES:
The geophysical results have been overlaid onto Survey and Engineering Projects basic topographic survey. Drawing reference 'S23553-001'.
The Ground Penetrating Radar (GPR) technique was collected using the Proceq G6000. Anomalous areas have been picked by interrogating the data in profile form. All depths are to the top of interpreted features and displayed in metres (m).
Features annotated as GPR indicate a series of consistent subsurface anomalies located using the Ground Penetrating Radar technique. They have been identified as localized changes in dielectric properties within the dataset which, although all reasonable care has been undertaken during the data processing and interpretation, SEP Geophysical cannot guarantee that every feature has been identified.

File Name: G-24_685-103) HOPWOOD ACADEMY FIGURE 1 SHEET 1

LEGEND

BOREHOLES, GEOTECHNICS, NOV 2021

RECORD POSITION OF FORMER RIVER ROCH ROUTE & WEIR

GPR SURVEY BOUNDARY

GPR DETECTION LINE - LIKELY RELATED TO A BURIED SERVICE OR REMNANT LINEAR FEATURE

GPR DETECTION LINE - INTERPRETED AS A REINFORCED CONCRETE SLAB JOIN. DEPTH SHOWS APPROXIMATE SLAB BASE.

A. GPR DETECTED ANOMALY INTERPRETED AS AN AREA OF REWORKED/DISTURBED MATERIAL LIKELY RELATED TO THE INSTALLATION OR REMOVAL OF SERVICES/INFRASTRUCTURE (THE POSSIBILITY OF SMALL-SCALE VOIDING CANNOT BE DISCOUNTED).

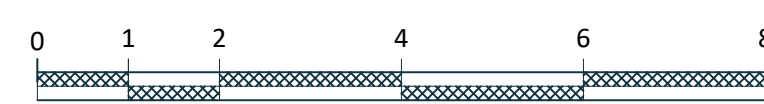
B. GPR DETECTED ANOMALY INDICATIVE OF A POSSIBLE BURIED OBSTRUCTION SUCH AS A REMNANT STRUCTURE OR A LARGE BODY OF FILL.

C. GPR DETECTED ANOMALY BROAD CHANGE IN REINFORCEMENT ARRANGEMENT, POSSIBLY INDICATING THE PRESENCE OF A BURIED STRUCTURE OR A CHANGE IN SLAB CONSTRUCTION.

D. GPR DETECTED ANOMALY HIGH AMPLITUDE DISCRETE RESPONSE WITH STRONG REVERBERATIONS OBSERVED. THIS COULD BE RELATED TO A BURIED MANHOLE OR STRONG CHANGE IN GROUND CONDITIONS.

E. GPR DETECTED ANOMALY REINFORCING BARS DETECTED THROUGHOUT THIS REGION BETWEEN 0.15D - 0.50D.

F. GPR DETECTED ANOMALY ANOMALOUS AREA BELOW CHANGE IN SLAB CONSTRUCTION, POSSIBLY RELATING TO A BURIED STRUCTURE. VAGUE CHARACTERISTICS OF A BURIED BASEMENT - LOW CONFIDENCE INTERPRETATION.



REV	DATE	DESCRIPTION
00	20/11/24	PRELIMINARY ISSUE TO CLIENT
01	28/11/24	FINAL ISSUED TO CLIENT

SEP
Geophysical

Client



Project Title
**HOPWOOD ACADEMY,
ROCHDALE**

Drawing Title
**GEOPHYSICAL RESULTS:
GPR INTERPRETATION**

Surveyed GA	Drawn JC	Checked TS
Scale 1:125	Date 28/11/24	Drawing Ref. FIGURE.1
No 01	Size A0	Rev 01