Troy Melhuish
RG Parkins & Partners Ltd
Meadowside
Shap Road
Kendal, Cumbria
LA9 6NY

Date: 06.08.2024
Project No: GEO2024-6310
Project: Griffin Close, Frizington
Report Title: Supplementary Mining Investigation Report

Dear Troy,

Geo Environmental Engineering Ltd (GEO) were commissioned by the Consultant, RG Parkins & Partners Ltd, on behalf of the Client, Home Group to carry out a Supplementary Mining Investigation to aid the proposed development.

It is understood that the Client plans to redevelop the land for residential end use. A proposed site layout plan has been provided and a copy is included. The plan indicates c.17 No. plots with private gardens, parking, access road, general soft landscaping and other associated infrastructure.

Previous Reports

GEO have previously completed a Desk Top Study and an Intrusive Ground Investigation Report for the site, details of which are included below.

- Desk Top Study (Preliminary Environmental Risk Assessment), ref: 2022-5436, dated: 17.08.2022
- Ground Investigation Report, ref: 2023-5696, dated: 03.02.2023

A brief summary of information relating to the geological setting and mining information is included below, however, it is recommended that the previous reports are read in conjunction.

The site is derelict and was formerly a care home that was demolished around c.2012. It is not known why the care home was demolished. Some tarmac hardstand and block paving was present with the remaining area being unmanaged grass.

Geological data indicated Glacial Till deposits overlying Pennine Middle Coal Measures strata (mudstone, siltstone and sandstone with productive coal seams). The Bannock Coal seam is indicated as sub cropping in the north east part of the site with a dip to the south west, thereby potentially being present beneath the majority of the site. The BGS indicate that the Bannock seam is up to c.2.00m in thickness. The DTS indicated that, if worked at shallow depth, the Bannock seam could pose a potential structural risk to the proposed houses.

The Coal Authority (CA) identify a mine shaft (ref:303517-006) in the northern part of the site with a further two shafts in close proximity. The CA do not hold any records with regard to treatment of the shafts.

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The DTS provided the following statement with regards to ground stability:

> *'It is generally accepted that there is a risk to the proposed development if the rock cover over a worked coal seam is less than ten times the seam thickness (a ratio of 1:10). There is some debate as to the exact thickness of rock cover required to mitigate the risk of collapse or disturbance at the surface and the Coal Authority recommends caution on the use of the standard 1:10 'rule of thumb'. As such, the required cover thickness will depend on the competency of the overlying rock. As the BNOK is recorded as being up to c.2m in thickness, this would require c.20m of competent rock cover.'*

The DTS also identified iron ore mining beneath the site but indicated that the workings were at sufficient depth (c.232m depth) that the risk of instability at the surface was deemed to be negligible. The report indicated a high to very high geotechnical risk associated with redevelopment due to the possible coal mining. An intrusive mining investigation was recommended to assess the risk of shallow mining and to locate the mine shaft.

An intrusive mining investigation was completed by GEO in October 2022. This comprised a series of trial trenches (Trench 1 to Trench 3) within the recorded mine shaft location, trial pits (TP01 to TP03), mini-percussive boreholes (WS01 to WS05) and rotary open-holed boreholes (RBH-A to RBH-C). Insitu testing, laboratory testing and ground gas monitoring were also completed.

Made ground was typically encountered to depths of between c.0.40m and c.2.70m bgl which appeared to be associated with the former care home development. Localised deeper made ground, soft deposits and a suspected void were recorded within the north eastern part of the site within boreholes WS02 and RBH-A to depths of c.5.00m and c.6.60m respectively. Further intrusive investigations were recommended in this locality to assess the risk. No evidence of the mine shaft was encountered within the trenches in the northern part of the site.

The made ground was underlain by stiff gravelly clay and possible weathered bedrock (stiff to very stiff clay with gravel of angular mudstone). Solid strata/bedrock was encountered in the percussive and rotary boreholes at depths of between c.2.70m and 6.60m bgl. This was described as light grey and reddish-brown mudstone with occasional thin, hard siltstone and sandstone bands. Up to three seams of coal were encountered in the rotary boreholes from depths of between 7.30m and 19.20m bgl. The seams appeared to dip to the south west. These varied between 0.20m and 1.40m in thickness. No evidence of workings was encountered, however, given the depth and thickness of the seams, it was noted that there could be shallow, unrecorded workings within these seams elsewhere on site.

Geophysical Survey

A geophysical survey was completed by Bentham Geoconsulting Limited in May 2024. This comprised an Electromagnetic (EM) Ground Conductivity Survey and an Electrical Resistivity Tomography (ERT) Survey. A copy of the survey is attached.

The survey identified several anomalies associated with the former development (possible infrastructure - man-hole covers and drainage) and the previous investigations (trenches and trial pits). However, the investigation also identified anomalies which could be representative of mining relicts or geological structures. Intrusive investigations were recommended at these locations to provide further information.

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Supplementary Intrusive Mining

GEO attended site in July 2024 to complete the supplementary intrusive ground investigation works. The exploratory holes were primarily targeted within the northern part of the site where deep made ground and a void had previously been encountered. However, the rotary boreholes were spread across the site to provide general site coverage and to infill between the previous borehole locations.

The supplementary investigation comprised:

- 21 No. Dynamic Probe Super Heavy tests (DP01 to DP21) to depths of between c.2.70m and c.8.40m bgl. The probes were targeting the soft ground and void that was encountered within boreholes WS01 and RBH-A which were sunk during the previous investigation.
    - The probes were completed in two lines, orientated at right angles to each other. Line One comprised DP01 to DP13, and Line Two comprised DP14 to DP21.
- 5 No. Rotary boreholes (RBH-D to RBH-H) to depths of between 15.20m and 24.00m bgl.
    - The boreholes were drilled with water flush due to the proximity of nearby housing.
- 8 No. Trenches (TT01 to TT08) excavated to depths of between c.1.20m and c.3.60m bgl.
    - The trenches were c.1.70m wide to provide a good overview of the geological structure and any mining relicts / structures.

Insitu Soil Infiltration Tests (soakaways) were undertaken concurrently with the mining investigation. A separate report will be issued for the infiltration assessment.

Ground Conditions and Mining Relicts

Dynamic Probes – Evidence of Poor Ground Conditions / Possible Mine Workings

The dynamic probes were sunk prior to any other works in order to delineate the area of soft ground in the northern part of the site within the vicinity of WS01 and RBH-A. The results have been colour graded with pink indicating loose ground, and red indicating extremely loose ground. The probes encountered variable ground conditions with very soft/loose ground in the north eastern part of the site to a maximum depth of c.7m bgl. N300 values of zero were occasionally recorded which indicate that the probe was falling under its own weight and may be representative of extremely loose ground or voids.

The results were interpreted as an area of very poor ground, possibly associated with former shallow unrecorded coal mine workings or a possible shaft, possibly dipping (becoming deeper) to the south west. However, heavy weathering associated with a possible geological fault could not be ruled out. Some of the probes recorded competent ground overlying very loose deposits at depth indicating possible shallow mine workings within weathered bedrock.

DP18 was identified as recording particularly poor ground conditions with N300 values of between 0 (zero) and 2 between 1.50m and 6.90m bgl. This was considered as potentially representative of a mine shaft or very poor ground conditions.

Trenches – Evidence of shallow Mine Workings and Mine Shaft

Trenches were excavated across the north eastern part of the site in parallel lines, working methodically from east to west and targeting possible anomalies identified by the geophysical survey and the probing. The extent of the trenches was limited by buried electricity cables which were noted as live.

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Trench TT01 encountered a sub-cropping coal seam at a depth of c.1.10m bgl. The seam was recovered as angular gravel of black glassy, brittle coal which had thin quartz veining. Thin bands of iron ore were also noted. The coal appeared highly fractured / folded and of poor quality. The seam appeared to deepen to the south although this was difficult to discern. The surrounding ground was recorded as suspected weathered mudstone which was excavated as a very stiff light grey clay with angular gravel of mudstone.

Trench TT03 encountered the monitoring well from borehole WS02 which had previously recorded deep made ground overlying a suspected void between c.3.50m and c.5.00m bgl. The excavation followed the well and continued to a depth of 3.10m within suspected weathered mudstone. A coal seam was encountered at a depth of c.3.10m bgl and this had a similar appearance to the coal in trench TT01. A void opened up from the base of the trial pit at a depth of c.3.20m bgl. The void was noted as large and extended several metres to the south, east and west. A wall of coal (at least 1m thick) was noted along the northern edge of the void. The wall of coal may have been a column, left insitu to support the workings or could have been the former coal face. The void extended to a depth of c.5m bgl, however, it may continue further as it had partially infilled with loose material falling in during the excavation. Photos of the void are included with the logs. No evidence of deep made ground was encountered in the trench as was noted in WS01. It is possible that fragments of brick from the overlying made ground had fallen into the borehole during the drilling and was therefore, interpreted as made ground during logging.

The remaining trenches encountered suspected shallow weathered mudstone bedrock from depths of between c1.20m and c.1.50m bgl which appeared consistent across this area. However, Trench TT06 encountered a column of soft / soft to firm brown clay with pockets of gravel which appeared reworked. The trench was extended to a depth of c.3.60m bgl (maximum reach of the 8T excavator) and the column of soft clay was noted to continue below this depth. Light grey weathered bedrock was recorded either side of this feature. The column of soft reworked clay has been interpreted as an infilled mine shaft. The approximate location of the shaft is indicated on the exploratory hole location plan. Photographs and annotations are included on the trial pit logs. The location was recorded using a hand-held GPS unit at NGR: 303377.8, 517408.2. However, as the hand-held unit is only accurate to within a few metres, a marker post was inserted into the ground to mark the shaft location. It is recommended that the location of the shaft is accurately recorded with appropriate surveying equipment.

TT08 was located at the approximate location of DP18 to investigate the reason for the poor dynamic probe values. The excavation was extended to a depth of c.3.10m bgl with no evidence of deep made ground or a mine shaft. However, the suspected weathered bedrock was noted as very loose from a depth of 2.40m bgl with the excavator being able to push the bucket vertically down into the material. This may indicate possible void migration or nearby workings which have loosened the deposits or have allowed significant weathering.

Rotary Boreholes – Evidence of Shallow Mine workings

The rotary boreholes were drilled to depths of between 15.50m and c.24.00m bgl and encountered solid bedrock at depths of between c.2.80m and c.5.20m bgl. It is likely that the shallow drift deposit that is described as ‘Clay with mudstone’ is in fact weathered mudstone bedrock that was encountered at shallow depth within the trenches. The ‘clay’ (weathered bedrock) was noted as soft and as ‘possible fill’ in places, however, no direct evidence for mine workings (voids, broken ground, anthropogenic materials, etc…) was encountered within this layer.

The boreholes encountered up to three coal seams which varied between 0.15m and 1.55m thick. The thickest seam was encountered within boreholes RBH-D and RBH-F in the northern part of the

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site at depths of 7.60m and 5.50m bgl respectively. This ties in well with the thick coal seam and evidence of workings (void) that was encountered within trench TT03. The BGS indicate that the seam dips to the south west and the findings from the intrusive investigation appear to agree with the geological records.

The same coal seam appears to have been worked within borehole RBH-E to the south west between 11m and 14m bgl. RBH-E was located to the north east of the car park and recorded loss of flush and soft ground from c.11.10m and no returns (complete loss of flush) and broken ground from 12.30m bgl. Solid ground was recorded from c.13.80m bgl.

Loss of flush and soft ground was also noted within borehole RBH-G in the central part of the site between 6.50m and c.7.30m bgl, however, the driller was able to continue drilling below this with full flush, therefore it is unclear if this anomaly is representative of workings or softer/weathered strata.

Conclusions and Recommendations

Shallow Unrecorded Coal Mine Workings

The supplementary ground investigation has confirmed the presence of coal seams and shallow unrecorded coal mine workings across the northern part of the site. The workings appear to be within the Bannock Coal seam which appears to sub-crop across the north eastern part of the site with a dip to the south west. The seam appears to be between 1.35m and 1.55m thick where it has been worked. The investigation suggests that the seam has been worked from depths of between 3.20m to over 11m bgl. Although workings have only been encountered across the northern parts of the site, workings elsewhere on site (further south) cannot be ruled out at this stage.

The dynamic probes and several of the boreholes indicate geotechnically poor ground across the north eastern part of the site. This may be associated with void migration which has loosened or destabilised the overlying bedrock or allowed further weathering to occur.

As indicated above, if the coal seam thickness to rock cover ratio is less than 1:10, there is a potential risk to the proposed development. The rock cover within trench TT03 was 2m, therefore the ratio was 1:1.3. Based on the ratio and the high weathering within the shallow bedrock, the workings at this location are considered to pose a significant risk to the proposed development.

The rock cover overlying the workings within borehole RBH-E was 9.6m. This gives a ratio of 1:6.4. Again, the workings within this borehole pose a significant risk to the proposed development.

Given the presence of shallow unrecorded coal mine workings and the significant risk that these pose to the proposed development, remedial measures are required in order to mitigate the risk and facilitate the proposed development.

Therefore, rotary probing is recommended to establish the area impacted by shallow mine workings and pressure injection grouting to stabilise the workings and prevent future collapse. It is recommended that the probing is undertaken across the whole site and on a tight grid pattern.

Assuming a coal seam thickness of c.1.55m and taking into account the geotechnically poor ground overlying the seam across the northern part of the site, it is recommended that any workings with a rock cover ratio of less than 1:15 are remediated. Therefore, a solid (competent) rock cover of at least 23m should be adopted when determining a sufficient depth for grouting.

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Mine Shaft

The supplementary investigation has confirmed the presence of a column of soft clay extending to a depth of at least c.3.6m bgl within the northern part of the site that has been interpreted as an infilled mine shaft. This feature is c.20m south east of the mine shaft location as recorded by the CA.

It is recommended that rotary probing is undertaken across this feature to confirm if it is a mine shaft and if so, what depth it extends to and how it has been filled beyond the depth of the trench. If the feature is confirmed to be a shaft, it is recommended that it is grouted (if possible) and/or stabilised using an appropriately designed geotextile or concrete cap. The remedial works should be completed under permit from The Coal Authority.

It is recommended that the site layout is redesigned to accommodate the mine shaft with no houses constructed within the zone of influence, i.e. 45 degrees from the intersection between the shaft and solid strata. Based on borehole RBH-F, solid strata was encountered at a depth of 5m bgl, therefore, no development should take place within 5m of the shaft edge.

Remedial works should be undertaken by an appropriate contractor and a report should be issued upon completion identifying where the workings were encountered, their depths and grout take. The works should be covered by appropriate insurances.

Foundations

Following remedial works to stabilise the shaft and any shallow unrecorded coal mine workings, consideration could be given to shallow strip foundations within the stiff gravelly clay or the weathered mudstone bedrock across the southern and western parts of the site. Deepening of foundations may be required where deeper made ground or soft, unsuitable deposits are encountered.

Given the results of the probing and boreholes, conventional strip foundations across the north eastern parts of the site are not considered suitable and an alternative solution such as a raft or piles should be considered. Where a raft is being considered, re-engineering of the made ground is recommended, especially in the vicinity of the deeper trenches to avoid the potential for differential settlement.

If a piling solution is adopted, the results of this investigation and the grouting report should be provided to the contractor in order to determine a suitable pile depth. It may be necessary to pile below the remediated workings, however, this should be discussed with the Local Building Authority and/or the Warranty provider to seek their approval of any foundation scheme prior to commencing on site.

General Comments and Limitations

Consideration must be made for variations to occur in the ground conditions between the exploratory hole locations for which GEO holds no responsibility. It is therefore recommended that a “watching brief” be applied to ensure that if ground conditions vary from those identified during this investigation then advice should be sought from a suitably qualified and experienced Geo-Environmental Engineer.

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The recommendations and opinions expressed in this report are based on the ground conditions observed. Consequently, GEO takes no responsibility for conditions that have not been revealed or which occur between them.

The conclusions and recommendations presented within this report are considered reasonable based on the available information. However, these cannot be guaranteed to gain regulatory approval. Therefore, the report should be passed to the appropriate regulatory authorities and/ or other key stakeholders, including warranty providers in order to seek their approval of the findings prior to undertaking any site works or development on site.

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If there are any queries, please do not hesitate to contact Geo-Environmental Engineering Ltd.

Yours Faithfully

……
James Brock *BSc (Hons), MSc*
Associate - Geo Environmental Engineering Ltd

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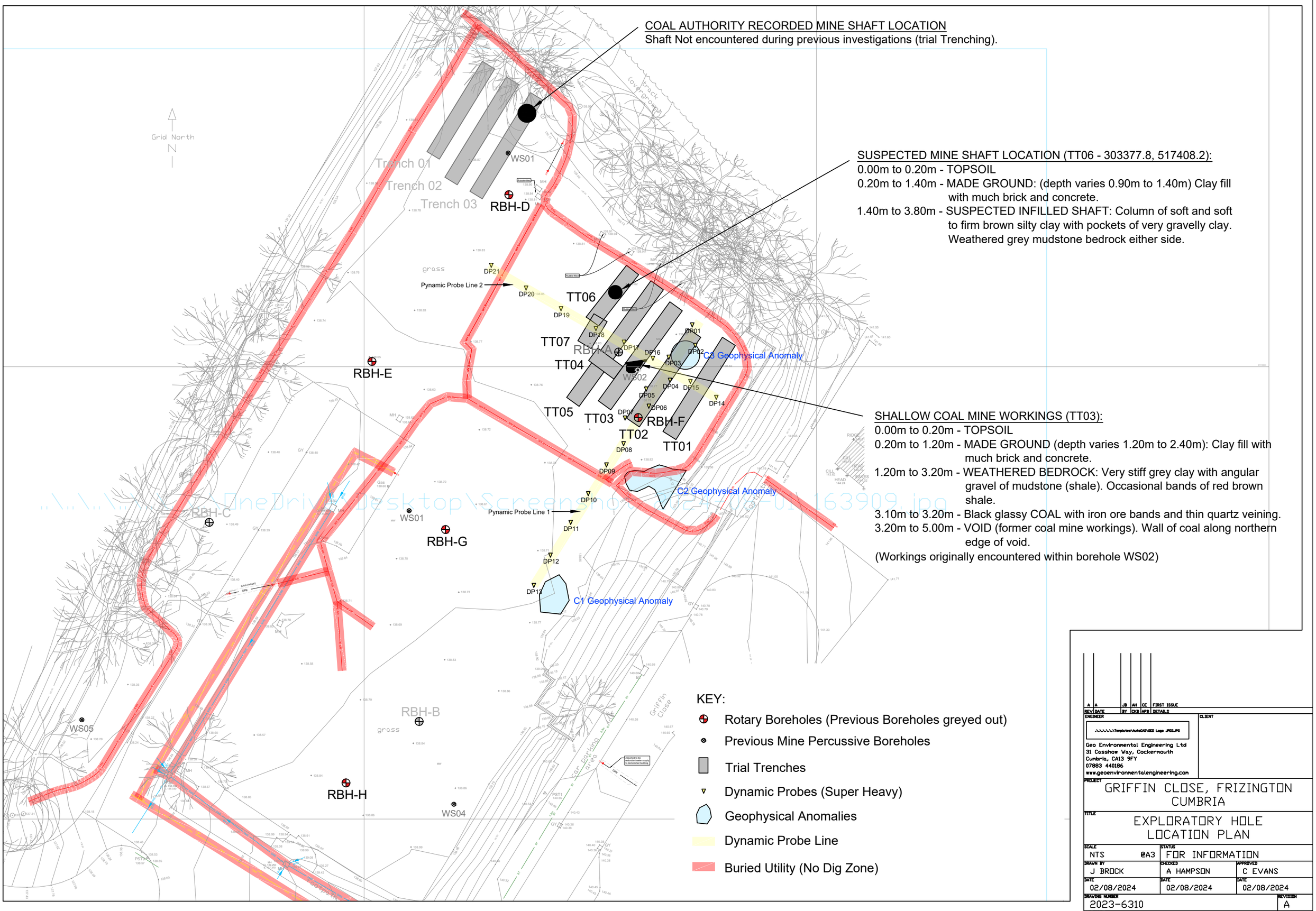

COAL AUTHORITY RECORDED MINE SHAFT LOCATION
Shaft Not encountered during previous investigations (trial Trenching).

SUSPECTED MINE SHAFT LOCATION (TT06 - 303377.8, 517408.2):
0.00m to 0.20m - TOPSOIL
0.20m to 1.40m - MADE GROUND: (depth varies 0.90m to 1.40m) Clay fill with much brick and concrete.
1.40m to 3.80m - SUSPECTED INFILLED SHAFT: Column of soft and soft to firm brown silty clay with pockets of very gravelly clay. Weathered grey mudstone bedrock either side.

SHALLOW COAL MINE WORKINGS (TT03):
0.00m to 0.20m - TOPSOIL
0.20m to 1.20m - MADE GROUND (depth varies 1.20m to 2.40m): Clay fill with much brick and concrete.
1.20m to 3.20m - WEATHERED BEDROCK: Very stiff grey clay with angular gravel of mudstone (shale). Occasional bands of red brown shale.
3.10m to 3.20m - Black glassy COAL with iron ore bands and thin quartz veining.
3.20m to 5.00m - VOID (former coal mine workings). Wall of coal along northern edge of void.
(Workings originally encountered within borehole WS02)

KEY:
- Rotary Boreholes (Previous Boreholes greyed out)
- Previous Mine Percussive Boreholes
- Trial Trenches
- Dynamic Probes (Super Heavy)
- Geophysical Anomalies
- Dynamic Probe Line
- Buried Utility (No Dig Zone)

REV	DATE	BY	CKD	APD	DETAILS
A	A	JB	AH	CE	FIRST ISSUE

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CLIENT

PROJECT
GRIFFIN CLOSE, FRIZINGTON
CUMBRIA

TITLE
EXPLORATORY HOLE
LOCATION PLAN

SCALE	STATUS		
NTS @A3	FOR INFORMATION		
DRAWN BY	CHECKED	APPROVED	
J BROCK	A HAMPSON	C EVANS	
DATE	DATE	DATE	
02/08/2024	02/08/2024	02/08/2024	

DRAWING NUMBER 2023-6310
REVISION A
FILE NAME

Proposed Site Plan

Griffin Close, Frizington

0 5m 10m 15m 20m

Scale 1:200 @ A1

Rev

Rev.	Date	Description	Revised by

RIBA stage: 3 - Developed Design

Status: For Comment

ARCHITECTS PLUS

Project: Residential Development
Griffin Close, Frizington

Client: Thomas Armstrong (Construction) Ltd

Drawing: Proposed Site Plan

Drawn by	Date
BG	06/22
Scale @A1	Computer file
1:200	P01

Drawing Number: 22031-02

Revision:

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GEO
Environmental Engineering

In-Situ Dynamic Probe Record Sheet - Super Heavy DPSH

Site Location: Griffin Close, Frizington
Project Ref: 2024-6310
Driller: MK
Engineer: JB
Fieldworks Date: 22/07/2024
Fieldworks Notes: N/A
Standard: BS1377 Part 9 DPSH

Dynamic Probe Line 1

Probe Location:	DP01		DP02		DP03		DP04		DP05		DP06		DP07		DP08		DP09		DP10		DP11		DP12		DP13	
Depth (m bgl):	N100	N300	N100	N300	N100	N300	N100	N300	N100	N300	N100	N300	N100	N300	N100	N300	N100	N300	N100	N300	N100	N300	N100	N300	N100	N300
0.1	1		2		1		1		2		2		1		3		1		2		0		0		0	
0.2	1	2	2	5	0	1	0	1	1	3	2	5	1	2	4	11	1	5	3	8	0	1	0	1	0	0
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3	21				2		1		1		2		5		5		3		7				25		4	
3.1	17				2		1		3		1		3		3		3		7				34		3	
3.2	22	51			3	7	0	1	2	6	2	5	4	12	1	5	4	13	8	23			36	106	6	22
3.3	12				2		0		1		2		5		1		6		8				36		13	
3.4	13				14		0		1		2		4		0		5		8				50		15	
3.5	14	37			50	64	0	0	1	3	2	5	2	8	0	1	4	13	8	26				>50	14	43
3.6	10						0		1		1		2		1		4		10						14	
3.7	9						0		1		1		1		1		5		12						14	
3.8	14	53					0	0	1	3	1	3	2	6	1	2	4	13	8	25					16	53
3.9	30						0		1		1		3		0		4		5						23	
4	50						0		1		1		3		0		3		7						32	
4.1		>50					0	1	1	5	1	4	9	20	1	2	3	9	8	27					34	116
4.2							1		3		2		8		1		3		12						50	
4.3							2		5		0		8		1		4		13							
4.4							1	4	5	13	0	0	10	29	2	5	4	19	15	41						
4.5							1		3		0		11		2		11		13							
4.6							1		5		1		8		1		10		11							
4.7							1	18	4	14	1	3	14	34	2	6	9	30	15	43						
4.8							16		5		1		12		3		11		17							
4.9							18		6		1		11		3		12		19							
5							27	95	4	13	2	6	5	20	5	11	24	51	24	54						
5.1							50		3		3		4		3		15		11							
5.2									3		1		5		1		24		8							
5.3									5	13	2	4	3	12	2	5	26	70	8	26						
5.4									5		1		4		2		20		10							
5.5									6		1		5		2		24		13							
5.6									5	17	1	3	9	20	1	4	30	85	12	40						
5.7									6		1		6		1		31		15							
5.8									5		17		7		1		50		17							
5.9									5	14	23	68	7	20	1	4		>50	19	61						
6									4		28		6		2				25							
6.1									5		50		3		2				27							
6.2									14	40		>50	3	10	7	20			32	105						
6.3									21				4		11				46							
6.4									50				5		5				50							
6.5										>50			3	11	1	7				>50						
6.6													3		1											
6.7													2		2											
6.8													1	4	2	5										
6.9													1		1											
7													2		6											
7.1													6	18	6	19										
7.2													10		7											
7.3													14		10											
7.4													23	67	12	37										
7.5													30		15											
7.6													50		22											
7.7														>50	50	>50										
7.8																										

KEY:
N300 = <4
N300 = 4 to 7
N300 = >7

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Notes:

The Dynamic Probe test is used to determine the resistance of soils in-situ to the intermittent penetration of a cone, driven dynamically in a standard manner and in accordance to B.S. 1377: Part 9. The equipment consists of a 90° cone which may be sacrificial or retained for recovery, a series of extension or driving rods, a torque wrench and a driving device.

There are two types of test: Heavy Dynamic Probing (DPH) and Super Heavy Dynamic Probing (DPSH). The dimensions of the cone and the mass and drop height of the driving weight differ between the two tests. The extension rods used in the test are either 0.5-metre-long (for top of the hole) or 1-metre-long, manufactured from 35mm diameter heat-treated alloy steel, with graduations marked every 100mm along their length. The rods are flush-coupled and designed such that rod ends butt-up fully against each other when driving, forming a continuous jointed series with a straight axis. The driving device may be an Automatic Trip Hammer as part of a Dynamic Sampling drilling rig or a purpose-designed Probing Rig with characteristics conforming to BS 1377: Part 9.

The blow count is recorded for every 100mm of driving (N100) and the results presented as a plot of blow count against depth. Where the DPSH is utilised the sum total of three N100 increments (c.300mm penetration – N300 value) correlates to an equivalent SPT "N" value.

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In-Situ Dynamic Probe Record Sheet - Super Heavy DPSH

Site Location: Griffin Close, Frizington
Project Ref: 2024-6310
Driller: MK
Engineer: JB
Fieldworks Date: 26/07/2024
Fieldworks Notes: N/A
Standard: BS1377 Part 9 DPSH

Dynamic Probe Line 2

Probe Location:	DP14		DP15		DP16		DP17		DP18		DP19		DP20		DP21	
Depth (m bgl):	N100	N300	N100	N300	N100	N300	N100	N300	N100	N300	N100	N300	N100	N300	N100	N300
0.1	1		0		0		1		1		1		0		0	
0.2	1	4	0	1	0	1	1	3	0	1	0	1	0	1	0	1
0.3	2		1		1		1		0		0		1		1	
0.4	2		1		1		0		1		2		2		1	
0.5	3	8	1	4	2	4	2	4	1	3	2	7	2	6	1	4
0.6	3		2		1		2		1		3		2		2	
0.7	3		2		2		0		2		4		3		2	
0.8	3	8	33	38	2	6	0	2	1	5	3	9	4	11	2	7
0.9	2		3		2		2		2		2		4		3	
1	4		3		3		2		1		2		4		3	
1.1	3	10	4	11	3	10	1	5	1	4	2	8	4	12	4	10
1.2	3		4		4		2		2		4		4		3	
1.3	2		4		4		6		3		3		3		3	
1.4	1	4	2	8	5	14	4	14	2	6	3	10	3	11	3	9
1.5	1		2		5		4		1		4		5		3	
1.6	1		3		4		4		1		4		5		3	
1.7	2	4	2	7	5	13	3	9	0	2	4	11	4	11	4	13
1.8	1		2		4		2		1		3		2		6	
1.9	1		2		3		2		1		3		2		5	
2	1	4	2	7	2	7	3	7	0	1	4	11	3	9	6	15
2.1	2		3		2		2		0		4		4		4	
2.2	1		5		2		3		0		6		4		4	
2.3	1	3	5	14	3	9	2	7	0	0	7	18	4	13	5	14
2.4	1		4		4		2		0		5		5		5	
2.5	1		2		4		2		0		5		6		5	
2.6	0	1	3	8	3	11	2	37	0	0	7	17	5	19	8	28
2.7	0		3		4		33		0		5		8		15	
2.8	0		12		7		5		0		5		10		12	
2.9	0	0	12	40	4	16	5	16	0	0	5	15	11	33	14	40
3	0		16		5		6		0		5		12		14	
3.1	0		14		4		5		0		3		13		9	
3.2	1	2	16	69	4	11	5	17	0	0	3	10	13	35	6	22
3.3	1		39		3		7		0		4		9		7	
3.4	3		44		4		8		0		5		9		7	
3.5	9	20	50	94	3	10	7	23	0	0	5	14	9	25	9	23
3.6	8				3		8		0		4		7		7	
3.7	20				4		4		0		4		9		5	
3.8	33	103			4	11	5	11	0	1	3	10	7	23	5	14
3.9	50				3		2		1		3		7		4	
4					4		2		1		4		6		4	
4.1					4	12	3	8	1	2	5	27	6	20	5	16
4.2					4		3		0		18		8		7	
4.3					4		4		0		17		8		7	
4.4					3	8	5	15	0	1	15	49	10	30	8	21
4.5					1		6		1		17		12		6	
4.6					0		5		0		21		17		7	
4.7					0	0	12	44	0	0	19	59	15	51	6	18
4.8					0		27		0		19		19		5	
4.9					0		50		1		13		19		6	
5					0	0		50	1	2	16	40	21	67	6	18
5.1					0				0		11		27		6	
5.2					0				0		11		32		6	
5.3					0	0			0	0	3	16	50	82	6	20
5.4					0				0		2				8	
5.5					0				0		1				10	
5.6					0	0			1	1	2	4			18	47
5.7					0				0		1				19	
5.8					0				0		1				27	
5.9					0	50			0	0	0	1			50	77
6					50				0		0					
6.1									1		1					
6.2									1	2	1	5				
6.3									0		3					
6.4									0		3					
6.5									0	0	4	9				
6.6									0		2					
6.7									0		3					
6.8									0	0	4	10				
6.9									0		3					
7									50		4					
7.1										>50	4	11				
7.2											3					
7.3											2					
7.4											1	6				
7.5											3					
7.6											4					
7.7											4	11				
7.8											3					
7.9											2					
8											1	4				
8.1											1					
8.2											1					
8.3											10	61				
8.4											50					

KEY:

- N300 = <4
- N300 = 4 to 7
- N300 = >7

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Notes:

The Dynamic Probe test is used to determine the resistance of soils in-situ to the intermittent penetration of a cone, driven dynamically in a standard manner and in accordance to B.S. 1377: Part 9. The equipment consists of a 90° cone which may be sacrificial or retained for recovery, a series of extension or driving rods, a torque wrench and a driving device.

There are two types of test: Heavy Dynamic Probing (DPH) and Super Heavy Dynamic Probing (DPSH). The dimensions of the cone and the mass and drop height of the driving weight differ between the two tests. The extension rods used in the test are either 0.5-metre-long (for top of the hole) or 1-metre-long, manufactured from 35mm diameter heat-treated alloy steel, with graduations marked every 100mm along their length. The rods are flush-coupled and designed such that rod ends butt-up fully against each other when driving, forming a continuous jointed series with a straight axis. The driving device may be an Automatic Trip Hammer as part of a Dynamic Sampling drilling rig or a purpose-designed Probing Rig with characteristics conforming to BS 1377: Part 9.

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GEO2024-6310: Griffin Close, Frizington, Cumbria – TT01

Depth From (m)	Depth To (m)	Strata Description	Legend	Testing / Samples
0.00	0.20	TOPSOIL: Dark brown loamy soil.		
0.20	1.10	MADE GROUND: Dark brown reworked silty very gravelly CLAY with much brick, concrete, aggregate. Depth varied 0.70m to c.1.10m bgl.		
1.10	1.60	SUSPECTED WEATHERED BEDROCK: Very stiff Light grey CLAY with much angular gravel of mudstone (shale). COAL SEAM sub-cropping along northern end of pit. Recovered as black angular brittle gravel of glassy coal with thin quartz veining.		
		Trench depth varies c.1.20m to c.1.60m. Trench length is 12.3m.		

Engineer: J.Brock
Site Works Date: 29/07/2024
Plant: 8T Tracked 360 Excavator

Log Notes:
HSV = Hand Shear Vane (kN/m^2)
LP = Limited Penetration (HSV/CBR)
B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub

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GEO Environmental Engineering

GEO2024-6310: Griffin Close, Frizington, Cumbria – TT02

Depth From (m)	Depth To (m)	Strata Description	Legend	Testing / Samples
0.00	0.20	TOPSOIL: Dark brown loamy soil.		
0.20	1.40	MADE GROUND: Dark brown reworked silty very gravelly CLAY with much brick, concrete, aggregate. Depth varied 0.80m to c.1.40m bgl.		
1.40	180	SUSPECTED WEATHERED BEDROCK: Very stiff Light grey CLAY with much angular gravel of mudstone (shale).		
		Trench depth varies c.1.50m to c.1.80m. Trench length is 12.0m.		

Engineer: J.Brock
Site Works Date: 29/07/2024
Plant: 8T Tracked 360 Excavator

Log Notes:
HSV = Hand Shear Vane (kN/m^2)
LP = Limited Penetration (HSV/CBR)
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GEO Environmental Engineering

GEO2024-6310: Griffin Close, Frizington, Cumbria – TT03

Depth From (m)	Depth To (m)	Strata Description	Legend	Testing / Samples
0.00	0.20	TOPSOIL: Dark brown loamy soil.		
0.20	1.20	MADE GROUND: Dark brown reworked silty very gravelly CLAY with much brick, concrete, pottery, asphalt and aggregate. Depth varied 1.20m to c.2.40m bgl.		
1.20	3.10	SUSPECTED WEATHERED BEDROCK: Very stiff Light grey CLAY with much angular gravel of mudstone (shale).		
3.10	3.20	COAL: Recovered as black angular gravel of brittle coal with thin quartz veining and ironstone banding.		
3.40	5.00	VOID (Coal Mine Workings): Large void with wall of coal along northern edge (possible column or coal face). See photos overleaf.		
		Trench depth varies c.1.50m to c.5.00m. Trench length is 13.5m.		

Engineer: J.Brock
Site Works Date: 29/07/2024
Plant: 8T Tracked 360 Excavator

Log Notes:
HSV = Hand Shear Vane (kN/m^2)
LP = Limited Penetration (HSV/CBR)
B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub

GEO2024-6310: Griffin Close, Frizington, Cumbria – TT03 (Void Photos)

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GEO2024-6310: Griffin Close, Frizington, Cumbria – TT03 (Void Photos)

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GEO2024-6310: Griffin Close, Frizington, Cumbria – TT04

Depth From (m)	Depth To (m)	Strata Description	Legend	Testing / Samples
0.00	0.20	TOPSOIL: Dark brown loamy soil.		
0.20	1.40	MADE GROUND: Dark brown reworked silty very gravelly CLAY with much brick, concrete, aggregate. Made Ground depth varied 1.20m to c.2.00m bgl (localised deeper made ground appears to be edge of former trial pit TP01).		
1.40	3.70	SUSPECTED WEATHERED BEDROCK: Very stiff Light grey CLAY with much angular gravel of mudstone (shale). No coal or evidence of workings.		
		Trench depth varies c.1.50m to c.3.70m (max reach). Trench length is 3.50m.		

Engineer: J.Brock
Site Works Date: 29/07/2024
Plant: 8T Tracked 360 Excavator

Log Notes:
HSV = Hand Shear Vane (kN/m^2)
LP = Limited Penetration (HSV/CBR)
B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub

GEO Environmental Engineering

GEO2024-6310: Griffin Close, Frizington, Cumbria – TT05

Depth From (m)	Depth To (m)	Strata Description	Legend	Testing / Samples
0.00	0.20	TOPSOIL: Dark brown loamy soil.		
0.20	1.50	MADE GROUND: Dark brown reworked silty very gravelly CLAY with much brick, concrete, aggregate. Made Ground Depth varied 0.90m to c.1.50m bgl.		
1.50	1.80	SUSPECTED WEATHERED BEDROCK: Very stiff Light grey CLAY with much angular gravel of mudstone (shale).		
		Trench depth varies c.1.40m to c.1.80m. Trench length is 15.90m.		

Engineer: J.Brock
Site Works Date: 29/07/2024
Plant: 8T Tracked 360 Excavator

Log Notes:
HSV = Hand Shear Vane (kN/m²)
LP = Limited Penetration (HSV/CBR)
B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub

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GEO2024-6310: Griffin Close, Frizington, Cumbria – TT06

Depth From (m)	Depth To (m)	Strata Description	Legend	Testing / Samples
0.00	0.20	TOPSOIL: Dark brown loamy soil.		
0.20	1.40	MADE GROUND: Dark brown reworked silty very gravelly CLAY with much brick, concrete, aggregate. Made Ground Depth varied 0.90m to c.1.50m bgl.		
1.40	3.60	MADE GROUND (Suspected Fill within Former Mine Shaft): Column of soft and soft to firm brown silty CLAY with pockets of gravel. Weathered Grey Mudstone either side of soft clay. See photos overleaf.		
		Logged at location of suspected mine shaft. Trench depth varies c.1.40m to c.3.80m (max reach). Trench length is 7.30m.		

Engineer: J.Brock
Site Works Date: 29/07/2024
Plant: 8T Tracked 360 Excavator

Log Notes:
HSV = Hand Shear Vane (kN/m^2)
LP = Limited Penetration (HSV/CBR)
B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub

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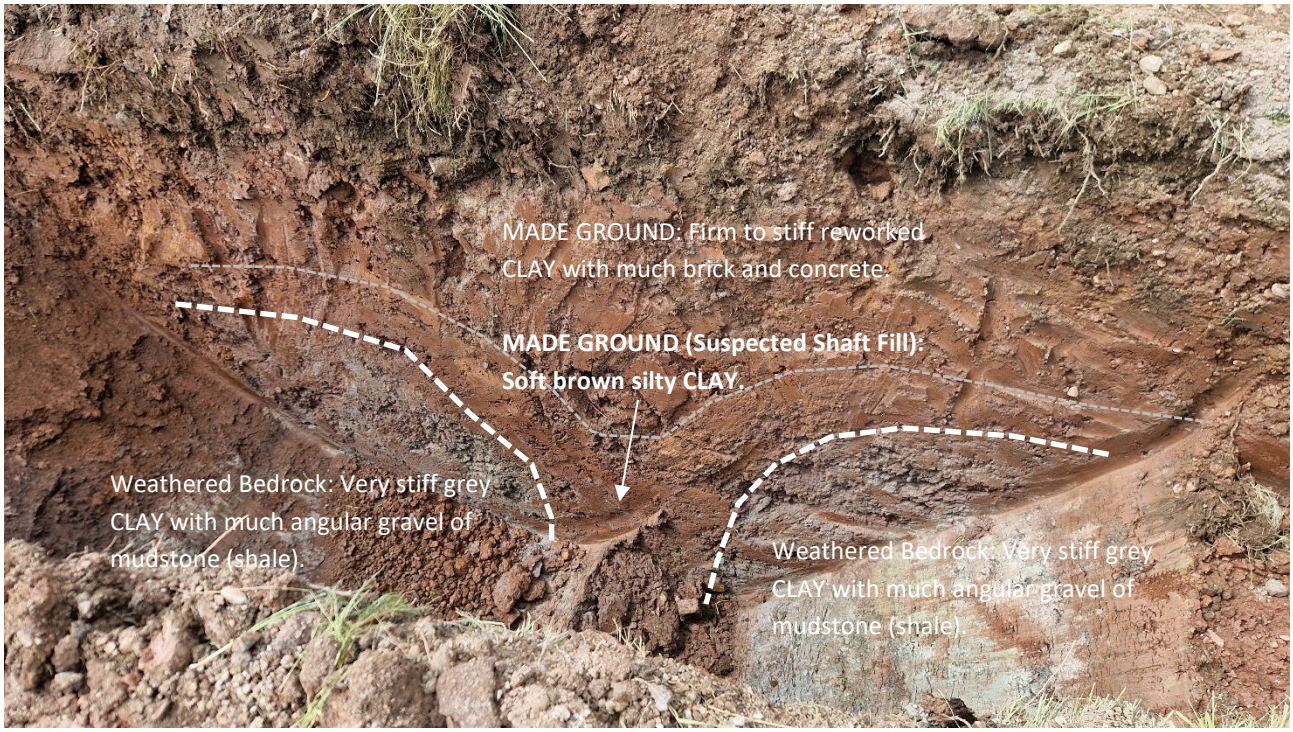
GEO2024-6310: Griffin Close, Frizington, Cumbria – TT06 (Suspected Shaft Photos)



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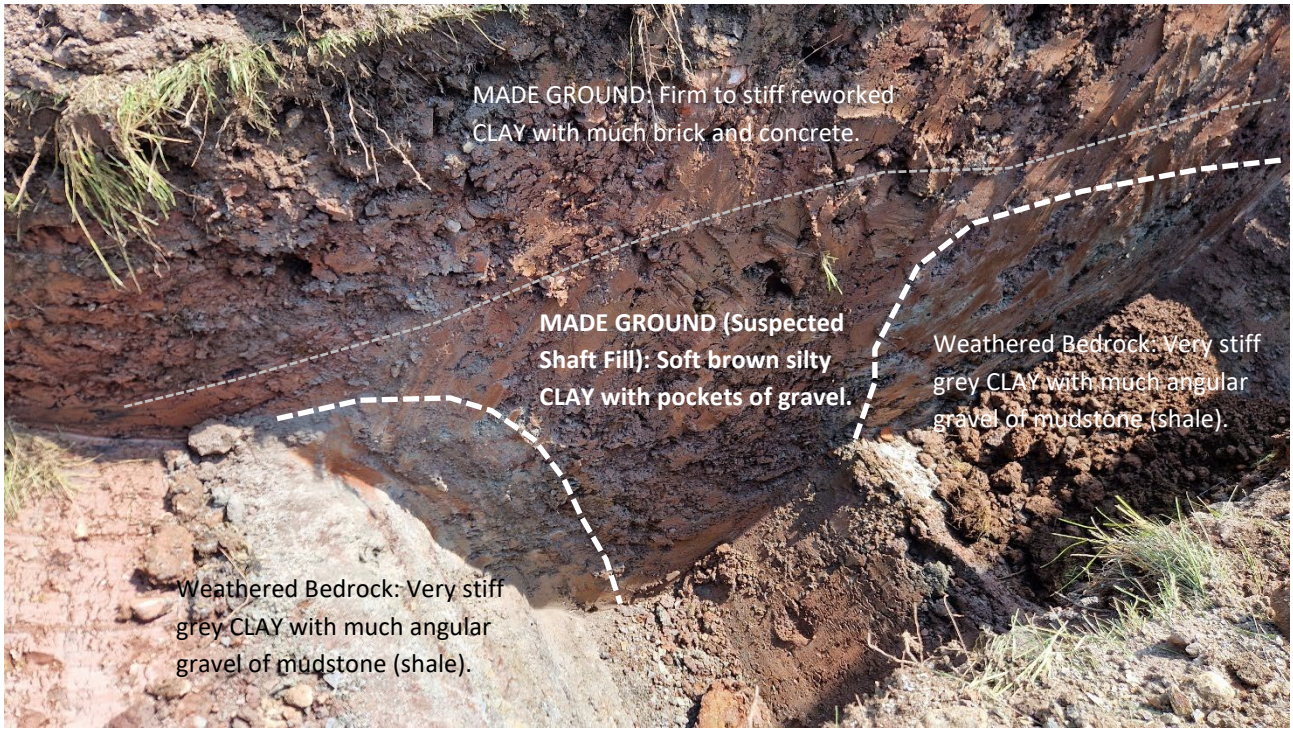
GEO2024-6310: Griffin Close, Frizington, Cumbria – TT06 (Suspected Shaft Photos)



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GEO Environmental Engineering

GEO2024-6310: Griffin Close, Frizington, Cumbria – TT07

Depth From (m)	Depth To (m)	Strata Description	Legend	Testing / Samples
0.00	0.20	TOPSOIL: Dark brown loamy soil.		
0.20	1.30	MADE GROUND: Dark brown reworked silty very gravelly CLAY with much brick, concrete, aggregate.		
1.30	2.40	SUSPECTED WEATHERED BEDROCK: Very stiff Light grey CLAY with much angular gravel of mudstone (shale).		
2.40	3.10	SUSPECTED WEATHERED BEDROCK: Stiff Light grey CLAY with much angular gravel of mudstone (shale). No resistance to excavator bucket (very loose). Appears natural.		
		Excavated over DP01 to investigate low prove values. Trench depth varies c.2.40m to c.3.10m (max reach). Trench length is 3.50m.		

Engineer: J.Brock
Site Works Date: 29/07/2024
Plant: 8T Tracked 360 Excavator

Log Notes:
HSV = Hand Shear Vane (kN/m^2)
LP = Limited Penetration (HSV/CBR)
B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub

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GEO Environmental Engineering

2024-6310: Griffin Close, Frizington – RBH-D

Depth From (m)	Depth To (m)	Strata Description	Legend	Testing / ROP Samples
0.00	0.30	TOPSOIL: Dark brown sandy gravelly LOAM.		
0.30	2.90	Reddish brown and grey CLAY with mudstone gravel and cobbles. Occasionally soft. Possible fill material		1.50-3.00: 4 mins
2.90	5.20	Light grey-brown silty, clayey SAND.		3.00-4.50: 7 mins 4.50-6.00: 9 mins
5.20	7.60	Grey MUDSTONE.		6.00-7.50: 8 mins 7.50-9.00: 3 mins
7.60	9.15	Black COAL (1.55m).		9.00-10.50: 15 mins
9.15	15.80	Grey MUDSTONE.		10.50-12.00: 19 mins 12.00-13.50: 14 mins 13.50-15.00: 20 mins 15.00-16.50: 46 mins
15.80	16.10	IRONSTONE.		
16.10	16.90	Grey MUDSTONE.		16.50-18.00: 42 mins
16.90	17.20	IRONSTONE.		
17.20	18.50	Grey MUDTONE.		18.00-19.50: 11 mins
18.50	19.20	Black COAL (0.7m).		
19.20	21.40	Grey MUDSTONE.		19.50-21.00: 24 mins 21.00-22.50: 12 mins
21.40	22.30	Black COAL (0.9m).		
22.30	24.00	Grey MUDSTONE.		22.50-24.00: 14 mins
		Borehole backfilled with bentonite. No adverse gas detected during or after drilling.		Hand dug before drilling. Cased to 3.00m.

Engineer: GE
Site Works Date: 25/07/2024
Plant: Beretta T2 Tracked rotary rig with water flush.

Log Notes:
ROP = Rate of penetration (rotary drilling)
NP = No penetration (HSV/CBR)
B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub

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GEO Environmental Engineering

2024-6310: Griffin Close, Frizington – RBH-E

Depth From (m)	Depth To (m)	Strata Description	Legend	Testing / ROP Samples
0.00	0.30	TOPSOIL: Dark brown sandy gravelly LOAM.		
0.30	1.50	MADE GROUND: Grey Gravel and cobbles with some plastic and polystyrene.		
1.50	4.10	Reddish brown CLAY with mudstone gravel and cobbles.		1.50-3.00: 5 mins 3.00-4.50: 5 mins
4.10	4.25	Black COAL (0.15m).		
4.25	6.00	Grey MUDSTONE. Noted as soft to 5.60m.		4.50-6.00: 8 mins
6.00	7.90	Hard light brown SANDSTONE.		6.00-7.50: 13 mins 7.50-9.00: 11 mins
7.90	11.10	Grey MUDSTONE with occasional harder siltstone bands.		9.00-10.50: 9 mins 10.50-12.00: 8 mins
11.10	11.90	Loss of flush. Noted as soft. Drill mud added.		
11.90	12.30	No returns. Solid.		
12.30	13.80	No returns. BROKEN GROUND.		12.00-13.50: 12 mins
13.80	15.50	No returns. Solid.		13.50-15.00: 8 mins
		Borehole backfilled with bentonite. No adverse gas detected during or after drilling.		Hand dug before drilling. Cased to 3.00m.

Engineer: GE
Site Works Date: 22/07/2024
Plant: Beretta T2 Tracked rotary rig with water flush

Log Notes:
ROP = Rate of penetration (rotary drilling)
NP = No penetration (HSV/CBR)
B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub

GEO Environmental Engineering

2024-6310: Griffin Close, Frizington – RBH-F

Depth From (m)	Depth To (m)	Strata Description	Legend	Testing / ROP Samples
0.00	0.20	TOPSOIL: Dark brown sandy gravelly LOAM.		
0.20	1.00	MADE GROUND: Brick FILL.		
1.00	5.00	Reddish brown and grey CLAY with mudstone gravel and cobbles. Occasionally soft. Possible fill material		1.50-3.00: 7 mins 3.00-4.50: 5 mins 4.50-6.00: 7 mins
5.00	5.50	Grey MUDSTONE.		
5.50	6.85	Black COAL (1.35m).		6.00-7.50: 9 mins
6.85	13.60	Grey MUDSTONE with occasional harder siltstone bands.		7.50-9.00: 15 mins 9.00-10.50: 18 mins 10.50-12.00: 32 mins 12.00-13.50: 21 mins
13.60	14.00	Hard IRONSTONE.		13.50-15.00: 79 mins
14.00	14.40	Grey MUDSTONE.		
14.40	14.70	Hard IRONSTONE.		
14.70	15.90	Grey MUDSTONE.		15.00-16.50: 12 mins
15.90	16.50	Black COAL (0.6m).		
16.50	18.60	Grey MUDSTONE.		16.50-18.00: 12 mins 18.00-19.50: 9 mins
18.60	19.50	Black COAL (0.9m).		
19.50	21.00	Grey MUDSTONE.		19.50-21.00: 16 mins
		Borehole backfilled with bentonite. No adverse gas detected during or after drilling.		Hand dug before drilling. Cased to 3.00m.

Engineer: GE
Site Works Date: 23/07/2024
Plant: Beretta T2 Tracked rotary rig with water flush

Log Notes:
ROP = Rate of penetration (rotary drilling)
NP = No penetration (HSV/CBR)
B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub

GEO Environmental Engineering

2024-6310: Griffin Close, Frizington – RBH-G

Depth From (m)	Depth To (m)	Strata Description	Legend	Testing / ROP Samples
0.00	0.20	TOPSOIL: Dark brown sandy gravelly LOAM.		
0.20	0.60	MADE GROUND: Brick FILL.		
0.60	3.50	Reddish brown and grey CLAY with mudstone gravel and cobbles. Occasionally soft. Possible fill material.		
3.50	4.70	Grey MUDSTONE.		4.50-6.00: 8 mins
4.70	6.50	Reddish brown clayey, sandy MUDSTONE. Noted as soft. Possible fill material.		6.00-7.50: 6 mins
6.50	7.30	Loss of flush. No returns. Noted as soft.		
7.30	8.80	Reddish-brown and grey MUDSTONE.		7.50-9.00: 12 mins
8.80	12.20	Grey MUDSTONE.		9.00-10.50: 11 mins 10.50-12.00: 11 mins 12.00-13.50: 5 mins
12.20	13.40	Black COAL (1.2m).		
13.40	16.50	Grey MUDSTONE.		13.50-15.00: 12 mins 15.00-16.50: 21 mins
		Borehole backfilled with bentonite. No adverse gas detected during or after drilling.		Hand dug before drilling. Cased to 3.00m.

Engineer: GE
Site Works Date: 24/07/2024
Plant: Beretta T2 Tracked rotary rig with water flush

Log Notes:
ROP = Rate of penetration (rotary drilling)
B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub

GEO Environmental Engineering

2024-6310: Griffin Close, Frizington – RBH-H

Depth From (m)	Depth To (m)	Strata Description	Legend	Testing / ROP Samples
0.00	0.25	TOPSOIL: Dark brown sandy gravelly LOAM.		
0.25	2.80	Reddish brown and grey CLAY with mudstone gravel and cobbles.		1.50-3.00: 8 mins
2.80	3.00	Black COAL (0.2m).		
3.00	7.50	Grey MUDSTONE with occasional sand and clay lenses. Possible drift.		3.00-4.50: 11 mins 4.50-6.00: 10 mins 6.00-7.50: 9 mins
7.50	18.60	Grey MUDSTONE with occasional harder siltstone and sandstone bands.		7.50-9.00: 11 mins 9.00-10.50: 13 mins 10.50-12.00: 16 mins 12.00-13.50: 12 mins 13.50-15.00: 17 mins 15.00-16.50: 15 mins 16.50-18.00: 16 mins 18.00-19.50: 9 mins
18.60	19.60	Black COAL (1.0m).		
19.60	19.90	Grey MUDSTONE.		19.50-21.00: 13 mins
19.90	20.30	Black COAL (0.4m).		
20.30	21.50	Grey MUDSTONE.		
		Borehole backfilled with bentonite. No adverse gas detected during or after drilling.		Hand dug before drilling. Cased to 3.00m.

Engineer: GE
Site Works Date: 26/07/2024
Plant: Beretta T2 Tracked rotary rig with water flush

Log Notes:
ROP = Rate of penetration (rotary drilling)
NP = No penetration (HSV/CBR)
B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub

Site: **Griffon Close, Frizington, Cumbria.**

Project Title: **Geophysical Survey.**

Survey Period: 22nd to 23rd May 2024

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THIS REPORT REPRESENTS THE BEST PROFESSIONAL OPINION OF THE AUTHOR. EVERY EFFORT HAS BEEN MADE TO ENSURE ACCURACY AND RELIABILITY OF GEOPHYSICAL SURVEY DATA.

GEOPHYSICAL SURVEY DATA SHOULD NOT BE USED AS THE SOLE MEANS OF SITE ASSESSMENT. GEOPHYSICAL DATA CAN BE INFLUENCED BY A COMBINATION OF MANY SUB-SURFACE FACTORS LEADING TO NON-UNIQUE INTERPRETATIONS. SURVEY RESULTS MUST BE COMBINED AND VERIFIED WITH INTRUSIVE METHODS FOR DEFINTIIVE CONFIRMATION.

A GEOPHYSICAL SURVEY MAY NOT LOCATE ALL SUB-SURFACE TARGETS SINCE DETECTION LIMITS WILL APPLY. A LACK OF GEOPHYSICAL TARGETS WITHIN THIS REPORT DOES NOT WARRANT THAT ALL TARGETS WITH POTENTIAL CONSEQUENCE FOR COSTS HAVE BEEN LOCATED.

ANY CHANGE IN SITE CONDITIONS POST-SURVEY, SUCH AS REDUCTION IN ELEVATION AND REMOVAL OF SURFACE OBSTRUCTIONS, MAY LEAD TO DISCOVERY OF UNFORESEEN GROUND CONDITIONS WHICH WERE BEYOND DETECTION AT THE TIME OF THE GEOPHYSICAL SURVEY. IT IS THE RESPONSIBILITY OF THE CLIENT TO UNDERSTAND AND ADVISE THAT NO COMBINATION OF GEOPHYSICAL SURVEY, INTRUSIVE WORKS OR DESK STUDIES CAN ELIMINATE ALL SUBSEQUENT CONSTRUCTION RISKS.

CONTENTS

1 Introduction 4

2 Site Details 4

3 Geophysical Survey 4

3.1 Survey Objectives 4
3.2 Survey Rationale 5
3.3 Electromagnetic (EM) Ground Conductivity Measurements 5
3.4 Electromagnetic (EM) Ground Conductivity Equipment 5
3.5 Electromagnetic (EM) Ground Conductivity Processing 5
3.6 Electrical Resistivity Tomography (ERT Measurements) 6
3.7 Resistivity Tomography Equipment 7
3.8 Resistivity Tomography Data Processing 7

4 Survey Layout 7

5 Results 8

6 Discussion and recommendations 10

6.3 Survey limitation statement 11

FIGURES

Figure 1: Site Location 13

Figure 2: Conductivity Survey Mapping. 14

Figure 3: Electrical Resistivity Tomography profiles 1 to 3. 15

1 Introduction

This report contains the results and conclusions following a geophysical investigation within the land area off Griffon Close, Frizington, Cumbria.

The purpose of the survey was to obtain geophysical indications that may relate to potential mineshafts reported as being located within the site. Previous site investigation works have not located any clear evidence for shafts but have encountered some unexpected sub-surface characteristics which cannot be ruled out as being mining related.

The initial survey was undertaken between the 22nd and 23rd May 2024.

2 Site Details

The Griffon Close site is located within Frizington, some 6km east of Whitehaven in Cumbria. The site is entered off the spur road of Greenvale Court. Figure 1 shows the site location.

The site comprises an area of flat lying, scrubland covering approximately 0.4Ha. Part of the site area is currently a car park. The site is bounded to its south-east and south-west by Greenvale Court and Griffon Close and by trees and hedging to its north-east and north-west.

The site was formerly a care home with the main buildings covering the majority of the site excepting the current car park area and a grassed area in the north-west. At the surface there is no visible evidence for remaining concrete slabs or footings, although some slabs and footings may remain in-situ. There are numerous open access chambers visible within the site area, indicating that the former surface water and foul drainage systems remains in-situ. A utility survey also indicates that electrical cables and gas pipes are present on site.

The Coal Authority record shaft reference 303517-006 as lying within the north-western corner of the site. A further two shafts are recorded just outside the site to its north-west. Despite extensive trenching within the north-west corner of the site, no definitive evidence for a shaft has been noted. Historic mining records can be inaccurate and thus it is possible that the shaft lies offsite, does not exist or lies elsewhere within the site.

Previous site investigation works noted a relatively consistent thickness of made ground of around 3m thickness within the site, excepting a single location in the north-east corner of the site, where thicknesses were in excess of 6.6m. Whether this anomalous location represents mining relicts or relates to the former care home was not possible to determine.

According to the British Geological Survey online resources, the likely geological sequence at the site is as follows: -

1. Superficial deposits. Till, Devensian - Diamicton. A recent site investigation noted light brown and grey, silty sandy gravelly clay.
2. Solid Geology. Pennine Middle Coal Measures Formation - Mudstone, siltstone and sandstone. A recent site investigations noted solid geology comprising a light grey and reddish-brown mudstone with occasional thin, hard siltstone and sandstone bands.

3 Geophysical Survey

3.1 Survey Objectives

The objectives of the survey were to:

- Cover the accessible areas within the site to determine any localised anomalies representative of possible mine shafts, and to indicate zonation of geophysical characteristics which may be representative of shallow materials changes, potentially relating to the former buildings, mining activities or geological changes.

3.2 Survey Rationale

To meet the survey aims we took the following approach.

1. Cover the site with a Phase 1 walk-over survey method providing data at a high spatial resolution to provide evidence in map form showing potential mining and other sub-surface characteristics over the site as a whole.
2. Where possible use the walk over geophysical data to locate a secondary, Phase 2 geophysical method over key anomalies and or zones, to provide information in vertical profile form over a greater depth range to confirm the depth characteristics of any anomalies or zones noted in the Phase 1 survey coverage.
3. We determined that this rationale could be me using the techniques discussed within the following section.

3.3 Electromagnetic (EM) Ground Conductivity Measurements

Electromagnetic measurements can be used to map out the variations in conductivity of sub-surface materials. Ground conductivity is measured in SI units of milli-Siemens per metre (mS/m). Ground conductivity variations can be caused by: -

- Changes in geology. For example, changes in the type of superficial cover and/or changes in its thickness.
- Changes in made ground composition. Potentially relating to natural or human influences.
- Variations in moisture/water content. Potentially influenced by preferential drainage about the location of shafts
- The presence of in-situ structural remains. Shafts often have brick linings and debris remaining about their portals.

3.4 Electromagnetic (EM) Ground Conductivity Equipment

The survey was undertaken using a Geophex GEM2. The instrument consists of a flat "ski" containing the transmitter, receiver and balancing coils together with the required control electronics.

The GEM2 is carried by an operator with data being continuously collected at linear intervals of around 0.15m. The instrument was located using a Hemisphere A101 dGPS system with an accuracy of ±0.5m. Raw data were recorded onto a Trimble Nomad field logger. As the site was open, dGPS position quality was always more than the minimum requirements.

The GEM2 can collect data simultaneously using a number of frequencies which can permit the results to be tailored to a particular depth range. The depth range covered is not a fixed relationship to a particular frequency. Based upon many previous surveys we *estimate* that the equipment may have recorded data over a depth range of 0 to 4/5m.

3.5 Electromagnetic (EM) Ground Conductivity Processing

After the survey was completed, the raw data were downloaded from the Trimble logger to ensure data security and to undertake a check on data quality. The raw binary data were inverted to EM conductivity values using WinGEM2. Subsequently, spreadsheet editing of null values and conversion of geodetic coordinates into OS National Grid using the OSTN02 transform within OS

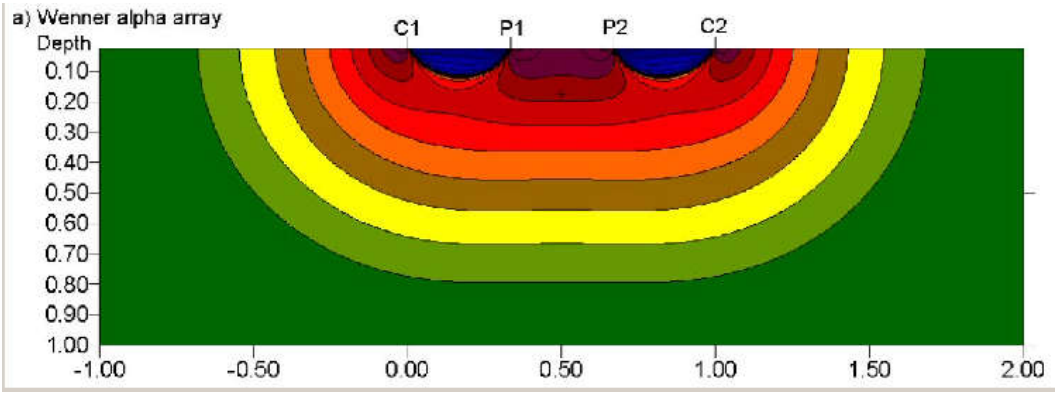
utility Grid InQuest were undertaken. Golden Surfer 26 was then used to combine the survey data, grid each data file, filter and colour code the data as contour plots.

3.6 Electrical Resistivity Tomography (ERT Measurements)

Electrical Resistivity Tomography (ERT) surveys produce vertical cross-sections of the sub-surface based upon modelling of measured electrical properties. The profiles can indicate stratigraphic boundaries, localised anomalies resulting from dissolution, voiding or fracturing and the presence of man-made structures.

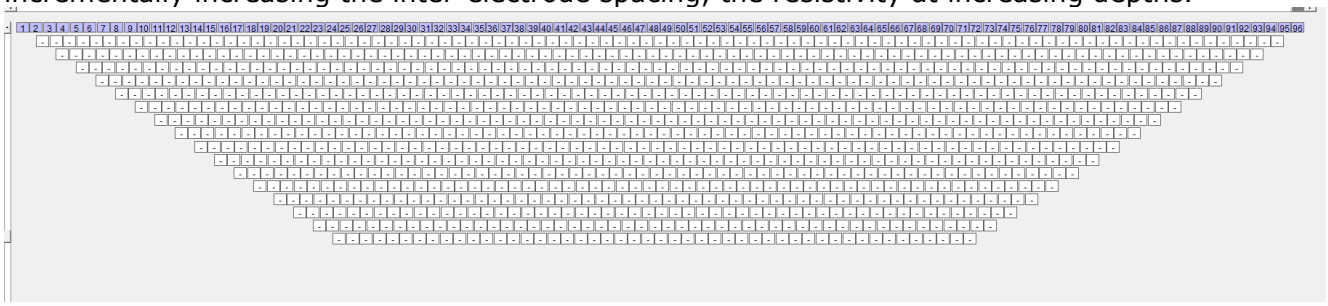
In geophysical terms the electrical properties of a material are expressed in terms of its resistivity. The SI unit of resistivity is ohm meter (Ohm-m). The resistivity technique requires that an electric current be driven into the ground using a pair of current electrodes and the resulting potential difference be measured at a pair of potential electrodes. In traditional resistivity measurements the current is driven into the ground and potential differences are measured using an array of 4 electrodes connected via cables to a resistivity meter.

The configuration of the electrodes depends on the type of survey being conducted. A common configuration is the Wenner array which has a high vertical resolution and is particularly suited to resolving horizontally layered lithology whilst achieving a high signal to noise ratio. In this method four electrodes are spaced equally with the current electrodes on the extremes. Picture 1 below shows the basic Wenner array and its current flow path.



Picture 1: Wenner array current flow and electrode arrangement

The diagram above shows the situation for a single measurement. In order to build a profile along a particular ERT survey line, measurements of resistivity are obtained in a sequence covering the overall electrode spread distance, typically comprising 64 to 96 electrodes. This procedure collects resistivity measurements along the distance covered by the electrode array, and by incrementally increasing the inter-electrode spacing, the resistivity at increasing depths.



Picture 2: ERT Wenner array diagram, showing the measurement distribution within a single profile. Each white box is a four-pole measurement location. The horizontal axis

is the distance over which the ERT profile is laid out. The vertical axis shows the depth levels measured by incrementally increasing the inter-electrode spacing.

3.7 Resistivity Tomography Equipment

The system used at Griffon Close was an Allied Tigre 128 resistivity system. This unit used up to 64 addressable electrodes connected by multicore cables. Measurements were sequenced by control software on a field laptop which also managed data storage. Depending upon the type of survey, a single profile can be collected in around 2-3 hours depending upon the number of electrodes, their configuration, the number of repeat measurements, the number of depth levels measured and the difficulty of working upon the local terrain.

During data collection the results from each measurement are displayed on the field laptop in a table and graphically as a raw profile.

3.8 Resistivity Tomography Data Processing

Individual resistivity measurements were stored as files on hard disk whilst the system completed its measurement programme. Data were stored in ASCII text format and were subsequently converted via software utilities so as to be readable by processing software, RES2DINV.

Res2DINV uses an optimisation method which tries to reduce the difference between the calculated and measured apparent resistivity values by adjusting the resistivity of the model blocks. A measure of this difference is given by the root-mean-squared (RMS) error. In general, the most prudent approach is to choose an apparent resistivity model at the iteration after which the RMS error does not change significantly. This usually occurs between the 3rd and 5th iterations.

Prior to any form of modelling outlying data points were removed. Such bad data points could be due to noise, poor electrode ground contact due to dry ground, or shorting across the cables due to very wet ground conditions.

Various parameters were set to optimise the model for each site including vertical and horizontal filters and the type of inversion method. We have used the robust inversion method which tends to highlight horizons more clearly. Various smoothing constraints have also been applied.

Whilst the software usually performs very well, we have to bear in mind that the final output is a model. Model quality is based entirely upon the collected data which is always influenced by the local conditions and environmental factors. As such modelled output must not be considered fully definitive but must be used as a guide and proven via intrusive investigations. The model is never an exact image of the sub-surface.

4 Survey Layout

The electromagnetic conductivity survey was undertaken between two baselines set out along the north-eastern and south-western ends of the open site. The GEM2 instrument was walked back and forth between the baselines at a line spacing of approximately 1.5m. A linear sampling rate of 0.15m was utilised throughout the survey period. The survey was undertaken where practically possible within the site area. A small area within the car park was not covered due to the presence of parked cars.

The ERT profiles were set out to run through some key anomalies noted within the conductivity survey data. Along each profile, electrodes were installed at a spacing interval of between 1m and 1.5m depending upon the space available. ERT profile 1 was more restricted on space across the

site than ERT profiles 2 and 3 which ran along the sites longer axis. Tapes were used to position the electrodes along each of the three profiles. The start and end locations of each profile were obtained using RTK GPS.

5 Results

Figure 2 shows the GEM2 conductivity mapping data. The locations of ERT profiles 1 to 3 are indicated by purple dashed lines. The locations of key surface features are also indicated including, the location of access chambers, the position of WS01 where infill depths exceeded 6m, and the extent of bonfire remains at the surface (burning may influence geophysical data). Locations of key conductivity anomalies and their references are also shown (C1, C2 etc).

5.1 Conductivity mapping

We can summarise the conductivity results as follows: -

1. Overall, the conductivity data has a low overall range between 5 and 20mS/m. Whilst this is a generally low range, there are some interesting anomalies and features within the conductivity distribution.
2. At the northern end of the site, we note what are likely to be in-situ drainage services as an east to west trending, low conductivity linear anomaly. The location of surface manhole covers coincides along the length of this anomaly.
3. Immediately to the south of the linear anomaly, we note a zone of increased conductivity. This area coincides with WS01 where made ground thicknesses were noted to reach 6.6m and TP01, where made ground was noted to 3m thickness. We note that WS01 lies within an embayment where conductivities are slightly reduced (Figure 2). The centre of this embayment may be worthy of some further investigations to attempt a better characterisation. The centre of the embayment is marked as anomaly reference C3. The increased conductivities may be caused by clay-rich materials, made ground, or wetter made ground materials.
4. In the north-western corner of the site, we note relatively higher conductivities. This may indicate a more clay-rich, wetter or thicker made ground and superficial cover. Shaft reference 303517-006 is recorded as lying within this area of the site but the conductivity mapping shows no obvious localised anomaly which could be interpreted as the shaft.
5. Within the central area of the site and under the car park, we note an extensive zone with a reduction in conductivity. This distribution does not appear to match the former footprint of the care home but may indicate drier more granular materials perhaps from demolition wastes being spread. TP03 confirmed a significant volume of brick and concrete. The lower conductivity under the current car park may be due to the influence of the current asphalt surfacing.
6. South of the site centre, conductivities show a relative increase. We note that the increased conductivity zone does have a regular appearance and thus may reflect debris from the former care home lying within its former footprint, as well as the presence of 3.0m of clay deposits confirmed within TP01 and WS04.

7. The following localised conductivity anomalies are also noted within the site area: -
    a. C1 and C2 are both located at the extreme east of the site and are both high conductivity anomalies.
    b. C4 is a vague but circular high conductivity anomaly noted close to surface access chambers. It is possible this target is related to the chambers but based upon site context, a localised anomaly could be a shaft.
    c. C5 and C6 are located within the car park and may be related to manhole covers.
    d. C7 is a localised higher conductivity anomaly within the grassed area to the west of the car park access road leading from Greenvale Court.

5.2 ERT Profiles

Three ERT profiles were collected such that they ran through some of the anomalies noted within the conductivity mapping data. The ERT profiles with notes are shown on Figure 3. We can summarise their results as follows: -

8. ERT profile one ran north-west to south-east across the northern end of the site. The profile was 50m in length and offered a depth of investigation to a maximum of 8m. The profile ran through, or close to anomalies C4 and C3 and passed close to WS01 where made ground thickness was noted to be anomalously thick.
9. Between chainage 0m and 17m in the north-west, we note no evidence for a shaft or a significant localised increase in the depth of made ground. We note low resistivity materials (blues) to a depth of 2m maximum before intermediate resistivity materials likely to be mudstones are encountered. This corresponds with the conductivity survey data in the same area which exhibits high conductivities.
10. At a chainage of 19.5m, ERT profile 1 shows a very localised low resistivity anomaly from surface to a depth of 0.5m. This will coincide with conductivity anomaly C4 and suggests that the anomaly is likely to be related to a very near-surface characteristic and is unlikely to be a shaft.
11. Where ERT profile 1 passes the position of WS01 and conductivity anomaly C3, at chainage 41m, we note low/intermediate conductivities above a sloped high resistivity boundary at 2m depth which dips and increases in depth to the west. Under chainage 36m this high resistivity boundary becomes vertical and dips below the base of the profile. Between chainage 36m and 24m intermediate conductivities are noted beyond the base of the profile before increased resistivities return at chainage 24m with their minimum depth of around 2m under chainage 15m. The area between chainage 24m and 36m is difficult to interpret without some additional intrusive works but could relate to historic infilling to a significant depth but may also be due to the influence of the nearby drainage run. Some further investigations to check for the possibility of mining relicts would be worthwhile in this location.

12. ERT profile 2 runs near-north to south along the approximate central long-axis of the site. The profile was 78m in length and had a maximum depth of investigation of approximately 12m. The profile was oriented such that it ran through conductivity anomaly C4 and covered the more widespread variations in site conductivity.
13. Conductivity anomaly C4 lies at ERT chainage 3m. As with ERT profile 1, the conductivity anomaly is noted as a very low resistivity zone with a maximum depth of 0.8m. There are no characteristics that we could associate with a potential shaft.
14. A low resistivity zone is noted between chainage 8.5m and 17m with minimum resistivities at a depth of 1.5m. This may be related to the north-western end of the intermediate resistivity zone noted between chainage 24 and 36m on ERT profile 1. Again, some additional investigations in this area may better characterise the sub-surface characteristics in this area.
15. Between chainage 18m and 39m we note a very high resistivity zone to a depth of 6m. This corresponds to the low conductivities noted within the site central areas on the conductivity mapping data of Figure 2. High resistivities typically suggest a drier, more granular material type. Intermediate resistivities are noted below the high resistivity zone persisting to below the base of ERT profile 2. These may be mudstones.
16. Between chainage 41m and the southern end of ERT profile 2 we note low resistivities. This corresponds with the increased conductivities on Figure 2. This suggests wetter more clay-rich deposits persist from surface to around 3.0m maximum in this area. This is confirmed within rotary hole RBH-B. Note that this area was affected by standing water during our survey and thus there may be some influence on the results.

17. ERT profile 3 runs along the eastern side of the site. The profile was 72m in length and achieved a maximum depth of investigation to around 10m. The profile was oriented to run though anomalies C1 and C2 as well as the overall conductivity variations throughout the site.
18. Centred on chainage 6.5m we note a narrow vertical zone of intermediate resistivity which persists to the base of the profile. This zone aligns approximately with the intermediate conductivities just to the east of WS01. This area is worthy of further intrusive confirmation as it is difficult to interpret from the geophysical and limited intrusive data collected thus far.
19. Conductivity anomaly C2 coincides with a high resistivity zone within the resistivity profile which descends to a depth of <1m. This suggests that conductivity anomaly C2 is a shallow target. The presence of a vertical low resistivity zone below the high resistivity shallow target suggests the potential for this being a possible capped shaft. As such we suggest this area is subject to further investigation.
20. Low resistivities are noted below the high resistivity zone and may indicate wetter more clay-rich materials to depth. It is possible that this is a processing artefact as shallow high resistivity can bias the resistivity model.
21. Conductivity anomaly C1 coincides with ERT profile 3 chainage 36m. ERT profile 3 suggests this is a shallow lying anomaly and is considered unlikely to be shaft related.
22. Between ERT profile 3 chainages 24m and 40m, we note intermediate resistivities which persist to the base of the profile. This coincides with the reduced conductivities within the central site area and may be related to mudstones which are predominate in this area as per the log of rotary hole RBH-B.
23. Beyond chainage 48m we note low resistance to the base of the profile which coincides with increased conductivities. WS04 notes clay-rich strata to a depth of 2.9m in this area.

6 Discussion and recommendations

The conductivity survey has covered the accessible site at a high spatial resolution. The conductivity mapping data has provided the ability to target the Electrical Resistivity Tomography profiles to pass over key targets and variations.

The conductivity mapping shows that whilst the site has a low overall range in conductivity, there are some significant variations from north to south.

The north-western corner of the site where shaft 303517-006 is recorded does have a higher relative conductivity. Based upon the recent trial trenches, these elevated conductivities are likely to be related to wet clays as noted within the trial trenches. The conductivity mapping does not identify any clear targets within the vicinity of shaft 303517-006 as per the Coal Authority recorded location. Note that detection of shafts, and in fact any other sub-surface target, is only possible if the target falls within geophysical detection limits and thus the survey cannot be classed as definitive in this regard.

A primary target for confirmation is conductivity anomaly C2, located at the east of the site. ERT profile 3 shows the anomaly takes the form of a shallow, high resistivity zone to around 1m depth with a relatively narrow, low resistivity zone persisting to the base of the profile. These characteristics could be applied to a possible capped shaft and thus we would recommend intrusive checks in this location.

The localised conductivity anomalies noted elsewhere within the site are confirmed by the ERT profiles as being shallow, with little depth extent. We suggest there are not related to shafts, but some localised investigations would confirm this.

A secondary location of interest C3, within the conductivity mapping is identified about WS01 in the north-east cover of the site. Whether the characteristics relate to a shaft or infilled pit cannot be fully determined from the geophysical data and the current intrusive data alone. As such any interpretation is somewhat speculative until intrusive works are undertaken. In this area the conductivity data shows increased conductivities whilst ERT profile 1 shows a high resistivity horizon at a depth of 2m dipping and therefore increasing in depth, to the north-west. Likewise, ERT profile 3 shows an intermediate resistivity zone which falls on a similar alignment. As this corresponds with an area of confirmed made ground to a depth of 6.6m, we would recommend some additional confirmation works around WS01 and anomaly C3. Additionally, some further exploratory works along the line of ERT profile 1, from WS01 towards the north-west, may help to better characterise the deeper intermediate resistivity zone between ERT profile 1 chainage 24 and 36m.

Elsewhere within the site the distribution of conductivity and the ERT profiles most likely indicate changes in the thickness of made ground and the underlying solid geology. There are no further anomalies or characteristics that would permit us to indicate a potential shaft, although some additional intrusive works may better characterise materials and their thicknesses if required.

Table 1 below contains the OS coordinates of some suggested intrusive works based upon the findings within this report. The table suggests primary locations with optional locations to confirm existing intrusive works.

Anomaly ID	Easting/Northing	Notes
Primary target investigation locations		
C2	**303381.92, 517387.97**	**Possible shaft cap with infilled shaft? Context based interpretation – intrusive check required**
C3	**303385.23, 517401.31**	**Located near WS01. Excavation in this location and to the north-west to confirm dipping horizon recommended. Coordinates are target centre.**
Possible additional confirmation points		
Centre of low conductivity / higher resistivity zone in site centre	303361.86, 517395.58	Suggest investigation to confirm materials as WS03 and TP02 indicate clay rich materials. Geophysical data suggests low conductivity / high resistivity which would normally be associated with drier clay-poor materials.
Centre of increased conductivity/ reduced resistivity to south of site centre.	303356.22, 517374.28	RBH-B suggests clay to 3m underlain by mudstones. Confirmed in ERT profile 2 from chainage 39m to end of profile.
Additional targets identified – less likely to be shaft related		
C4	303373.41, 517420.47	Shallow anomaly. Near-surface debris or related to chambers?
C5	303347.89, 517385.19	MH cover?
C6	303344.77, 517384.84	MH cover?
C7	303325.16, 517368.46	Anomaly on grass verge.

6.3 Survey limitation statement

1. Geophysical survey data must not be used as the sole means of a site assessment. Survey data must be combined with desktop studies and intrusive site investigation methods to

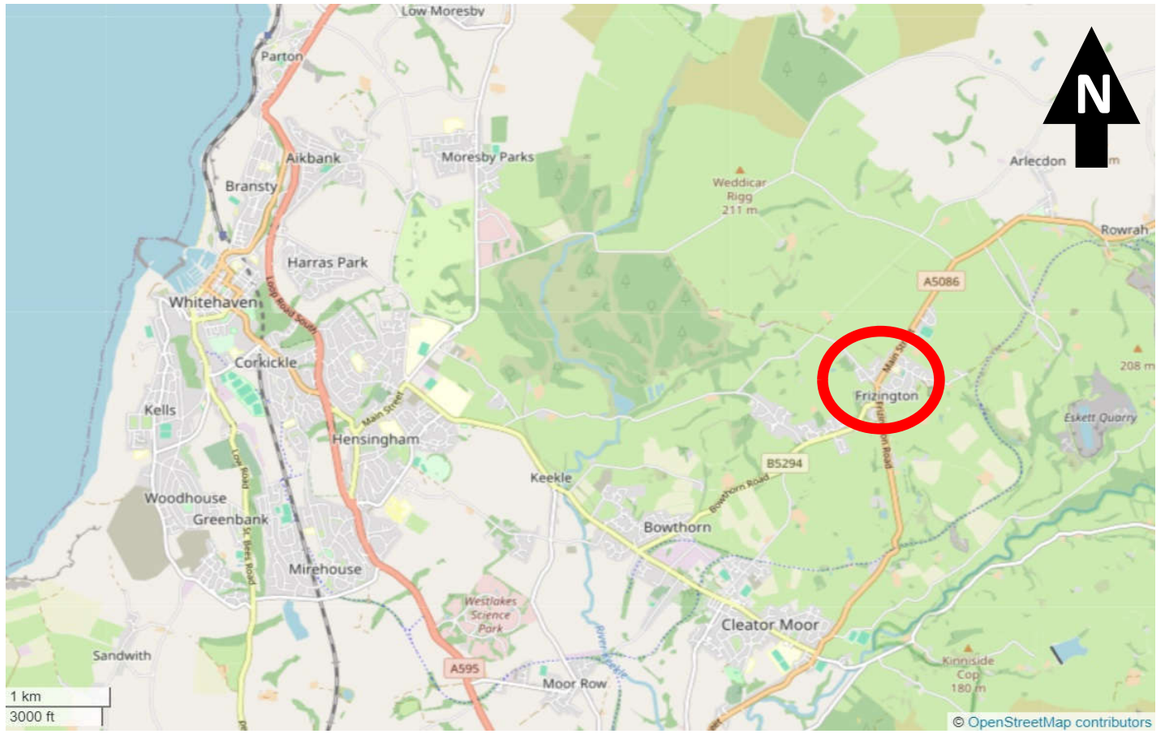
provide the ultimate client with the best possible understanding of sub-surface conditions and risks. This understanding and the assessment of risk will be based upon the volume of investigative works undertaken, coupled with the limitations of all site investigation strategies.

2. Geophysical methods rely on detecting contrasts in materials properties. Where complex relationships exist or where there is an insufficient geophysical contrast between materials or targets, the detection of sub-surface targets will lie beyond the working limits of any geophysical instrumentation or interpretation. **A lack of geophysical targets cannot therefore be used to infer that there are no targets or that there is no risk to future construction operations or related costs.**
3. The remit for this survey and the methodologies used will not meet those required by a PAS128 utility survey.
4. The survey data reflect the geophysical conditions offered by the site at the time of the survey. Reduction is elevations, deeper excavations and operations such as piling, will reach depths beyond the effective range of surface-based geophysical methods. Risks to these operations must be considered.
5. The survey data reflect only those areas covered and the results cannot be used to imply sub-surface characteristics elsewhere about the site.

Dr. Steven Openshaw (BSc, PhD, FGS)

Director
For Bentham Geoconsulting Limited
10th June 2024

Figure 1: Site Location



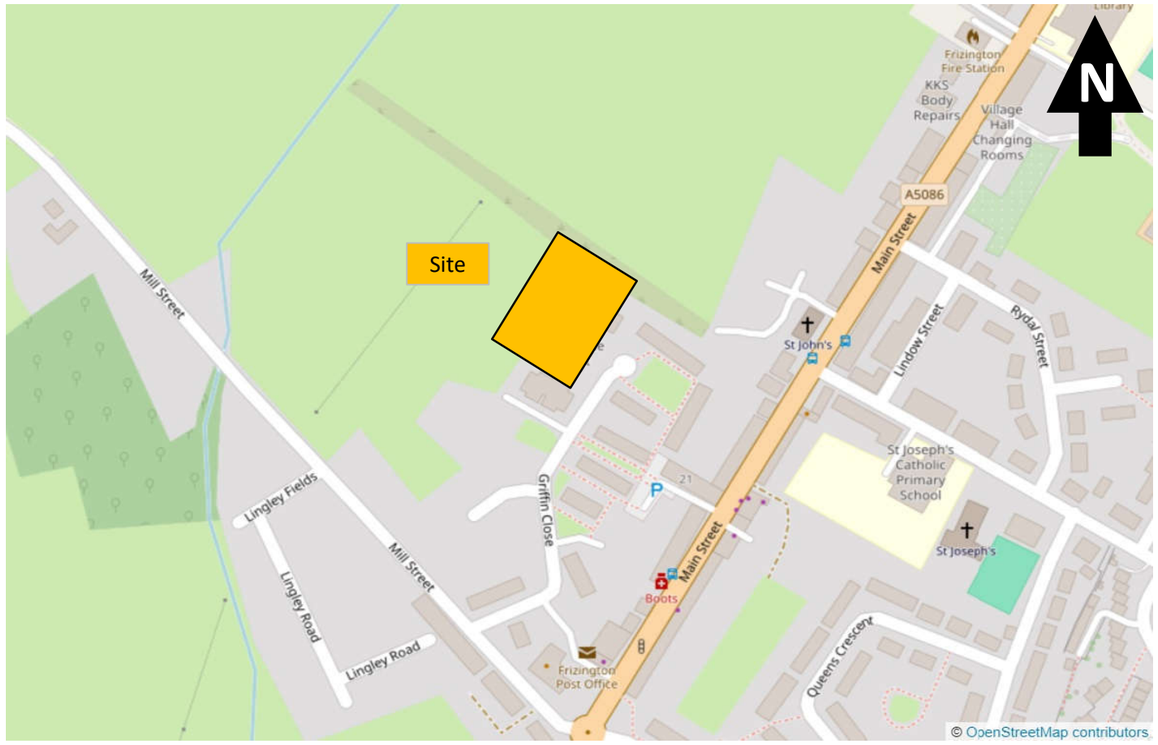


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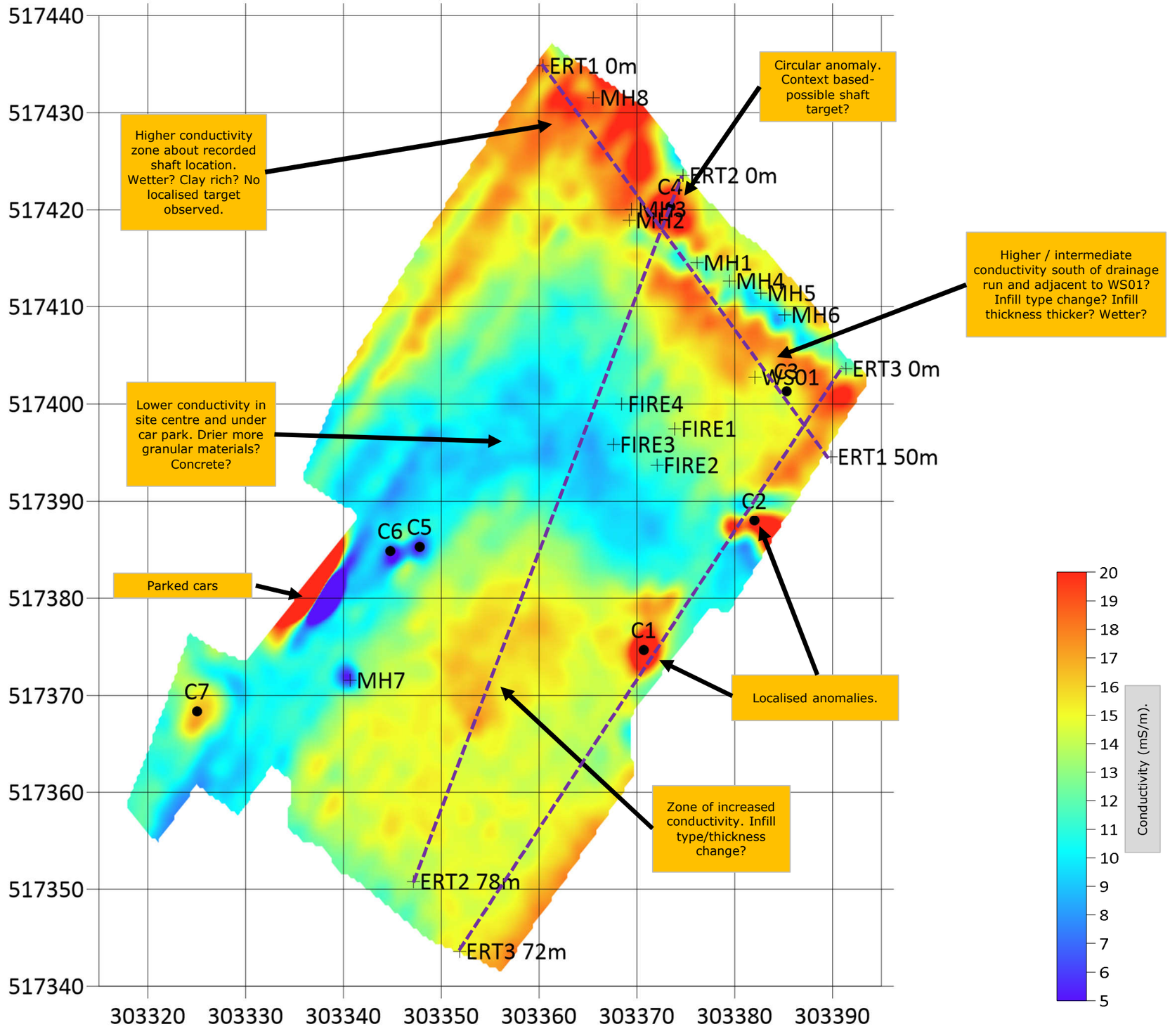
Figure 1. Site location.

Site : Griffon Close, Frizington
Survey Dates : 22-23 May 2024

Figure 2: Conductivity Survey Mapping.



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ERT profile
Conductivity anomaly
Surface feature MH = Man hole Fire = extents of bonfire

Figure 2. Conductivity mapping on OS grid

Site : Griffon Close, Frizington
Survey Dates : 22-23 May 2024

Figure 3: Electrical Resistivity Tomography profiles 1 to 3.

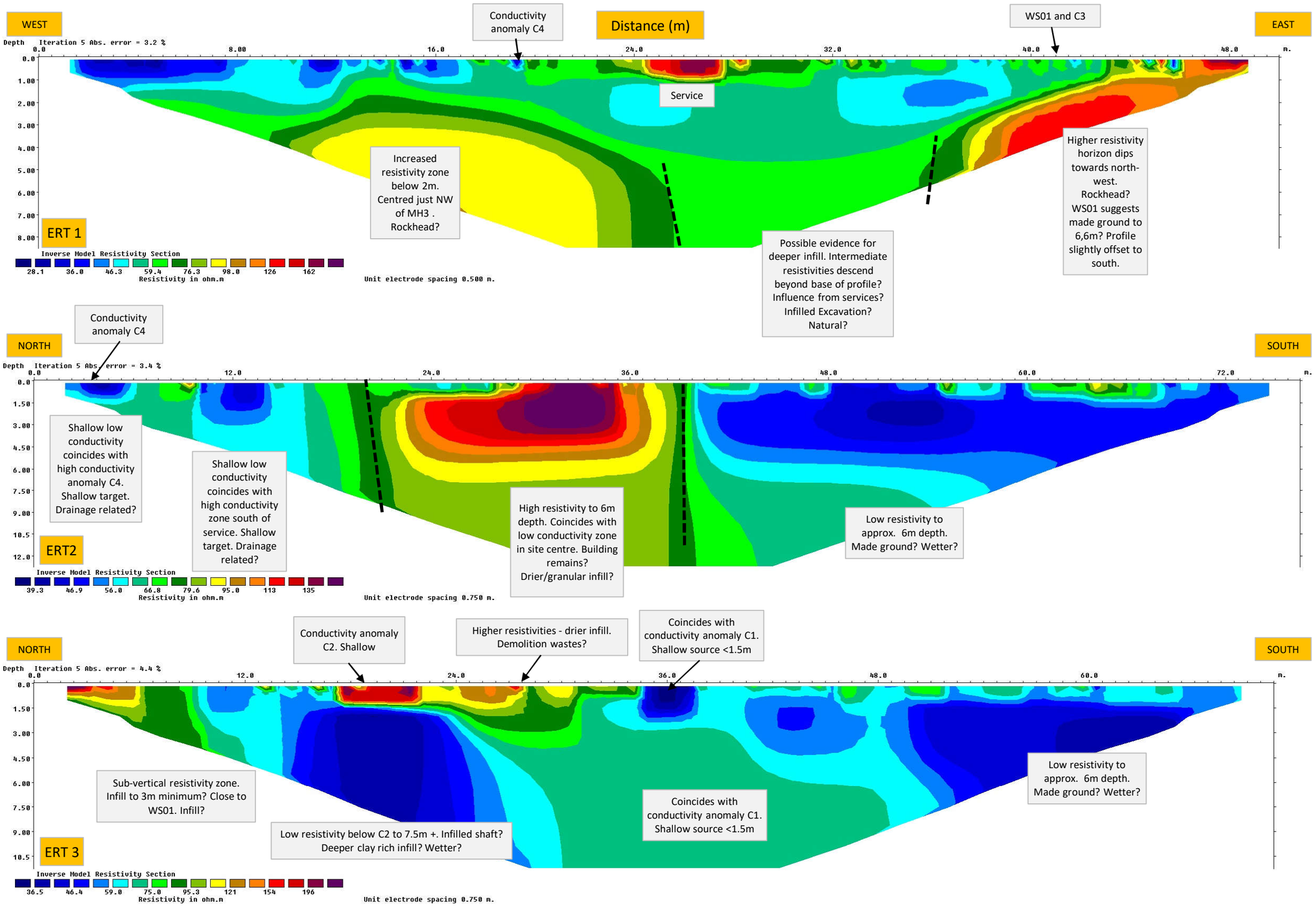

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Figure 3. Electrical Resistivity Tomography profiles 1 to 3.
For location see Figure 2

Site : Griffon Close, Frizington
Survey Dates : 22-23 May 2024

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