

WHITBROOK POWER FLEXIBLE ENERGY FACILITY

Ground Investigation Report
Prepared for: AMP Energy Services Ltd

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1.0 Introduction

1.1 Appointment

In November 2022, SLR Consulting Limited (SLR) was appointed by AMP Energy Services Ltd to undertake a geotechnical ground investigation at Land West of Hanson Street, Middleton, M24 6BR (the Site).

SLR have previously produced a Coal Mining Risk Assessment¹ for the Site where it was concluded that the overall risk to the proposed development was low, however The Coal Authority require Condition 4 to be discharged prior to development.

SLR carried out the ground investigation between 10th – 18th January 2023.

1.2 Proposed Development

SLR understands that AMP Energy Services Ltd are proposing to construct a new gas-powered energy reserve plant with associated infrastructure, landscaping, perimeter fencing and new vehicular access on the Site. The Site location plan is included as Drawing 001.

1.3 Objectives

The main objective of the ground investigation is to enable Condition 4 (Ref: 20/01585/FUL) to be discharged.

Condition 4 states:

‘No development shall commence until intrusive investigations have been carried out on site to establish the exact situation in respect of coal mining legacy features. The findings of the intrusive site investigations shall be submitted to the Local Planning Authority for consideration and approval in writing. The intrusive site investigations shall be carried out in accordance with authoritative UK guidance.

Where the findings of the intrusive site investigations (required by the condition above) identify that coal mining legacy on the site poses risk to surface stability, no development shall commence until a detailed remediation scheme to protect the development from the effects of such land instability has been submitted to the Local Planning Authority for consideration and approval in writing. Following approval, the remedial works shall be implemented on site in complete accordance with the approved details.

Reason: The undertaking of intrusive site investigations, prior to the commencement of development, is considered to be necessary to ensure that adequate information pertaining to ground conditions and coal mining legacy is available to enable appropriate remedial and mitigatory measures to be identified and carried out before building works commence on site. This is in order to ensure the safety and stability of the development, in accordance with paragraphs 178 and 179 of the National Planning Policy Framework.

Reason for Pre-Commencement Condition: Coal Mining Legacy investigation and any required mitigation measures will require investigation before the significant disturbance to ground and removal of material.’

This report presents basic site information and ground investigation results, primarily to characterise the ground conditions beneath the site, including information on coal mining legacy, but will also provide guidance on the design of foundations for the proposed infrastructure. Analysis of field observations and laboratory test results will determine the ground conditions and geotechnical parameters to inform the design.

¹ SLR Consulting Ltd. (2021). ‘Whitbrook Power – Coal Mining Risk Assessment’. SLR Ref: 404.08071.00001.0075.

1.4 Scope of Work

The scope of work for this assessment was devised by SLR, it included:

- review of the current use of the site and surrounding area;
- review of the underlying soils and the geological, hydrological and hydrogeological features within the vicinity of the site;
- review of any readily accessible information from regulatory authorities and other sources such as the Environment Agency, the Local Authority, the Coal Authority, the British Geological Survey and the Ordnance Survey;
- preparation of relevant health and safety documentation including a detailed Health & Safety Plan, Risk assessments and Method Statements for the proposed works;
- provision of service utility plans and clearance of investigation locations using a Cable Avoidance Tool (C.A.T);
- drilling of two boreholes to 30.0m bgl (metres below ground level) with in-situ Standard Penetration Testing (SPTs);
- collection and submission of selected samples for various geotechnical laboratory testing;
- backfill of boreholes with bentonite; and,
- supervision and logging of boreholes in accordance with BS5930:2015+A2:2020² by a suitably qualified geotechnical engineer.

² British Standards Institution (2020). BS5930 BSI Standards Publication Code of Practice for Ground Investigations.

2.0 Site Setting

2.1 Site Details

Table 2-1 provides a summary of the site details based on a review of published information. Information has been obtained from Ordnance Survey, Environment Agency and BGS mapping.

**Table 2-1:
Site Details**

Detail	Description	
Location	The Site is located at the following address: Land West of Hanson Street, Middleton, M24 6BR National Grid Reference: SD 87371 06107	
Site Description and Use	The Site is a hardstanding storage yard with a disused/derelict building to the west and two corrugated metal shelters to the east, under which stores metal rods, brick, waste skips and various other items. The Whit Brook runs north-south along the western edge of the Site, separated by a metal fence and banking. The entrance and exit access is to the east, located off Hanson Street, running between the gated site to the south and small warehouse to the north which bounds the Site.	
Surrounding Land Use	North	The Site is bounded by a furniture warehouse
	East	The Site is bounded by Hanson Street, with an industrial estate beyond.
	South	Commercial, leisure and industrial warehouse buildings with associated car parking.
	West	The Whit Brook

2.2 Site Setting

Table 2-2 provides a summary of the site setting including anticipated ground conditions and details of the hydrological and hydrogeological environment and sensitivity based on a review of published information.

**Table 2-2:
Summary of Physical Site Features**

Feature	Detail	Description
Geography and Geology	Topography and gradient	The Site is level at approximately 87m above Ordnance Datum (aOD).
	Made Ground	Nearby borehole records for the Spring Vale road indicate shallow Made Ground
	Superficial Drift Geology	Alluvium - clay, silt, sand and gravel to the east Glaciofluvial Sheet Deposits - sand and gravel to the west
	Solid Geology	Pennine Lower Coal Measures Formation - mudstone, siltstone and sandstone.
Hydrology	Surface Water	The Whit Brook runs north-south along the western edge of the Site, joining the River Irk which runs west-east approximately 123m south of the Site
Hydrogeology	Aquifer Status	Both the Pennine Lower Coal Measures Formation bedrock and the superficial deposits in this area are designated as Secondary A Aquifers.
	Source Protection Zones (SPZ)	The Site is not located within a groundwater Source Protection Zone (SPZ).

3.0 Results of the Ground Investigation

3.1 Scope of Work

SLR completed the ground investigation between 10th – 18th January 2023. The scope of work included the following:

- clearance of all exploratory locations by an on-site survey utilising a C.A.T and Genny;
- concrete coring of two boreholes (BH01 and BH02);
- drilling of two boreholes (BH01 and BH02) to 30.0m bgl utilising rotary coring techniques;
- in-situ Standard Penetration Testing (SPT);
- recovery of representative disturbed, bulk and core samples for geotechnical laboratory testing;
- sampling and logging of the strata in accordance with BS5930:2015+A2:2020; and
- backfilling of all exploratory hole locations with bentonite and arisings.

The results of the assessment are described below.

3.2 Utility Clearance

A desktop utilities search was conducted prior to attending site to obtain current service plans from asset owners. No services were noted to be within the Site boundary; therefore a utility survey wasn't commissioned. Notwithstanding this, all exploratory locations were cleared with a C.A.T scanner before breaking ground. The utility report for the Site is presented as Appendix 01.

3.3 Boreholes

Two boreholes (BH01 and BH02) were positioned to provide a representative spread across the proposed development. Hand dug pits were excavated to a depth of 1.2m bgl to confirm the absence of services.

The boreholes were then advanced to 30.1m bgl by a tracked Pioneer 305 rig utilising rotary coring techniques using water flush, as defined in the Coal Authority Permit No. 26044.1. On completion, the boreholes were backfilled with bentonite and completed by reinstating the hardstanding concrete.

In-situ Standard Penetration Tests (SPT) were conducted during advancement of the boreholes in suitable material. Disturbed, bulk and core samples were recovered for subsequent geotechnical laboratory testing.

The location of the completed boreholes are presented as Drawing 002.

3.4 Ground Conditions

The recorded ground conditions are presented on exploratory hole logs included in Appendix 02. Photographs of the investigation, including those of the recovered core, are included as Appendix 03.

The ground conditions across the Site were consistent and as anticipated. Underlying the concrete hardstanding and Made Ground at shallow depths, both boreholes encountered superficial deposits of Alluvium and Glaciofluvial Sheet Deposits; comprising sand, gravel, clay and silt at variable compositions. The underlying Pennine Lower Coal Measures Formation comprised siltstone interbedded with very stiff gravelly clay.

Made Ground was encountered underlying the concrete hardstanding in BH01 from 0.27m to 2.7m bgl and in BH02 from 0.20m to 3.2m bgl. The Made Ground comprised black, grey, cream and brown sandy gravel with cobbles. The

gravel and cobbles comprised brick (whole and broken), concrete, chalk and siltstone. Anthropogenic materials such as fibreglass insulation were also noted.

Two superficial deposits were encountered in the boreholes; Alluvium and Glaciofluvial Sheet Deposits. The Alluvium, comprising firm sandy gravelly clay and gravelly coarse sand was present in BH01 from 2.7m to 4.2m bgl and in BH02 from 3.2m to 4.7m bgl. Underlying the Alluvium, Glaciofluvial Sheet Deposits comprising dense medium sand (interbedded with sandy gravel and gravelly clay in BH02) were present in BH01 from 4.2m to 24.7m bgl and in BH02 from 4.7m to 27.3m bgl.

The Pennine Lower Coal Measures Formation was encountered in both boreholes to termination and the base was not proven. It was observed as a medium strong to very strong siltstone interbedded with stiff to very stiff clay in BH01 from 24.7m bgl and as very stiff gravelly clay in BH02 from 27.3m bgl. The very stiff gravelly clay is anticipated to be the weathered surface of the formation.

3.4.1 Rock Core Recovery

Rock logging parameters Total Core Recovery (TCR), Solid Core Recovery (SCR) and Rock Quality Designation (RQD) were recorded for all core recovered and are presented on the borehole logs in Appendix 02. The first core run of solid geology generated an RQD <25%, this is to be expected as uppermost sections of bedrock are typically weathered, becoming more competent with depth.

Table 3-1 shows the core parameters of BH01; BH02 did not encounter rock.

Table 3-1:
Rock Core Parameters

Location	Depth (m bgl)	Depth (mAOD)	TCR (%)	SCR (%)	RQD (%)
BH01	24.7 – 27.1	62.3 – 59.9	96	96	25
	27.1 – 30.1	59.9 – 56.9	97	87	37

3.4.2 Coal Mining Legacy

No voids or evidence of workings such as backfilled material or wood were encountered during the progression of the boreholes.

3.4.3 Groundwater

Groundwater was encountered during the intrusive investigation, however due to the nature of the flush, it was not possible to determine any groundwater strikes during drilling. Despite this, both boreholes were monitored at the start and end of each shift and the groundwater was recorded to sit between 2.3m and 4.6m bgl.

3.4.4 Standard Penetration Testing

SPTs were conducted during the advancement of both boreholes with results presented on the borehole logs in Appendix 02. SPTs were only conducted within the Made Ground and superficial deposits. The SPT values highlight a difference between the Alluvium and the Glaciofluvial Sheet Deposits, showing a marked increase in N-value in the Glaciofluvial Sheet Deposits.

SPT N-values range between 0 and 18 within the Made Ground at depths of between 1.25m and 2.2m bgl. Silt within the Made Ground resulted in N-values of 0 and 1 which is indicative of a very soft material. The presence of gravel in BH01 resulted in an N-value of 18, indicative of a medium dense material.

SPT N-values range between 0 and 5 within the Alluvium at depths of between 3.2m and 4.2m bgl. The Alluvium resulted in N-values of between 0 and 5 which is indicative of a very loose to loose material.

SPT N-values range between 6 and 50 within the Glaciofluvial Sheet Deposit at depths of between 4.2m and 19.7m bgl. The fine-grained proportion resulted in N-values of between 6 and 50 which is indicative of a soft to very stiff material. The Glaciofluvial Sheet Deposits described as coarse-grained resulted in N-values of 17 and 50 indicative of a medium dense to very dense material.

A correlation between undrained strength in clay and SPT N-value is proposed by Stroud³ (1989) which indicates the fine-grained Made Ground is an extremely low strength material with an undrained shear strength of between 0 and 4kPa. The fine-grained proportion of the Glaciofluvial Sheet Deposits is a low to very high strength material with an undrained shear strength of between 24 and 200kPa. However, the relationship is not considered to be as reliable as laboratory testing.

Figure 3-1 shows a general increase in N-value with depth.

³ Stroud, M.A. (1989). The Standard Penetration Test – its application and interpretation. Penetration testing in the UK, Thomas Telford.

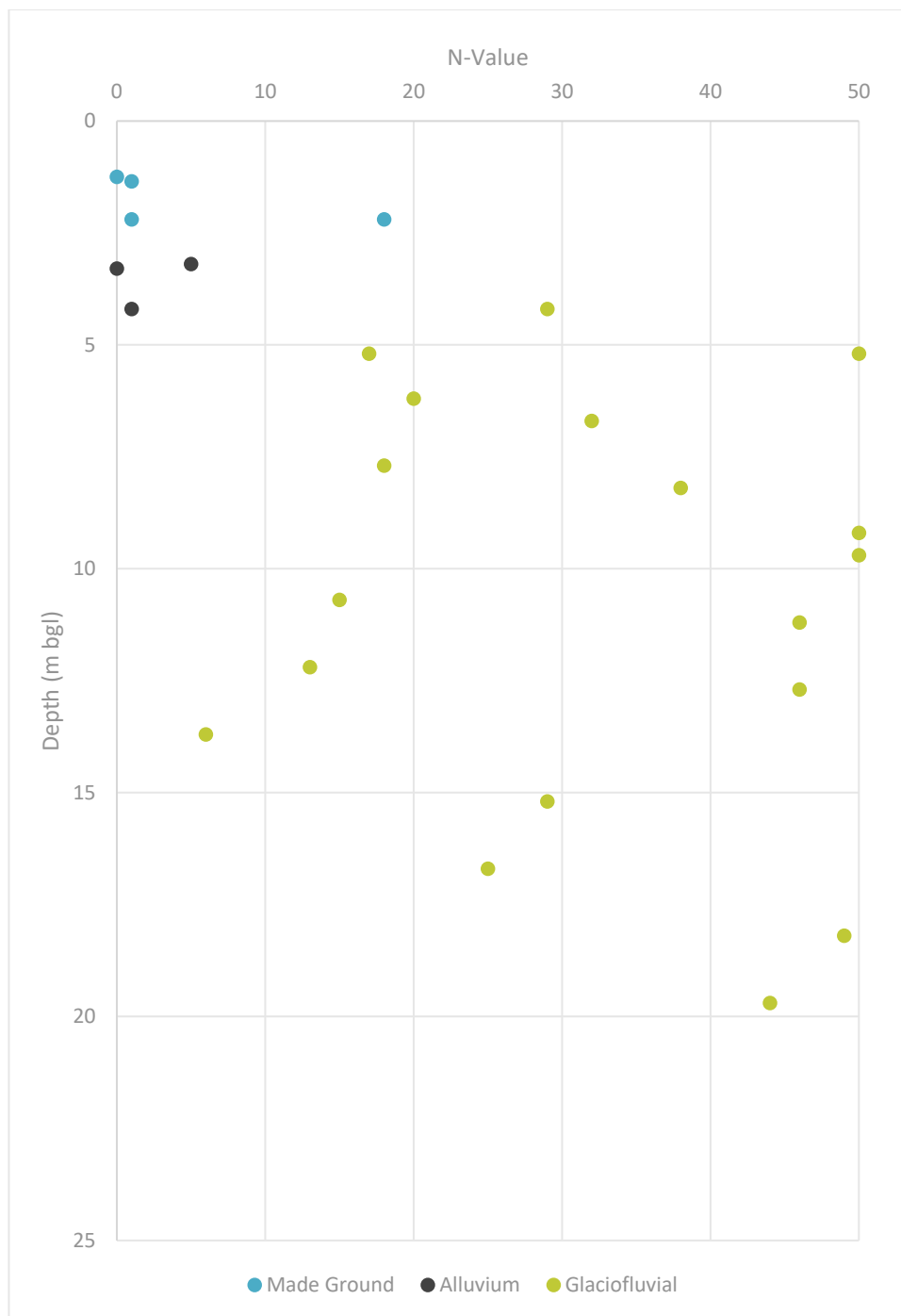


Figure 3-1:
SPT N-Value with Depth

4.0 Laboratory Testing

4.1 Geotechnical Laboratory Testing

On completion of the fieldwork, samples were submitted for laboratory testing at an accredited geotechnical laboratory.

Geotechnical testing comprised the following:

- water content;
- Atterberg Limits;
- particle size distribution;
- organic content
- Uniaxial Compressive Strength (UCS); and
- pH and sulphate content by 2:1 aqueous.

The results are summarised in Table 4-1 and Table 4-2 below and the laboratory certificates are included in Appendix 04.

Table 4-1:
Summary of Geotechnical Laboratory Results (Soils)

Location ID	Depth (m)	Water Content (%)	Organic Content (%)	% passing <425µm sieve	Particle Size Distribution					Chemical Tests	
					Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	pH	2:1 WS SO ₄ (g/L)
BH01	0.6 – 0.8	32.0	-	-	3.6	29.2	24.2	36.7	6.3	9.1	0.81
	1.5 – 2.2	53.8	-	-	0.0	40.6	38.5	18.4	2.5	8.4	0.34
	2.2 – 2.7	57.0	-	-	0.0	56.0	32.0	10.0	2.0	8.7	0.87
	3.03 – 3.12	26.3	4.3	81	0.0	6.3	64.2	19.7	9.8	8.3	0.58
	5.2 – 6.7	21.4	<0.40	-	0.0	0.2	59.4	35.6	4.8	8.7	0.062
BH02	1.5 – 1.6	50.6	-	96	0.0	1.6	8.1	85.8	4.5	9.0	<0.010
	2.8 – 2.9	69.9	-	86	0.0	10.6	6.6	76.5	6.3	9.3	0.75

Location ID	Depth (m)	Water Content (%)	Organic Content (%)	% passing <425µm sieve	Particle Size Distribution					Chemical Tests	
					Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	pH	2:1 WS SO ₄ (g/L)
	4.2 – 4.67	21.2	-	-	0.0	2.1	79.8	12.1	6.0	8.5	0.38
	4.67 – 6.20	18.0	-	-	9.7	40.5	45.4	4.4		8.7	0.18

Table 4-2:
Summary of Geotechnical Laboratory Results (Rock)

Location ID	Depth (m)	Moisture Content (%)	Degree of Saturation (%)	Load at Failure (kN)	Bulk Density (Mg/m ³)	Dry Density (Mg/m ³)	UCS (MPa)
BH01	24.70 – 24.89	1.3	40.3	711.2	2.69	2.66	112.0
BH01	25.60 – 26.00	4.4	57.3	378.8	2.47	2.37	59.7

5.0 Discussion of Geotechnical Laboratory Results

5.1 Water Content

Water content testing was carried out on the Made Ground and superficial deposits on five samples from BH01 and four samples from BH02.

Five samples of Made Ground were tested for water content, producing values ranging between 32.0% and 69.9% at depths between 0.8m and 2.9m bgl. Figure 5-1 shows an increase in water content with depth.

In the Alluvium, water content values range between 21.2% and 26.3% at depths of between 3.12m and 4.67m bgl and show a decrease with depth. Water content values range between 18.0% and 21.4% in the Glaciofluvial Sheet Deposits, at depths between 6.2m and 6.7m bgl and show a slight increase with depth.

5.2 Atterberg Limits

Atterberg Limited testing was scheduled on three samples. One sample was taken in BH01 with a depth range of 3.03 – 3.12m bgl and two samples in BH02 (1.5 – 1.6m bgl and 2.8 – 2.9m bgl). All three samples were recorded as Not Determined (Liquid Limit) and Non-Plastic (Plastic Limit).

5.3 Particle Size Distribution

Particle size distribution analysis was undertaken on nine samples recovered from BH01 and BH02. Results are summarised in Table 5-1 below. Laboratory analysis is comparable with the field descriptions determined during the ground investigation.

Four samples of Made Ground were tested at depths of between 0.60m and 4.67m bgl. Testing determines the material from BH01 as a slightly clayey silty sand and gravel, and a slightly clayey silty very sandy gravel. In BH02, the material is a slightly sandy slightly gravelly slightly clayey silt.

Two samples of Alluvium were submitted for testing at 3.03m and 4.20m bgl. Results determine that the formation is similar in both boreholes, identifying the material as a slightly clayey slightly gravelly silty sand.

Two samples of the Glaciofluvial Sheet Deposits were submitted for testing at depths of 4.20m and 4.67m bgl. In BH01 the sample was identified as a slightly clayey very silty sand. In BH02, the sample was identified as a slightly clayey, slightly silty sand and gravel. Field descriptions and laboratory analysis highlight the variability within this material, which varies between clay, silt, sand, and gravel.

Table 5-1:
Particle Size Distribution

Lithology	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Cobble (%)
Made Ground	6.3	36.7	24.2	29.2	3.6
	2.5	18.4	38.5	40.6	0.0
	2.0	10.0	32.0	56.0	0.0
	4.5	85.8	8.1	1.6	0.0
	6.3	76.5	6.6	10.6	0.0

Lithology	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Cobble (%)
Alluvium	9.8	19.7	64.2	6.3	0.0
	6.0	12.1	79.8	2.1	0.0
Glaciofluvial Sheet Deposits	4.8	35.6	59.4	0.2	0.0
	4.4		45.4	40.5	9.7

5.4 Organic Content

Two samples from BH01 were tested for organic content, with levels recorded as 4.3% (3.03m bgl) and <0.4% (5.2m bgl).

5.5 Rock Strength Testing

Two samples of the siltstone from the Pennine Lower Coal Measures Formation were submitted for uniaxial compressive strength (UCS) testing. Both samples were from BH01 at depths of 24.89m and 26.00m bgl. Testing returned values of 112MPa and 59.7Mpa, respectively, indicating strong to very strong rock, which is comparable with field descriptions.

5.6 Chemical Tests

Five samples from BH01 and four samples from BH02 were submitted for chemical testing within the Made Ground and superficial deposits, ranging from 0.6m to 6.7m bgl. The pH tests record slightly alkali pH between 8.3% and 9.3%. Testing to determine soluble sulphate content returned values between <0.010g/l and 0.87g/l 2:1 WS SO₄. This needs to be taken into account when selecting the concrete qualities for construction. Based on BRE guidelines⁴ the site is classified as Design Sulphate class DS-2 and as ACEC (aggressive chemical environment for concrete) AC-1s.

⁴ BRE Construction Division. Special Digest 1: Concrete in Aggressive Ground. Third edition 2005.

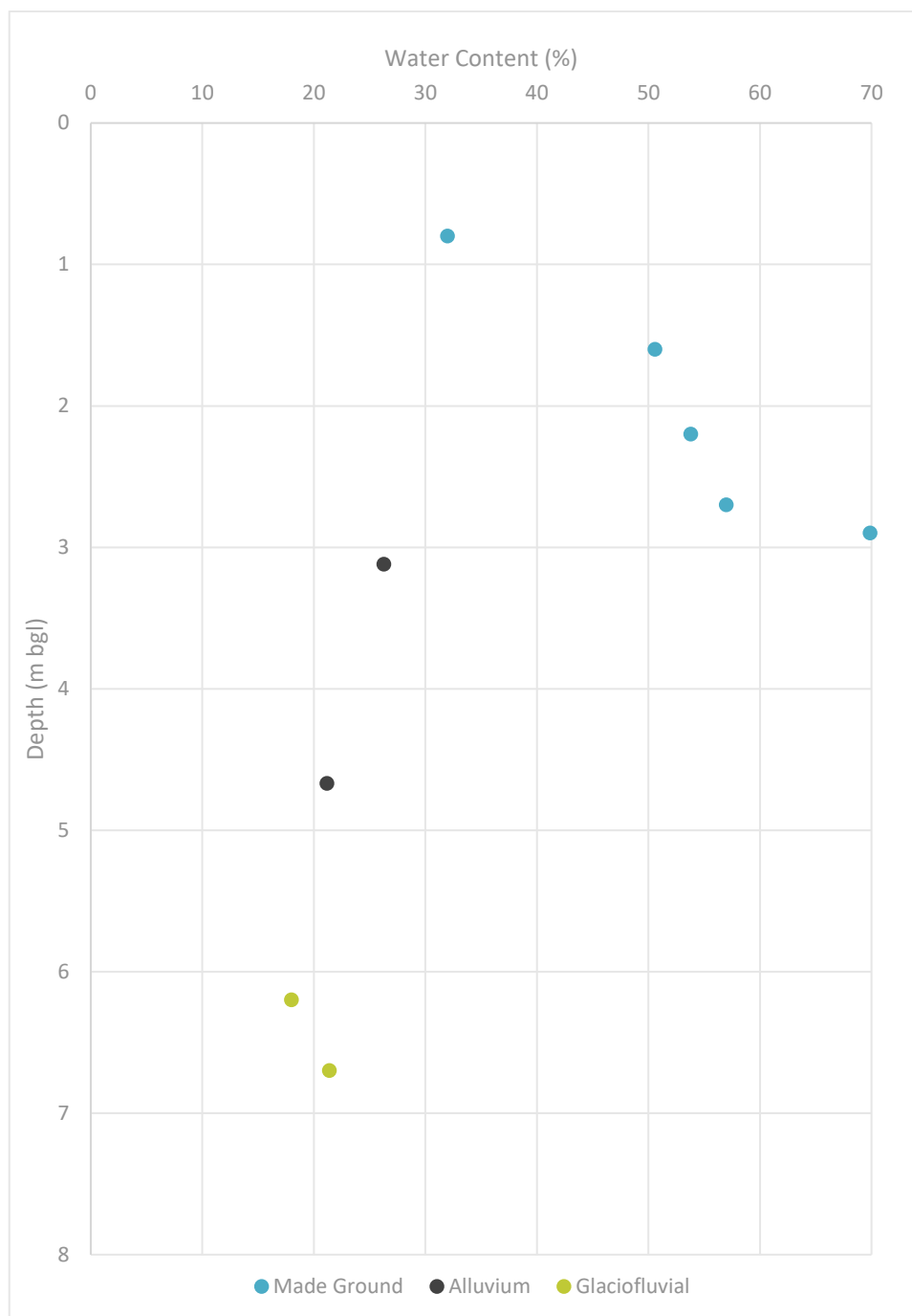


Figure 5-1:
Water Content with Depth

6.0 Geotechnical Conclusions and Recommendations

The proposed development will comprise a gas-powered energy reserve plant comprising six small containers, which will be located to the west of the covered existing storage area and east of the Whit Brook.

6.1 Coal Mining Legacy

As per The Coal Authority Guidance⁵, shallow workings are defined as:

“...at a depth of up to 10 x the thickness of coal seam extraction down to a maximum depth of 30 metres. Underground workings deeper than 30m do not readily constitute a threat to surface stability due to the ability of the overlying strata to dissipate any movement from within the workings before they reach the surface.”

In order to discharge Condition 4 (Ref: 20/01585/FUL), 2No. boreholes were drilled to a minimum depth of 30.0m bgl. No evidence of workings or loss of drilling flush were noted during the investigation.

6.2 Foundation Options

The ground investigation encountered Made Ground at shallow depths, overlying superficial deposits of Alluvium and Glaciofluvial Sheet Deposits, comprising sand, gravel, clay and silt at variable compositions. The underlying Pennine Lower Coal Measures Formation comprised siltstone interbedded with very stiff gravelly clay. Based on the strata encountered it has been assumed that ground conditions are reasonably consistent across the Site.

During foundation assessment a worst-case scenario is considered. This uses the lowest bearing ground conditions with the highest load. This allows for the variation across the site as well as considering a maximum load. Design parameters selected are based on field observations, laboratory results and published guidance where relevant.

6.2.1 Bearing Capacity and Settlement Performance

The proposed development comprises the construction of several low loading structures. The largest structure onsite are the two generators. The client has provided a load of 41,400kg for the engines including the fluids.

Made Ground was encountered onsite to a maximum depth of 3.2m bgl. It is recommended that foundations are not installed in Made Ground deposits due to the risk of differential settlement as a result of varying behaviour and potential soft spots. Removal of the Made Ground to replace with suitable backfill material is not viable due to the thickness and of the Made Ground onsite.

Therefore, due to the relatively low loadings, shallow foundations are considered suitable and raft foundations are recommended. Constructing raft foundations, typically the same size as the proposed structure will spread the load of the proposed structure to the underlying soil across the entire footprint.

Based on a loading of 406kN for the engines, with a 12m x 2m raft foundation and 0.6m thick into the underlying soft Made Ground, will achieve a bearing capacity of 35kPa. Calculated settlement of <5mm is anticipated, which is within acceptable limits for the design of the structure.

Raft foundations should be constructed with thickened edge beams to increase their stiffness to manage settlement within the proposed structure and accommodate any differential settlement associated with the variable ground conditions.

⁵ The Coal Authority (2019). 'Guidance – Past Shallow Coal Mine Workings Metadata. <https://www.gov.uk/government/publications/coal-mining-data-past-shallow-coal-mine-workings/past-shallow-coal-mine-workings-metadata>.

Due to the presence of the Made Ground, any proposed underground services should be fitted with flexible couplings when entering and leaving the proposed structures.

It should be noted that foundations installed within Made Ground deposits are at risk of additional, unforeseen settlement as a result of sudden variations in the composition of the materials in question. Where structures are constructed within granular material, settlement is likely to occur during and immediately following loading; however, structures constructed in cohesive material will settle over a longer period. Due to the variability in the Made Ground it is not possible to precisely predict where settlement will occur and its absolute magnitude.

There is potential for areas of softer material, with a reduced allowable bearing capacity, to be present within the development area. Prior to construction foundation excavations should be proof rolled with a Wacker plate to highlight any soft areas. These should then be removed and backfilled with suitable granular material to ensure the structure remains stable.

6.3 General

In addition to the above recommendations, it is recommended that all design and construction works be carried out on site in accordance with recognised engineering codes of practice including BS 8004 (2015: Code of Practice for Foundations) and BS 6031 (2009: Code of Practice for Earthworks).

DRAWING 001

Site Location Plan

DRAWING 002

Borehole Location Plan

APPENDIX 01

Utility Report

APPENDIX 02

Borehole Logs

APPENDIX 03

Investigation Photographs

APPENDIX 04

Laboratory Certificates

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