



Geotechnical and Geoenvironmental Report

Site: Neath Working Men's Club

Prepared For: Castle Construction Limited

Issue Date: March 2023

Job No: 17464

REPORT TITLE : **Geotechnical and Geoenvironmental Report:
Proposed Residential Development, Neath
Workingman's Club, High Street, Neath**

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01	28.11.22	DRAFT
02	28.03.23	Additional Rotary Borehole
03	31.03.23	Change in pile design
04	07.07.23	Final

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Executive Summary

Site Location and Proposed Development	Castle Construction Ltd (the Client) is proposing the demolition of the current building on site and development of a four-story block of apartments at Neath Workingman's and Social Club in Neath. The development site is irregular in shape and locates between High Street and Wind Street in the centre of Neath. The site centres on an approximate National Grid Reference of 275430, 197700, occupying a plan area of approximately 0.13 Hectares. The site is currently occupied by Neath Workingmen's and Social Club, a large building with access off High Street.																										
Site History	The earliest historic map, circa 1877, shows the site to have a road, Mackworth Lane, running through the centre, trending north-south. The rest of the site is occupied by 19 residential houses. By 1970 the residential houses have been demolished and a large building now occupies the centre of the site. Mackworth Lane has been demolished, with a small section of High Street left undeveloped for the access to the new building. In 1993 the building was extended to occupy the entire site and fronting onto High Street and Wind Street. The site remains unchanged to this day.																										
Geology	The 1:50,000 scale British Geological Map of the area (Sheet 247) was consulted for geology underlying the site. The site is shown to be underlain by the Brithdir Member which is Carboniferous in age and consists of sandstone with conglomerate lenses at bases of units with thin mudstone/siltstone and seatearth interbeds and mainly thin coal seams. Strata are typically dipping 9° to the south in the local area. Superficial deposits are recorded as Glaciofluvial Sheet Deposits. Made ground is anticipated at the site associated with past use.																										
Radon	The Envirocheck Report (Annex A) details that <u>no</u> radon protective measures are required for new developments on the investigation site.																										
Coal Mining Risk Assessment	The overall risk to the surface stability of the site from possible unrecorded workings is considered negligible.																										
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Contamination of Concern	Contamination was seen across the site, the contaminants found above their threshold level were Arsenic, Lead, Sulphate, Benzo(a)pyrene, Benzo(b)Fluoranthene, Dibenz(a,h)Anthracene.																										
Foundation Solution	Based upon the limited ground investigation data that could be obtained while the building was still standing the variability of shallow ground conditions particularly those in W0S1 and WS05 combined with the presence of the basement, at this stage it is recommended that a piled foundation is used. It is recommended a CFA piled foundation solution founded within the medium dense to dense brown gravels at a depth of 3.30m below existing ground level is used. For a 300mm bored pile with a typical length of 15.00m an allowable working load of 350kN should be achieved. Measurements should be put in place to monitor vibrations during pile installation. If vibrations exceed guideline levels, then measures should also be taken to dampen																										

	<i>such vibrations. If, however, vibrations exceed permissible values then consideration should be given to an alternative solution such as bored piles.</i> <i>The estimated working pile loads, pile type and lengths are given for guidance only and should be confirmed by a specialist piling contractor and it may be prudent to test drive piles at selected locations.</i>
Recommended Further Works	<i>The following additional work is recommended:</i> • <i>Trial pitting and/or window sampling following demolition of the existing building and removal of underground services, to aid further contamination testing.</i>

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SECTION 1 Introduction and Proposed Development

1.1 Introduction

Castle Construction Ltd (the Client) is proposing the demolition of the current building on site and development of a four-story block of apartments at Neath Workingman's and Social Club in Neath.

Terra Firma (Wales) Limited have been commissioned by the Client to undertake a geoenvironmental assessment and geotechnical investigation of the site.

The main objectives of the geoenvironmental assessment programme are:

- Investigate the potential human health and environmental liabilities at the site associated with any contamination
- Provide a summary of the human health and environmental conditions at the site, together with any necessary further intrusive works and / or remediation works to render the site fit for its intended use

The main objectives of the geotechnical site investigation are:

- Investigated the type, strength and bearing characteristics of the shallow superficial and underlying solid geology
- Investigate the risk, if any, from historical shallow underground mining features
- Provide engineering foundation and floor slab recommendations for the proposed development
- Provide infiltration rates and stormwater drainage viability.
- Provide recommendations regarding any other geotechnical aspects pertaining to the development

In order to achieve the above objectives, Terra Firma (Wales) Limited carried out an assessment programme including a review of existing data, followed by a field investigation to collect geotechnical and geoenvironmental data from selected locations.

1.2 Limitations and Exceptions of Investigation

The Client has requested that a Geoenvironmental Site Assessment (GSA) and Geotechnical Investigation (GI) be performed to enable the outlined main objectives.

The GSA and GI were conducted, and this report has been prepared for the sole internal reliance of the Client and their design and construction team. This report shall not be relied upon or transferred to any other parties without the express written authorisation of Terra Firma (Wales) Limited. If an unauthorised third party comes into possession of this report, they rely on it at their peril and the authors owe them no duty of care and skill. The report represents the findings and opinions of experienced geoenvironmental and geotechnical consultants. Terra Firma (Wales) Limited does not provide legal advice and the advice of lawyers may be required.

The subsurface geological profiles, any contamination and other plots are generalised by necessity and have been based on the information found at the locations of the exploratory holes and depths sampled and tested.

The investigation was limited by the presence of the Workingman's club occupying the site and associated underground services.

1.3 Quality Assurance

The quality and environmental aspects of the assessment comply with Terra Firma Wales Ltd business management system which is UKAS Accredited to ISO 9001:2015 and ISO 14001:2015 standards.

SECTION 2 Review of Existing Data

2.1 Physical Setting and Current Site Use

The development site is irregular in shape and locates between High Street and Wind Street in the centre of Neath. The site centres on an approximate National Grid Reference of 275430, 197700, occupying a plan area of approximately 0.13 Hectares.

The site is currently occupied by Neath Workingmen's and Social Club, a large building with access from High Street.

Site boundaries are defined by High Street to the north, Wind Steet to the south, a car park to the east and commercial buildings to the west.

The site elevation is approximately 9m AOD.

The site location can be seen on **Figure 2.1** along with the proposed site layout on **Figure 2.1** and the borehole layout on **Drawing 01**.



Figure 2.1 Site Location



Figure 2.2 Proposed Site Layout

2.2 Site History

Historical maps of the site have been obtained in an Envirocheck Report, provided by Landmark Information Group. The history plans are supplied in **Annex A** of this report, and the most relevant editions are summarised in **Table 2.1**. Distances, where quoted are approximate, and any changes in-between map editions may not be recorded.

Table 2.1 Historical Development from Map Information

Map Edition & Scale	Key Features on Site	Key Features off Site
1877 1:2500	The Site has a road, Mackworth Lane, running through the centre, trending north-south. The rest of the site is occupied by 19 residential houses.	The site is bound by High Street to the north, Wind Street to the south, with residential houses to the east and west. The majority of the surrounding area is residential housing with a Tannery just under 100m to the north. The Neath Canal runs east-west approximately 100m north of the site with the River Neath 200m north of the site. There is a Gas Works approximately 150m northwest of the site. There is a railway line, trending north-south 270m west of the site.
1889 1:2500	No significant changes.	The Gas Works and Tannery to the north have been demolished.
1919 1:2500	No significant changes.	The land between the Neath Canal and River Neath has started to be infilled.
1935 1:2500	No significant changes.	The land between Neath Canal and River Neath has been infilled and is now an embankment with allotment gardens. Some residential houses south of the site have been demolished.
1962 – 1967 1:1250	All the houses have been demolished, apart from three in the northwest corner facing onto High Street. Mackworth Lane is still present.	Several areas of residential houses, within 100m of the site, have been demolished and car parks have been built in their place. There is a Warehouse just over 100m southwest of the site.
1970 1:2500	The remaining residential houses in the northwest have been demolished and a large building now occupies the centre of the site. Mackworth Lane has been removed, with a small section of High Street left for the access to the new building.	The allotment gardens to the north have been replaced by a large carpark.
1993 1:1250	The building has now been extended and occupies the entire site, fronting onto High Street and Wind Street.	No significant changes.
1999 1:10000	No significant changes.	The carpark between the canal and river has now been developed into housing and commercial buildings.
2006 1:10000	No significant changes.	No significant changes.
2021 1:10000	No significant changes.	No significant changes.

2.3 Geological Setting

2.3.1 Geology

The 1:10560 and 1:50,000 scale British Geological Map of the area (Sheets SS79NE & 247) were consulted for geology underlying the site. The site is shown to be underlain by the Brithdir Member which is Carboniferous in age and consists of sandstone with conglomerate lenses at bases of units with thin mudstone/siltstone and seatearth interbeds and mainly thin coal seams.

Strata are typically dipping 9° to the south in the local area.

Superficial deposits are recorded as Glaciofluvial Sheet Deposits.

Made ground is anticipated at the site associated with its past use.

The Neath Disturbance fault, a strike-slip fault, is located approximately 200m southeast of the site trending northwest to southwest. The Rhydding Fault is located approximately 340m to the west, trending north to south with the downthrow to the west.

The nearest coal seam to the site is the Hughes or Wenallt seam, located approximately 630m northwest. The Hughes or Wenallt seam is recorded as 3ft to 4ft.

2.3.2 BGS Borehole Information

The nearest borehole to site is approximately 85m east and is 23m deep, the encountered ground conditions are shown in **Table 5.1**.

Table 2.2 Summary of BGS Borehole

Depth (m)			Stratum
0.00	-	0.60	MADE GROUND
0.60	-	1.25	Soft to firm reddish brown silty CLAY with gravel
1.25	-	23.00	Very dense sandy GRAVEL with cobbles and some boulders

A deeper borehole, approximately 500m northwest of the site, was drilled to 31m. Bedrock was encountered at 14m. Two coal seams were encountered, one at 25.90-26.20m and the second at 29.00-30.20m.

2.3.3 Radon

The Envirocheck Report (**Annex A**) details that no radon protective measures are required for new developments on the investigation site.

2.3.4 Mining

The site situates inside the South Wales Coal Field.

There are no recorded BGS mineral sites within 250m of the site.

Coal Authority Report states the following:
 Past underground mining: No past mining recorded
 Probable unrecorded shallow workings: None
 Spine roadways: None recorded at shallow depth
 Mine entries: None recorded within 100m
 Outcrops: No outcrops recorded
 Mine gas: None recorded within 500m

The Coal Authority Consultants Coal Mining Report is appended in (**Annex C**).

2.3.5 Natural Hazards

The underlying geology is not prone to dissolution due to the significant mudstone component of the geological units and the risk of natural cavities in the bedrock is considered negligible.

Shallow superficial soils have no hazard for compressible ground, ground dissolution and shrink/swell clay potential, very low potential for collapsible ground, landslides and running sand conditions.

2.4 Environmental Setting

The following sections have been compiled using the Landmark Information Group Envirocheck datasheet and maps which can be found in **Annex A**.

2.4.1 Hydrogeology

Superficial deposits beneath the site have an aquifer designation of secondary aquifer – A.

The bedrock deposits beneath the site have an aquifer designation of secondary aquifer – A.

Deeper groundwater flow within the underlying bedrock will be controlled by the strata dip and any fractures or bedding planes within the rock units.

The hydraulic gradient will be at its steepest during periods of heavy rainfall and aquifer recharge.

It is anticipated that the groundwater is in hydrological continuity with the River Neath to the northeast.

The site does not locate within a groundwater source protection zone.

There are no groundwater abstraction points within 1000m of the site boundary.

2.4.2 Hydrology

The nearest surface water feature locates offsite 97m to the northeast and comprises an the Neath canal.

The topography of the site is level but surface water is likely to drain towards the River Neath to the northeast.

2.4.3 Flooding

The site is not at risk from extreme flooding from rivers, sea or surface water.

The site is not at risk from surface water flooding.

The site has potential for groundwater flooding to occur at the surface.

2.4.4 Waste

There are no recorded landfills, licensed waste management facilities or waste transfer sites within 250m of the site.

Discharge consents within 250m of the site are summarised in **Table 2.**

Table 2.3 Discharge Consents Summary

Operator	Distance/Direction from site	Discharge type	Status
Dwr Cymru Cyfyngedig	181m North	Not supplied	Expired
Dwr Cymru Cyfyngedig	189m North	Sewage discharges	Effective
Dwr Cymru Cyfyngedig	190m North	Sewage discharges	Effective
Dwr Cymru Cyfyngedig	191m North	Sewage discharges	Effective

2.4.5 Pollution

Three pollution incidents are recorded to have occurred within 250m radius of the site. The details are summarised in **Table 2..**

Table 2.4 Discharge Consents Summary

Distance/Direction from site	Pollutant	Incident Date	Incident Severity
219m Northwest	Unknown	06/09/1994	Category 3 - Minor
233m Northeast	Crude Sewage	02/08/1994	Category 2 - Significant
237m Northeast	Mud/clay/soil	02/02/1995	Category 3 - Minor

2.4.6 Sensitive Land Use

The site is not located within a sensitive land use area.

2.4.7 Industrial Land Use

Relevant contemporary trade directory entries recorded within proximity of the site are summarised in **Table 2..**

Table 2.5 Relevant Contemporary Trade Summary

Company	Distance / Direction	Classification	Status
Brighthouse	79m Southwest	Electrical goods sales, manufacturers and wholesalers	Inactive
Neath Port Authority	116m Southwest	Ports, Docks and Harbours	Inactive
Supasnap	169m Southwest	Photographic Processors	Inactive
Valley Sealants	173m West	Adhesives, glues and sealants	Inactive
FibreClean	193m West	Cleaning products - domestic	Inactive
At Your Service	216m West	Cleaning products - domestic	Inactive
Morrisons Filling Station	223m Northwest	Petrol filling station	Active
Ford Spares - Neath	237m West	Car breakers and dismantlers	Inactive
Polar Print	238m West	Printers	Inactive

2.4.8 Infilled Land

Potentially infilled land features within 250m of the site are summarised in **Table 2..**

Table 2.6 Potentially Infilled Land

Feature	Distance/Direction from site
Infilled water – associated with construction of Allotment gardens	128m North

SECTION 3 Coal Mining Risk Assessment

3.1 Geotechnical Risk

3.1.1 Underground Mining

Based upon geological map data, the stratigraphical sequence within 50m of the ground surface of the site is illustrated in **Figure 3.1**.

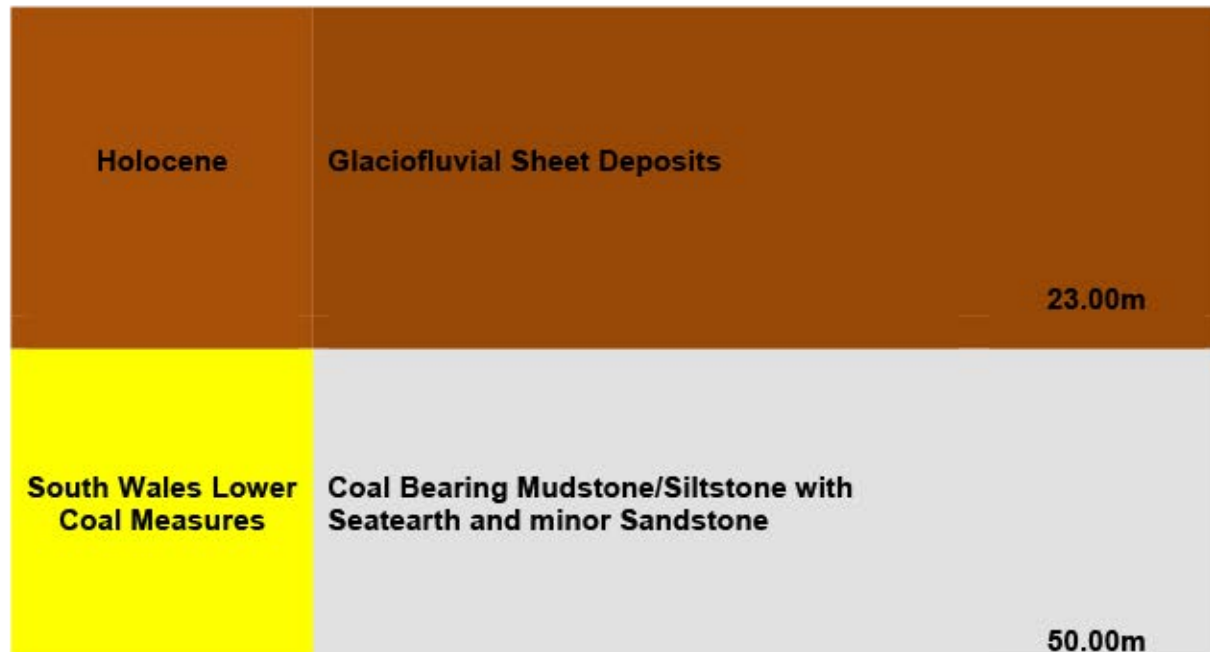


Figure 3.1 Geology and Strata Base below Ground Level

The Coal Authority states that no past underground mining has been recorded and that there are no probable unrecorded shallow workings at the site. There have also been no recorded mine gas incidences within 500m of the site, according to the Coal Authority.

Geological map evidence indicates the nearest coal out crop, north of the Neath Disturbance Fault, is the Hughes or Wenallt seam, located approximately 630m northwest. The Hughes or Wenallt coal seam is 3-4ft thick. The distance from the site and the angle of the dip would mean the coal seam would be present below 50m of the site.

3.1.2 Shafts & Adits

The Coal Authority Report states there are no known mine entries within 100m of the site.

3.1.3 Conclusion

The overall risk to the surface stability of the site from possible unrecorded workings is considered negligible.

SECTION 4 Preliminary Human Health and Environmental Risk Assessment

4.1 General

The preliminary human health and environmental risk assessment is a qualitative evaluation of unacceptable risks to human health or the environment from potential 'contaminated land', based on reviewed information in preceding sections of this report.

For 'contaminated land' to exist as defined in Part 2A of the Environmental Protection Act (EPA) 1990, a Pollutant Linkage needs to be identified. Pollutant linkages are defined by having a valid 'source – pathway – receptor' as established in the preliminary conceptual site model.

For our definitions of pollution linkage and how we define risk please refer to **Annex B** which includes our classifications of consequence and probability, and risk assessment matrix.

4.2 Potential Sources of Contamination

Potential or known sources of contamination associated the sites current and historical land use are summarised in **Table 4.1**.

Table 4.1 Contamination Sources

ID	Source	Contaminant
S1	Made ground – Historic land use	Metals, Metalloids, Organics and Inorganics Asbestos, Hydrocarbons, TPH and PAH

No other significant potential on-site or off-site sources of contamination have been identified during the desk study.

4.3 Potential Pollution Pathways

Potential contaminant pathways associated with a residential with home grown produce land use are as follows.

- P1 – Direct soil and dust ingestion
- P2 – Consumption of home grown produce
- P3 – Dermal contact
- P4 – Inhalation of dust and vapours
- P5 – Vertical migration of leachates (unsaturated zone)
- P6 – Horizontal and vertical migration of contaminants (saturated zone)
- P7 – Artificial contaminant pathway (borehole, pile, excavation etc)
- P8 – Surface run-off
- P9 – Plant uptake
- P10 – Horizontal and vertical migration of ground gasses and vapours
- P11 – Direct contact with construction materials
- P12 – Inhalation of asbestos fibres

4.4 Potential Receptors

There are human and hydrological receptors to any contamination that may be present on site. Potential receptors include.

- R1 – Construction and maintenance workers
- R2 – Future site users (residents)
- R3 – Passers-by or neighbouring site users
- R4 – Groundwater (aquifer)
- R5 – Surface waters (river/lake)
- R6 – Area of public open space
- R7 – Construction materials (concrete/potable water pipes)

4.5 Preliminary Conceptual Site Model

The preliminary conceptual site model establishes potential pollutant linkages between contaminants (source), pathways and receptors, realised during the preparation of the desk study report. Where a potential pollutant linkage is identified an assessment of risk is subsequently undertaken. The preliminary conceptual site model is tabulated in **Table 4.2**.

Outcomes of the preliminary conceptual site model are used as a basis for the design and implementation of the site investigation, whereby areas of potential contamination can be targeted as well as investigating the wider site.

Findings of the site investigation can in turn be used to develop and refine the conceptual site model.

Table 4.2 Preliminary Conceptual Site Model

Source	Pathway	Receptor	Preliminary Risk Assessment		
			Consequence	Probability	Risk
Human Health					
Contaminated Soils S1	Direct soil and dust ingestion P1 Dermal contact P3 Inhalation of dust and vapours P4	Construction and maintenance workers R1	Medium	Likely	Medium Risk - COSHH assessment and good level of PPE/ hygiene by site workers/ staff; dust suppression measures if required. Suitably designed site investigation recommended
		Passers-by or neighbouring site users R3	Medium	Unlikely	Near Zero Risk - Dust suppression measures if required.
		Future site users (residents) R2	Medium	Low Likelihood	Low Risk - Suitably designed site investigation recommended
Ground Gas S1	Horizontal and vertical migration of ground gasses and vapours P10	Future site users (residents) R2, Construction and maintenance workers R1	Severe	Unlikely	Low Risk - No significant source identified.
Vapours S1			Severe	Unlikely	Low Risk - No significant source identified.
Mine Gas S4					
Impacted Groundwaters S1	Horizontal and vertical migration of contaminants (saturated zone) P6 Dermal contact P3	Construction and maintenance workers R1	Medium	Unlikely	Near Zero Risk - No significant source identified and impacted ground waters are therefore not anticipated on the site.
Contaminated Soils S1	Direct Contact P11	Construction materials (water pipes) R7	Mild	Low Likelihood	Low Risk - An appropriate water supply pipe material should be chosen after the potable water supplier has completed an assessment in accordance with UK Water Industry Research guidance; Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites, UKWIR Report Ref: 10/WM/03/21.
Aggressive ground conditions - Sulphates S1		Construction materials (concrete) R7	Mild	Low Likelihood	Low Risk - Chemical analysis of the soils should be undertaken and the appropriate classification of concrete should be specified as per BRE Special Digest 1: Concrete in Aggressive Ground.
Aquatic Environment					
Contaminated Soils S1	Vertical migration of leachates (unsaturated zone) P5	Groundwater (aquifer) R4 Surface waters (river/lake) R5	Mild	Low Likelihood	Low Risk - No significant source identified.
	Surface run-off P8	Surface waters (river/lake) R5			
	Horizontal and vertical migration of contaminants (saturated zone) P6				

SECTION 5 Field Investigation

5.1 Site Works

A geotechnical and geoenvironmental site investigation comprising six window sample boreholes and two trial pits for soakaway testing were undertaken between the 26/09/2022 and 27/10/2022.

An additional rotary borehole was drilled between the 14/03/2023 and 15/03/2023.

The fieldwork was supervised by Terra Firma (Wales) Limited, who logged the exploratory holes to the requirements of BS 5930:2015+A1:2020. The proposed locations of the exploratory holes were determined by Terra Firma (Wales) Ltd in general accordance with BS 10175:2011+A2:2017 in order to assess the findings of the preliminary conceptual site model.

The boreholes referenced WS01 and WS06, were formed using a Terrier 2000 rig. Dynamic sampling techniques were employed from surface to produce a continuous disturbed sample.

Standard penetration tests (SPT) were carried out at regular intervals in general accordance with BS1377: Part 9:1990:3.3. SPT results summarised as N values are presented on the borehole log.

Boreholes were monitored for groundwater ingress as drilling proceeded.

Representative disturbed samples were taken and retained in airtight containers for environmental and geotechnical testing.

The borehole logs are presented in **Annex F**.

Trial pits referenced TP01 to TP02, were formed using a JCB 3CX excavator with a 0.60m wide bucket.

Breaking out of the hardstanding was required at trial pits TP01-TP02 prior to excavation.

On completion all trial pits were backfilled with materials arisings compacted in layers using the excavator bucket. The ground surface was reinstated.

The trial pit logs are presented in **Annex D**.

Soakaway tests were carried out in trial pits TP01 and TP02 in general accordance with BRE DG 365:2016. The excavation sides were squared using the excavator bucket and dimensions recorded within the test section. The trial pit was partially filled with clean water using a dedicated bowser with a 75mm diameter outlet and the fall in level recorded against time. The results are presented in **Annex E**.

Borehole reference BH01 was formed using a track mounted rotary drilling rig. The borehole was advanced from surface using a tri-cone bit with air-mist as the flushing medium. On completion BH01 was backfilled with materials arising.

Standard penetration tests (SPT) were carried out at regular intervals in general accordance with BS1377: Part 9:1990:3.3. SPT results summarised as N values are presented on the borehole log.

Boreholes were monitored for groundwater ingress as drilling proceeded.

The borehole logs are presented in **Annex F**.

Exploratory hole locations are shown on **Drawing 01**.

5.2 Ground Conditions

The ground conditions encountered by the exploratory holes can in general be summarised as shown in.

Table 5.1 Summary of Typical Ground Conditions

Depth (m)			Thickness (m)	Stratum
0.00	-	0.15 - 0.25	0.15 - 0.25	MADE GROUND: Black TARMAC over SUB-BASE .
0.00	-	0.16 - 0.18	0.16 - 0.18	MADE GROUND: CONCRETE .
0.15 - 0.75	-	0.50 - 3.30	0.30 - 2.84	MADE GROUND: Loose to medium dense dark grey / brown ashy sandy GRAVEL and cobbles.
0.50 - 3.3	-	3.3	0.0/2.8	Medium dense to dense brown sandy GRAVEL ., layers of firm and stiff clay/gravelly clay
3.3	-	20.50	12.00	Dense to very dense SAND and GRAVEL .

5.2.1 Miscellaneous Ground Conditions

A possible void was encountered in WS05 between 3.00-3.30m.

5.3 Groundwater

Groundwater was encountered in BH01 at 9.00m.

5.4 Obstructions

Advancement of the inspection pit of WS02 was obstructed at 0.70m by a concrete base and the inspection pit of WS03 was obstructed at 1.00m due to dense cobbles.

5.5 Laboratory Chemical Testing

5.5.1 Sampling Strategy

Soil sampling locations were selected on a targeted basis to investigate suspected/known sources of contamination or potential contamination migration pathways.

Sample locations, depths and suspected/known contamination source targets are summarised in **Table 5.:**

Table 5.2 Sample Locations, Depths and Targets

Location	Depth (m)	Contamination Targets
WS02	0.40	S1
WS03	0.20	S1
WS04	0.30	S1
WS05	0.20 - 0.40	S1
WS05	1.20 - 1.40	S1
WS06	0.40 - 0.60	S1
WS06	0.80 - 1.00	S1

5.5.2 Soil Laboratory Analysis

During the site investigation works soil samples were taken and despatched to the accredited laboratories of Eurofins Chemtest for laboratory chemical testing. Soil samples were tested for the determinants listed in **Table 5..**

Table 5.3 Soil Laboratory Analysis

Metals & Metalloids	In-Organics	Organics	Others
Arsenic	Cyanide	Phenols	pH (acidity)
Boron	Sulphate	PAH	Asbestos
Cadmium		Petroleum Hydrocarbons	
Chromium III			
Chromium VI			
Copper			
Lead			
Mercury			
Nickel			
Selenium			
Zinc			

The results are discussed in detail in **SECTION 6** and the laboratory test results certificates may be found in **Annex G**.

5.6 Soil Property Testing

The test results are discussed in **SECTION 7** and the calculation sheets may be found in **Annex H**.

5.6.1 Soakaway Testing.

During the site investigation two trial pit soakaway test was undertaken in TP01 and TP02 and carried out in general accordance with BRE DG 365:2016.

Soakaway test results are summarised in **Table 5..**

Table 5.4 Soil Laboratory Analysis

Trial Pit	Depth Range of Test (m)	Infiltration Rate (ms^{-1})
TP01	0.60-1.00m	2.56×10^{-04}
		2.22×10^{-04}
		2.38×10^{-04}
TP02	0.80-1.20m	1.40×10^{-05}
		7.75×10^{-08}

The test results are discussed in **SECTION 10.6** and the calculation sheets may be found in **Annex E**.

5.6.2 Laboratory Geotechnical Testing

A schedule of laboratory tests was prepared by Terra Firma (Wales) Ltd and samples were despatched to the accredited laboratories of Apex Testing Solutions. A summary of the testing carried out is presented in **Table 5..**

Table 5.5 Summary of Geotechnical Testing

Geotechnical Test	Standard (BS1377:1990)	No. Tested
Moisture Content	Part 2, Clause 3.2	1
4 Point Liquid and Plastic Limit	Part 2, Clause 4.3 & 5.3	1

The test results are presented in **Annex H** and discussed in **SECTION 7** of this report.

SECTION 6 Evaluation of Geoenvironmental Analytical Results

6.1 Assessment Methodology

Comparison of the analytical results has been made with the 2015 Suitable 4 Use Levels (S4UL) provided by Land Quality Management (LQM) Limited and the Chartered Institute of Environmental Health (CIEH) or provisional Category 4 Screening Levels (pC4SL).

Sulphate results have been compared to guidelines presented in British Research Establishment (BRE SD1:2015). Sulphate levels need only be considered for buried concrete risk assessment and are not human health related.

6.2 Soil Test Results

A summary of the chemical test results which include the regulatory soil guideline values used in a residential setting without plant uptake are given in the following tables. The complete results can be found in **Annex G**.

6.2.1 Inorganics & Miscellaneous

Seven samples were tested for a standard suite of inorganics, pH and organic matter. The summarised results are in **Table 6.1**.

Table 6.1 Summary of Soil Chemical Test Results – Inorganics & Miscellaneous

Substance	Threshold Value (mg/kg)	Source	Measured Concentrations (mg/kg)		Number of Exceedances
			Minimum	Maximum	
Arsenic	40	LQM/CIEH	2.9	730	2
Cadmium	85	LQM/CIEH	<0.10	19	0
Chromium III	910	LQM/CIEH	1.8	19	0
Chromium VI	6	LQM/CIEH	<0.5	<0.5	0
Copper	7100	LQM/CIEH	6.8	2100	0
Lead	310	pC4SL	23	1800	6
Mercury (inorganic)	56	LQM/CIEH	<0.05	0.93	0
Nickel	180	LQM/CIEH	8.4	78	0
Selenium	430	LQM/CIEH	0.25	1.7	0
Zinc	40000	LQM/CIEH	27	2500	0
Cyanide	-	-	<0.5	1.8	-
Boron	11000	LQM/CIEH	0.48	2.2	0
Sulphate (%)	0.24	BRE	0.010	1.7	1
Organic Matter (%)	-	-	0.3	4.9	-
pH	-	-	6.3	8.7	-
Phenols	120	LQM/CIEH	<0.10	<0.10	0
Notes:					
- No available guideline					

6.2.2 Organics

Seven samples were tested for speciated polycyclic aromatic hydrocarbons. The summarised results are in **Table 6.2**.

Table 6.2 Summary of Soil Chemical Test Results – Speciated PAH

Substance	Threshold Value (mg/kg)	Source	Measured Concentrations (mg/kg)		Number of Exceedances
			Minimum	Maximum	
Naphthalene	2.3	LQM/CIEH	<0.1	1.3	0
Acenaphthylene	2900	LQM/CIEH	<0.1	0.76	0
Acenaphthene	3000	LQM/CIEH	<0.1	0.49	0
Fluorene	2800	LQM/CIEH	<0.1	0.76	0
Phenanthrene	1300	LQM/CIEH	<0.1	4.3	0
Anthracene	31000	LQM/CIEH	<0.1	1.2	0
Fluoranthene	1500	LQM/CIEH	<0.1	7.0	0
Pyrene	3700	LQM/CIEH	<0.1	6.3	0
Benzo(a)anthracene	11	LQM/CIEH	<0.1	3.1	0
Chrysene	30	LQM/CIEH	<0.1	3.8	0
Benzo(b)fluoranthene	3.9	LQM/CIEH	<0.1	4.2	1
Benzo(k)fluoranthene	110	LQM/CIEH	<0.1	1.7	0
Benzo(a)pyrene	3.2	LQM/CIEH	<0.1	3.6	1
Indeno(123cd)pyrene	45	LQM/CIEH	<0.1	2.1	0
Dibenzo(ah)anthracene	0.31	LQM/CIEH	<0.1	0.47	4
Benzo(ghi)perylene	360	LQM/CIEH	<0.1	2.3	0
Total PAH	-	-	4.7	42	-
Notes:					
Thresholds based on 1.0% soil organic matter					
- No available guidelines					

Seven samples were tested for petroleum hydrocarbon. The summarised results are shown in **Table 6.3**.

Table 6.3 Summary of Soil Chemical Test Results – Petroleum Hydrocarbons

Substance	Threshold Value (mg/kg)	Source	Measured Concentrations (mg/kg)		Number of Exceedances
			Minimum	Maximum	
Aliphatic					
PH C5 – C6 Ali	42	LQM/CIEH	<1.0	<1.0	0
PH C6 – C8 Ali	100	LQM/CIEH	<1.0	<1.0	0
PH C8 – C10 Ali	27	LQM/CIEH	<1.0	<1.0	0
PH C10 – C12 Ali	130	LQM/CIEH	<1.0	<1.0	0
PH C12 – C16 Ali	1100	LQM/CIEH	<1.0	<1.0	0
PH C16 – C21 Ali	65000*	LQM/CIEH	<1.0	<1.0	0
PH C21 – C35 Ali	65000*	LQM/CIEH	<1.0	<1.0	0
PH C35 – C44 Ali	65000	LQM/CIEH	<1.0	<1.0	0
Aromatic					
PH C5 – C7 Arom	370	LQM/CIEH	<1.0	<1.0	0
PH C7 – C8 Arom	860	LQM/CIEH	<1.0	<1.0	0
PH C8 – C10 Arom	47	LQM/CIEH	<1.0	<1.0	0
PH C10 – C12 Arom	250	LQM/CIEH	<1.0	<1.0	0
PH C12 – C16 Arom	1800	LQM/CIEH	<1.0	<1.0	0
PH C16 – C21 Arom	1900	LQM/CIEH	<1.0	<1.0	0
PH C21 – C35 Arom	1900	LQM/CIEH	<1.0	<1.0	0
PH C35 – C44 Arom	1900	LQM/CIEH	<1.0	<1.0	0
Notes: PH – Petroleum Hydrocarbon Ali – Aliphatic Arom – Aromatic Thresholds based on 1.0% soil organic matter * – Ali C16-21 and C21-C35 based on criteria for Ali EC >16-35					

6.2.3 Asbestos Testing

All soil samples were scheduled for asbestos screening. Asbestos was not detected.

SECTION 7 Geotechnical Testing Results

Geotechnical testing results are summarised in the following sections and presented in their entirety in **Annex H**.

7.1 Plasticity & Moisture Content Testing

During the investigation one sample of the shallow clay material was taken and submitted for plasticity testing. The test results are summarised in **Table 7.**

Table 7.1 Plasticity & Moisture Content Test Results

Location	Depth (m)	Laboratory Principal Soil Type	Moisture Content (%)	Plasticity Index (%)	Passing 425µm Sieve (%)	Modified Plasticity Index (%)	Volume Change Potential
WS06	1.00 – 1.20	SILT	13.1	16	65	10.4	Low

In line with the NHBC (Chapter 4.2), the modified plasticity index for each sample was calculated. For design purposes the soils on site should be assumed to have a low volume change potential.

SECTION 8 Quantitative Risk Assessment

8.1 Contaminants of Concern

Contaminants identified as part of the investigation are summarised in **Table 8.1**, along with an interpretation of the likely contamination source. Where applicable, the contaminant, source relationship is based on the inferences made in the preliminary conceptual site model.

Table 8.1 Contaminants of Concern

Location	Depth	Contaminant	Source
WS02	0.40	Lead	S1 – Made ground
WS03	0.20	Lead, Benzo(a)pyrene, Dibenz(a,h)Anthracene	S1 – Made ground
WS04	0.30	Arsenic, Lead	S1 – Made ground
WS05	1.20 - 1.40	Lead, Dibenz(a,h)Anthracene	S1 – Made ground
WS06	0.40 - 0.60	Arsenic, Lead, Sulphate	S1 – Made ground
TP01	0.60	Lead, Dibenz(a,h)Anthracene	S1 – Made ground
TP01	1.00	Benzo(b)Fluoranthene, Dibenz(a,h)Anthracene	Natural Soil

8.2 Pollutant Linkages

Based on the findings of the intrusive site investigation and identified contaminants, the preliminary conceptual site model has been revised. Significant pollutant linkages are tabulated in the refined conceptual site model **Table 8.2**. Identified pollutant linkages will require detailed risk assessment, appropriate mitigation or remedial measures.

Table 8.2 Refined Conceptual Site Model

Source	Pathway	Receptor
Contaminated Soils S1	Direct soil and dust ingestion P1 Dermal contact P3 Inhalation of dust and vapours P4	Construction and maintenance workers R1 Passers-by or neighbouring site users R3 Future site users (residents) R2

8.3 Mitigation and Remedial Measures

The following sections summarise the likely mitigation and remedial measures suitable for the identified contamination and proposed development. Detailed methodology to achieve the measures should be prescribed in a Remediation Strategy Report and the results presented in a Validation Report upon completion of the development.

8.3.1 Human Health

8.3.1.1 Contaminated Soils

To protect future site users from the identified contamination the site will need to be capped. The capping should consist of the proposed buildings and hard standings. In soft landscaped areas the capping should consist of 600mm of suitable inert topsoil, and subsoil if desired. The soils should also be physically suitable and contain no 'sharps' as defined in BS8332:2015 Specification for Topsoil and BS8601:2013 Specification for Subsoil and Requirements for Use.

Alternatively made ground soils could be removed from site and disposed of at a suitably licenced landfill site.

As good practice, construction workers should adhere to good site management, COSHH, good standards of hygiene and appropriate health & safety on site, with personal protection equipment (PPE) and dust suppression where appropriate.

All imported soils should be validated as clean and suitable for use in accordance with 'Requirements for the Chemical Testing of Imported Soils for Various End Uses and Validation Cover Systems'.

For proposed new supply water pipes, the UK Water Industry Research publication 'Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites (Report 10/WM/03/21)' should be consulted.

In accordance with EC Regulation 1272/2008 and Environment Agency Guidance WM3 soils destined for off-site disposal should be classified on the basis of their hazard phrases prior to disposal. Soils are classified as a mirror entry waste and should be classified on the basis of their specific chemical properties.

If during earthworks ground conditions are encountered that are markedly different to those found during the investigation then the ground should be subject to additional sampling and testing and any necessary remedial measures designed and implemented before continuing with the works.

8.3.2 Aquatic Environment

The bedrock and superficial deposits beneath the site have an aquifer designation of 'Secondary A'.

The site does not locate within a groundwater source protection zone.

There are no groundwater abstraction points within 1000m of the site boundary

The nearest surface water feature locates on offsite 97m to the northeast and comprises an inland river, the River Neath.

A number of contaminants have been found above their respective guideline values as described above. Defra guidance (Environmental Protection Act 1990: Part 2A) "seeks to identify and deal with significant pollution (rather than lesser levels of pollution), the local authority should seek to focus on pollution which: (i) may be harmful to human health or the quality of aquatic ecosystems or terrestrial ecosystems directly depending on aquatic ecosystems; (ii) which may result in damage to material property; or (iii) which may impair or interfere with amenities and other legitimate uses of the environment."

Part 2A also defines that the following types of pollution (Points 1 to 4) should be considered to constitute significant pollution of controlled waters:

1. Pollution equivalent to "environmental damage" to surface water or groundwater as defined by The Environmental Damage (Prevention and Remediation) Regulations 2009, but which cannot be dealt with under those Regulations.

The contamination identified in the waters on the site are highly unlikely to equate to environmental damage as there is unlikely to be, or is imminent threat of damage to protect species and habitats, surface and ground water and land.

2. Inputs resulting in deterioration of the quality of water abstracted, or intended to be used in the future, for human consumption such that additional treatment would be required to enable that use.

There are no groundwater abstraction points in the area around the site intended for human consumption.

3. A breach of a statutory surface water Environment Quality Standard, either directly or via a groundwater pathway.

It is highly unlikely that impacted waters on the site would produce exceedances in the adjacent surface water bodies as given the concentrations encountered on site the impact of any contamination would be rendered insignificant given the massive dilution upon entry to the River Neath.

4. Input of a substance into groundwater resulting in a significant and sustained upward trend in concentration of contaminants (as defined in Article 2(3) of the Groundwater Daughter Directive (2006/118/EC)5).

The CL:AIRE document, Petroleum Hydrocarbons in Groundwater identifies the PAH determinants in exceedance to also have a very low potential mobility ranking, in addition the majority of the site is to be capped with proposed buildings and hard standings which reduce the amount of water entering the ground and reduce the potential for leachate generation. Post development surface water would be collected by the proposed drainage systems. This would reduce the potential for contaminants underlying the site being mobilised and migrating to the River Neath.

While a piled foundation solution is recommended clean drilling techniques will need to be employed and there should not therefore be a sustained upward trend in the concentration of contaminants in groundwater.

For the above reasons it is considered that the site falls into the 'lesser level of pollution and that the risk to the aquatic environment from waters and soils under the site is low.

During the construction period, there is a risk to the environment/adjacent sites from de-watering, digging foundations, moving contaminated soil, drainage misconceptions, discharges to local surface waters or the ground, runoff from construction materials and/or exposed ground, wheel washings and oil or chemical spills.

The risk is considered to be negligible as any adverse effects will be easily preventable by due diligence to good construction practise and housekeeping in preventing surface runoff and the spillage of materials.

The basic measures that should be taken are as follows:

- Prepare a drainage plan and mark the manholes to prevent pollutants accidentally reaching the surface water sewers;
- Carry out any activities that could cause pollution in a designated, bunded area, away from rivers or boreholes. Where possible it should drain to the foul sewer;
- Use settlement ponds to remove silty water;
- Store all oils and chemicals in a fully bunded area to prevent leaks or spills;
- Get advice on whether you need an environmental permit and apply in good time

SECTION 9 Engineering Recommendations

9.1 Preparation of Site

Prior to modification or demolition the existing building should be subject to a refurbishment and demolition survey to identify any ACMs. Any deleterious materials should be removed by a suitably qualified person and disposed of at an appropriately licenced landfill. Precautions should be in place to prevent any contamination of the soils on site during the removal process. The building should then be demolished including all foundations and removed from site.

Areas of vegetation including all roots should be stripped and removed from beneath the proposed development site.

Allowances should be for the breaking out and removal of hard standings and buried obstructions including the basement known to be present on site.

Allowances should be made for any temporary/permanent support works to any existing adjacent structure necessary as a result of the proposed works.

Contingencies should be made for the protection/diversion of any underground/overhead services present beneath/above the site brought about as a result of the proposed works.

Any reduced levels should be brought up to the required levels with suitable inert mainly granular materials. Department of Transport (DTp) type 2 sub-base or similar should be used and compacted in layers to the requirements of the Specification for Highway Works.

Allowances should also be made for the excavation of any soft spots/areas and their replacement with well compacted imported granular materials.

In accordance with EC Regulation 1272/2008 and Environment Agency Guidance WM3 soils and other materials destined for off-site disposal should be classified on the basis of their hazard phrases prior to disposal. Soils are classified as a mirror entry waste and should be classified on the basis of their specific chemical properties. Terra Firma (Wales) Ltd offer this service if required.

9.2 Foundation and Floor Slab Solution

Based upon the limited ground investigation data that could be obtained while the building was still standing the variability of shallow ground conditions particularly those in W0S1 and WS05 combined with the presence of the basement, at this stage it is recommended that a piled foundation is used.

It is recommended a CFA piled foundation solution founded within the medium dense to dense brown gravels at a depth of 3.30m below existing ground level is used. For a 300mm bored pile with a typical length of 15.00m an allowable working load of 350kN should be achieved.

Measurements should be put in place to monitor vibrations during pile installation. If vibrations exceed guideline levels, then measures should also be taken to dampen such vibrations. If, however, vibrations exceed permissible values then consideration should be given to an alternative solution such as bored piles.

The estimated working pile loads, pile type and lengths are given for guidance only and should be confirmed by a specialist piling contractor.

For the quoted pile sizes, founded within the competent in-situ materials, total settlements should not exceed 10mm with differential movements between adjacent piles being less than half this value.

Allowances should be made for redriving piles where deeper obstructions are encountered such as in the area of the existing basement.

The floor slabs should be designed as suspended.

All foundation formations should be inspected by a suitably qualified Engineer before being concreted.

9.3 Excavations and Formations

Most of the shallow excavations will be possible with normal soil excavating machinery. However, hydraulic breakers will be required when excavating buried obstructions such as old foundations or floor slabs.

Shallow perched water and groundwater flows were not encountered during the investigation. Any water inflows together with rainwater infiltration should be dealt with by conventional pumping techniques. However, it should be noted that during times of heavy rainfall a higher water table will be encountered.

The sides of any excavations deeper than 1.20m, or shallower if unstable, should be supported by planking and strutting or other proprietary means.

The sub-formations/formations are likely to be susceptible to loosening, softening and deterioration by exposure to weather (rain, frost and drying conditions), the action of water (flood water or removal of groundwater) and site traffic.

Formations should never be left unprotected and continuously exposed to rain causing degradation, or left exposed/uncovered overnight, unless permitted by a qualified engineer.

Construction plant and other vehicular traffic should not be operated on unprotected formations.

As a minimum the formation/excavation surfaces must be protected by blinding concrete immediately after exposure.

Allowances should be made for the removal of soft spots/areas and their replacement with well compacted granular materials.

Allowances should also be made for special precautions to prevent formation deterioration in addition to the above.

9.4 Protection of Buried Concrete

When the results are compared with Table C1/C2 of BRE Digest 1:2005, it indicates that buried concrete should generally conform to DS-4 Class AC-3s.

9.5 Storm Water Drainage

During the site investigation two soakaway tests were undertaken in general accordance with BRE DG 365:2016. The soakaway test was carried out in trial pits TP01 and TP02 within natural materials.

The soakaway tests recorded relatively consistent infiltration across the site of between $2.56 \times 10^{-04} \text{ ms}^{-01}$ and $7.75 \times 10^{-06} \text{ ms}^{-01}$. The use of soakaway stormwater drainage is therefore considered viable on site in the locations and depths tested.

Proposed soakaways should be positioned at least 5.0m away from any structure.

SECTION 10 Recommended Further Works

The following additional work is recommended:

- Trial pitting and/or window sampling following demolition of the existing building and removal of underground services, to aid further contamination testing.