



PROPOSED DEVELOPMENT

AT YSTALYFERA SCHOOL PHASE III, SWANSEA

Ground Investigation Interpretive Report

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0.0 FOREWORD

The following Conditions and Notes on Site Investigation Procedures should be read in conjunction with this report.

0.1 General

Recommendations made and opinions expressed in the report are based on the strata observed in the excavations, together with the results of site and laboratory tests. No responsibility can be held for conditions which have not been revealed by the Exploratory Holes or which occur between Exploratory Holes. Whilst the report may suggest the likely configuration of strata, both between Exploratory Holes and below the maximum depth of investigation, this is only indicative and liability cannot be accepted for its accuracy.

Unless specifically stated, no account has been taken of possible subsidence due to mineral extraction below or close to the site.

0.2 Investigation Procedures

Cable Percussive, Rotary Percussive and Trial Pitting techniques for ground investigation have been employed within the project. All Exploratory Hole operations, sampling and logging of soils, rocks and in-situ testing complies with the recommendations of the British Code of Practice BS 5930: 2015 'Site Investigations + A1:2020', British Code of Practice BS 10175: 2011 +A1:2013 'Investigation of Potentially Contaminated Sites' and BS 1377: 1990, 'Methods of Test for Soils for Engineering Purposes'.

0.3 Routine Sampling

Representative bulk disturbed and environmental samples of the different strata. All samples are returned from site to QGL's laboratory for controlled storage within 24 hours of sampling to await test scheduling/requirements.

0.4 In-Situ Testing, Surveying & Instrumentation

In-situ testing comprised:

- Soakaway Testing
- Environmental & Geotechnical Sampling
- Standard Penetration Testing

0.5 Groundwater

Where possible, the depth of entry of any influx of groundwater is recorded during the course of excavation or boring operations. The rate of inflow into the excavation or borehole is monitored during the course of the excavation or during boring procedures. Upon encountering any water strikes, work is temporarily halted, and the water levels monitored for a standard twenty-minute period recording the change in water level at the end of the twenty minutes.

Groundwater conditions observed in the excavations are those appertaining to the period of investigation. It should be noted, however, that groundwater levels are subject to diurnal, seasonal and climatic variations and can also be affected by drainage conditions or other causes.

0.6 Retention of Samples

After satisfactory completion of all the scheduled laboratory tests on any sample, the remaining material is discarded. Further to notifying the Engineer/ Client with one week's notice all soil and/or rock samples not tested will be discarded 28 days after submission of the approved final report.

1.0 INTRODUCTION

1.1 General

Upon the instructions of the Client, Andrew Scott Ltd, Quantum Geotechnic Limited (QGL) was commissioned to undertake a Ground Investigation for the proposed development at Ysgol Gyfun Ystalyfera, Glanyrafon, Ystalyfera, Swansea, SA9 2JJ. In this interpretative report, a factual account of the fieldwork, the strata encountered including groundwater observations are detailed. Guidance and recommendations on geotechnical matters are provided. Both environmental/ contaminated land issues are part of this scheme remit.

1.2 Purpose of Ground Investigation

In order to allow a site-specific geotechnical assessment of existing ground conditions, to aid with the foundation design and identify any other potential geotechnical issues that may be present within the shallow ground on site. The proposed investigation works / techniques were a series of trial pits to a maximum depth of 4mbgl or refusal including two soakaway test pits. Cable Percussive boreholes were also implemented into the scheme to assess the ground and permit sampling for geotechnical/geo-environmental lab analysis.

1.3 Previous Studies

The site has been subject to Seven previous studies them being:

- Land Adjacent to Ystalyfera School, Geotechnical and Geo-Environmental Desk Study (JACOBS)
- Document Reference Number: B1844758/01/R1 (December 2013)
- Ysgol Gyfun Ystalyfera, Nr Swansea Factual and Interpretative Report on Ground Investigation (ESG)
- Report Number: H4011-14/1 (September 2014)
- Ysgol Gyfun Ystalyfera School, Phase II Preliminary Risk Assessment/ Desk Study
- Report Number: G40035/PRA (Quantum Geotechnical Ltd – May 2017)
- Ysgol Gyfun Ystalyfera School, Phase II Ground Investigation Interpretative Report
- Report Number: G40035/IR (Quantum Geotechnical Ltd – May 2017)
- Ysgol Gyfun Ystalyfera School, Phase II Remediation Strategy Report
- Report Number: G40035/RS (Quantum Geotechnical Ltd – January 2018)
- Ysgol Gyfun Ystalyfera School, Phase II Remediation Validation Assessment Report
- Report Number: G40035/VR (Quantum Geotechnical Ltd – May 2018)
- Ysgol Gyfun Ystalyfera School, Phase III Preliminary Risk Assessment/ Desk Study
- Report Number: Q0229/PRA (Quantum Geotechnic Ltd – March 2020)

Quantum Geotechnic Ltd have been granted permission to use these previous studies to help aid the Interpretative report for the new Phase III development.

Identified Geotechnical Highlights:

- The Geological maps for the area indicate superficial deposits comprising Alluvium and Glacial Fluvial soils. Whilst no Made Ground is mapped there may well be a thin mantling, as identified locally within previous development areas.
- The solid geology of the site is indicated to be Mudstones, Siltstones and Sandstones, with possible coal seams from the South Wales Coal Measures of Carboniferous age.
- An unnamed fault line is mapped below the Phase III development site which suggests the potential for fractured and weakened bedrock below the site, which in turn can lead to variations in the erosion of the bedrock surface by rivers or glaciation (shown as variations in rock head levels).
- The site lies in an area of former coal mining. The site-specific mining report indicates workings to be at depth (minimum of 60m) with any related movement having stopped by now. No mine entries have been recorded. The geological map review concurs with this and the risk from former shallow coal mining is considered low.
- The site is highlighted as being in an area of either very low risk or negligible risk from shrink swell clays, collapsible deposits, landslides and running sands.

Identified Environmental Highlights:

- Possible Made Ground on-site as identified within the previous development sites which potentially contains contaminants at concentrations that may pose a risk to future site users.
- Potential for groundwater contamination from off-site to impact the soils and groundwater beneath the site.
- Potential for ground gas from off-site sources to on-site that may impact human health and/or buildings on site.

Recommendations for Ground Investigation

The QGL PRA report March 2020 provided recommendations for the intrusive ground investigation to assess any potential geotechnical or geo-environmental hazards as well as obtaining all relevant information needed for the client to progress to scheme's design and construction. The following was recommended in line with the Scheme Engineer recommendations and specification.

- Sampling of soils to determine the underlying ground conditions and to obtain samples to determine the geo-environmental characterisation of the underlying shallow ground conditions. The geotechnical characteristics of the shallow soils can also be determined as part of the same exercise.
- A human health assessment to determine whether any pollutant source exists and if any exceedances of recognised thresholds occur.
- An assessment to determine the risk from pollution pathway linkages between sources and receptors on and off site.

If any exceedances and viable pollution pathway linkages are found, the guidance and recommendations for remedial strategies to permit progression of the proposed development of the site should be given.



1.4 Scope of Work

The general scope of work undertaken in the preparation of this assessment was as follows:

- Conduct an intrusive ground investigation with the aim to identify the underlying ground conditions targeting the issues that could potentially impact the proposed development.
- Carry out laboratory testing to gain further geotechnical and geo-chemical data.
- Provide an interpretative report presenting an analysis of the available information and offering recommendations on site suitability for the proposed development with regards to geotechnical parameters including soakaway capacities, and geo-environmental assessment in relation to risks to human health and the immediate environment.

General notes on the techniques employed by Quantum Geotechnic are described in the Foreword together with the limitations inherent in carrying out ground investigation work.



2.2 Published Geology

The British Geological Survey map of the area, Sheet 230 Ammanford 1: 50,000 scale, Solid edition, shows the site is underlain by alluvium deposits, normally soft to firm consolidate, compressible silty clay, but can contain layers of silt, sand, peat, and basal gravel. This map also indicates that the underlying bedrock geology to be comprised of strata from the South Wales Middle Coal Measures Formation. Such strata comprise of grey, coal bearing mudstones/siltstones, with seatearths and minor sandstones.

There are numerous faults found on the BGS geological map sheet 230 Ammanford that covers Ystalyfera. The map indicates a north-south trending fault along the western boundary of the school 20-30m away from the site. East of the site just across the River Tawe in a neighbouring field a northeast-southwest trending Swansea Valley Disturbance. The Swansea Valley Disturbance also known as the Tawe Valley Disturbance is a zone of faults and folds extending for dozens of kilometres across the country from Swansea Bay up to the valley of the Tawe, with this disturbance being a Caledonid structure.

2.3 Hydrology

The local hydrology of the area shows a body of water east of the site flowing just across the road a north-south of the site that being of the River Tawe.

2.4 Topography

General topography of the site is around 66m above sea level and consists of low-lying undulating hills which are moderate to highly vegetated

3.0 FIELDWORK

3.1 General

The fieldwork comprised of 10 No. trial pits including 6 No. soakaway test pit with environmental and geotechnical sampling. 5 No. Boreholes were carried out across the site study area with the aim to identify the underlying ground conditions targeting the issues that could potentially impact the proposed development. Site works were carried out between the 7th September and 13th of October 2020 with no incidents or near misses recorded during fieldworks. No deviations from the standards and procedures adopted for the works were recorded.

All of the exploratory holes were machine excavated by a trained and competent excavator driver provided by client along with each area under investigation fully CAT ('Cable Avoidance Tool') scanned prior to breaking ground. Site supervision and attendance by an engineering geologist from Quantum Geotechnic was provided on all aspects of the site works.

Services were provided by the Client prior to starting the site works. Safe digging practices in accordance with HS(G)47 were employed when breaking and excavating grounds with all traceable services demarcated prior to works commencing.

A summary of the fieldworks is outlined below;

- 12 No. Trial pits (Including 6 No. Soakaway Test Pits)
- 3 No. Cable Percussive Borehole
- 2 No. Rotary Probe Boreholes
- Standard Penetration Testing (SPTs)
- Both Geotechnical and Geo-Environmental Sampling/Testing

3.2 Exploratory Hole Locations

The exploratory hole locations were set out by the client Andrew Scott where access could be gained with the investigation equipment and to obtain general coverage of the site. Figure 2 overpage illustrates the exploratory hole locations.

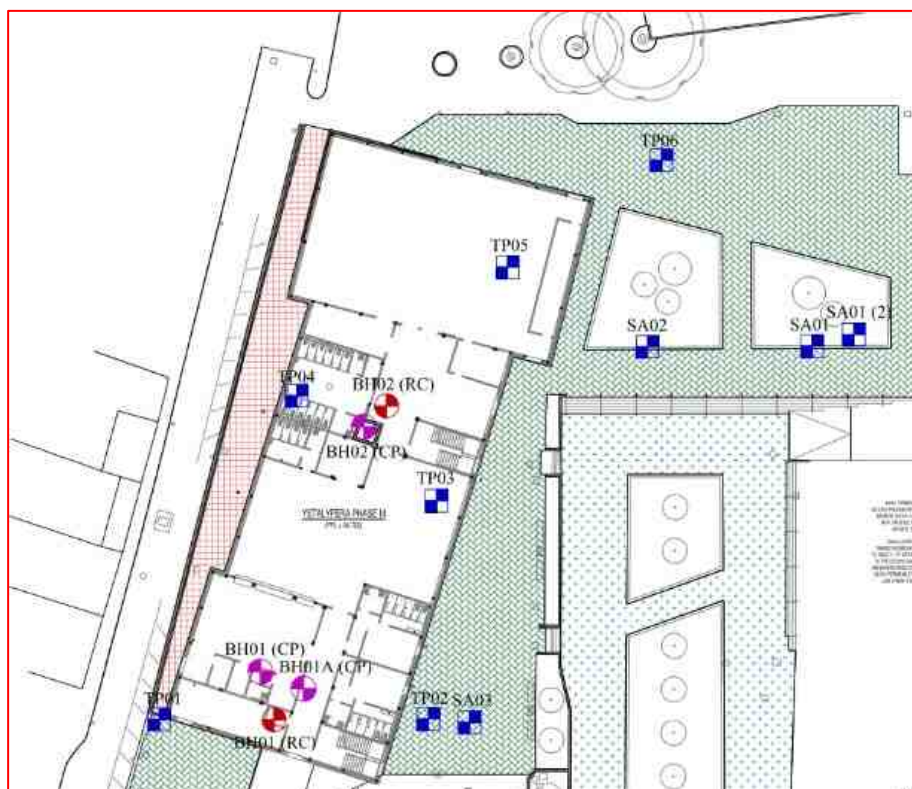


Figure 3: Exploratory Hole Locations. *Not to Scale*

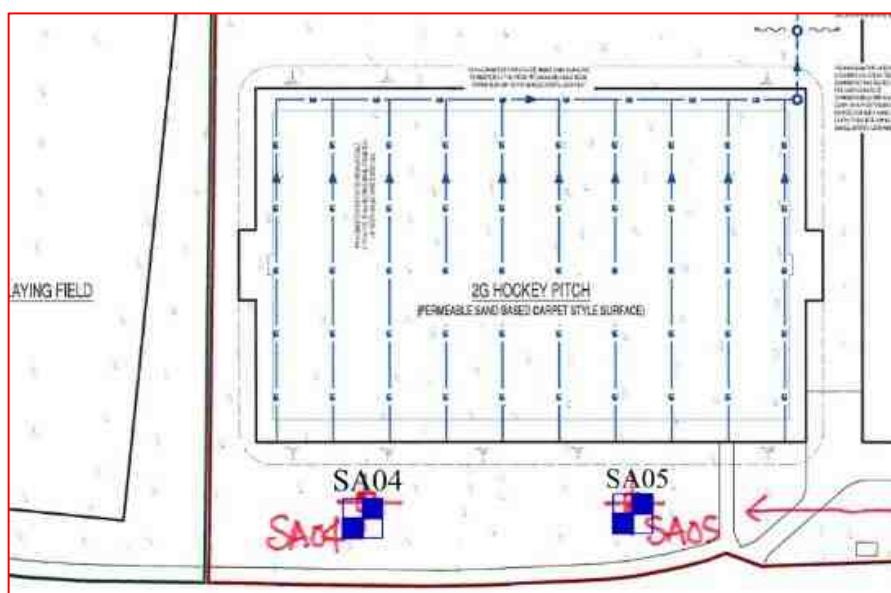


Figure 3a: Exploratory Hole Locations. *Not to Scale*

3.3 Cable Percussive Boreholes

A Dando 2000 cable percussive rig was used to progress boreholes through the overlying Made Ground and superficial deposits. A winch capacity of 2 tonnes using a wire rope is controlled via the clutch of a diesel engine which generates the percussive action used in this drilling method. Various drill tools connected to the end of the winch are used to recover samples (shell) or break up rock and obstructions (chisel). Steel casing keeps the borehole open and prevents collapse as it progresses through the overburden which is removed on completion of each borehole.

Representative bulk disturbed and small disturbed samples were recovered from the cable percussive boreholes for geotechnical characterisation of the underlying ground conditions. Environmental samples were taken at regular intervals for subsequent laboratory contamination testing.

Target depths for the cable percussive boreholes were set at 10 – 15mbgl, however due to the presence of significant granular obstructions the target depths were not achieved.

A summary of the cable percussive boreholes including termination details are presented in Table 1 below. A complete set of engineering geologist cable percussive borehole logs are presented within Appendix II.

Table 1: Cable Percussive boreholes termination depth

Exploratory Hole ID	Terminated Depth (mbgl)	Termination Strata	Reason for Termination
BH01(CP)	1.40	Dense Gravels	Refusal Upon Dense Granular Strata
BH01A(CP)	1.50	Dense Gravels	Refusal Upon Dense Granular Strata
BH02(CP)	1.50	Dense Gravels	Refusal Upon Dense Granular Strata

3.4 Rotary Boreholes

A Comacchio MC450P track-mounted rotary drilling rig was used to progress the 2No. rotary open-hole boreholes to target depths of 25 – 30mbgl.

115mm diameter casing was drilled through the overlying superficial deposits (ODS System) to keep the hole open and a 4-inch hammer used to break through obstructions and progress (probe) through rock. A combined air/mist flush was used to clear the hole of returns and cuttings on all boreholes.

Upon completion of the rotary boreholes BH01(RC) and BH02(RC) bentonite pellets were used to backfill and seal the exploratory hole.

A summary of the cable percussive boreholes including termination details are presented in Table 2 overpage. A complete set of engineering geologist cable percussive borehole logs are presented within Appendix II.

Table 2: Rotary boreholes termination depth

Exploratory Hole ID	Terminated Depth (mbgl)	Termination Strata	Reason for Termination
BH01(RC)	25.10	Interbedded Mudstone and Sandstone	Issues with Artesian Water
BH02(RC)	24.00	Interbedded Mudstone and Sandstone	Issues with Artesian Water

3.5 Machine Excavated Trial Pits

10 No. Trial Pits were excavated using a 9-ton tracked excavator at the positions shown on the exploratory hole location plan (Figure 3). The purpose of these pits was to assess the shallow ground conditions, undertake soakaway testing, permit sampling and identify if any services were present.

This method of investigation allows direct sampling of the near surface deposits for identification purposes, as well as assessment of any salient features and made ground or disturbed ground. The trial pits were logged in accordance with BS5930:2015; EN ISO 14688-1:2002 and BS EN ISO 14688-2:2004, and supervised at all times by an Engineering Geologist from QGL.

All the trial pits were backfilled with compacted layers of arisings upon completion of sampling and soakaway testing with suitable surface reinstatement when required.

Geotechnical and Environmental samples were taken within the superficial deposits for laboratory testing purposes.

Details of the trial pits, including final depths in metres below ground level (mbgl) are provided in Table 3:

Table 3: Trial Pit termination depth

Exploratory Hole ID	Terminated Depth (mbgl)	Termination Strata	Reason for Termination
SA01	1.60	Dense Gravels	Refusal Upon Dense Granular Strata
SA01(2)	2.30	Dense Gravels	Specification Depth
SA02	1.50	Dense Gravels	Refusal Upon Dense Granular Strata
SA03	1.00	Dense Gravels	Specification Depth
SA04	1.50	Dense Gravels	Specification Depth
SA05	1.40	Dense Gravels	Specification Depth
TP01	1.50	Dense Gravels	Refusal Upon Dense Granular Strata
TP02	1.20	Dense Gravels	Refusal Upon Dense Granular Strata
TP03	1.50	Dense Gravels	Refusal Upon Dense Granular Strata
TP04	1.30	Dense Gravels	Refusal Upon Dense Granular Strata



TP05	1.50	Dense Gravels	Refusal Upon Dense Granular Strata
TP06	1.10	Dense Gravels	Refusal Upon Dense Granular Strata

A complete set of Engineering Geologists Machine Excavated Trial Pit Logs are presented within Appendix III.

3.6 In-Situ Testing

3.6.1 Soakaway Tests

Soakaway tests were undertaken within SA01, SA01(2), SA02 and SA03 to assess the suitability of the strata for use as a drainage solution. The tests were undertaken in accordance with BRE 365 and involves filling the trial pit with water and measuring the time elapsed whilst the water level drops within the pit.

Soakaway test results are provided in Appendix IV.

3.7 Soil Sampling

Geotechnical bulk and disturbed samples were taken where required within the superficial deposits for strata identification and laboratory testing purposes. In addition, environmental samples were taken for laboratory testing. All samples are returned from site to Quantum's Laboratory for controlled storage within 24 hours of sampling to await test scheduling/ requirements. Sample type and sample depth are all recorded on the Engineering Geologist's Exploratory Hole Logs found within the appropriate Appendix.

4.0 LABORATORY TESTING

4.1 General

The laboratory testing was scheduled by Quantum and comprised minimal geotechnical and geo-chemical testing on selected soil samples obtained during the investigation.

4.2 Geotechnical Laboratory Testing

All the geotechnical soil testing work was carried out in accordance with the procedure stipulated in the various sections of BS 1377:1999 Parts 1 – 9 Methods of test for soils for civil engineering purposes. Table 4 details the tests undertaken.

Table 4: Geotechnical Tests Undertaken

Type of Test	No of Tests
Moisture Content	4
Liquid Limit, Plastic Limit and Plasticity Index	1
PSD Wet Sieve (Only)	5

A full set of geotechnical laboratory test certificates are provided within Appendix V.

4.3 Geo-Environmental Laboratory Testing

Geo-environmental testing was carried out on selected soil, soil leachate and groundwater samples gained from the ground investigation. The purpose of the testing is to gain a holistic view of any raised levels of contaminants that may exist onsite. Table 5 lists tests undertaken:

Table 5: Geo-environmental tests undertaken on soil samples

Heavy Metals			
• Arsenic	• Barium	• Beryllium	• Boron
• Cadmium	• Chromium (VI)	• Copper	• Lead
• Mercury	• Nickel	• Selenium	• Vanadium
• Zinc			
Inorganics			
• pH	• Total Sulphate	• Soluble Sulphate	• Sulphide
• Sulphur	• Organic Matter (soil only)	• Total Cyanide	• Complex Cyanide
• Free Cyanide	• Asbestos (soil only)		
Poly Aromatic Hydrocarbons			
• Naphthalene	• Acenaphthylene	• Acenaphthene	• Fluorene
• Phenanthrene	• Anthracene	• Fluoranthene	• Pyrene
• Benzo(a)anthracene	• Chrysene	• Benzo(b)fluoranthene	• Benzo(k)fluoranthene
• Benzo(a)pyrene	• Indeno(1,2,3-cd) pyrene	• Dibenzo(a,h)anthracene	• Benzo(ghi)perylene



Total Petroleum Hydrocarbons			
<i>TPH-CWG Aliphatic Split:</i>			
• EC10 – EC12	• EC5 – EC6	• EC6 – EC8	• EC8 – EC10
	• EC12 – EC16	• EC16 – EC21	• EC21 – EC35
<i>TPH-CWG Aromatic Split:</i>			
• EC10 – EC12	• EC5 – EC7	• EC7 – EC8	• EC8 – EC10
	• EC12 – EC16	• EC16 – EC21	• EC21 – EC35
Aromatic, Monoaromatics & Oxygenates			
• Phenol	• Benzene	• Toluene	• Ethylbenzene
• p & m - xylene	• o - xylene	• MTBE	
Additional Tests for Soil Leachate			
• Hardness			
Specialist Tests			
• Organochlorine Pesticides	• Organonitrogen Pesticides	• Organophosphorus Pesticides	

A full set of Geo-Environmental laboratory test certificates are provided within Appendix VI

5.0 GROUND CONDITIONS ENCOUNTERED

5.1 Overview of strata encountered

The sequence of deposits encountered during the investigation is detailed within the Engineering Geologist's logs presented in Appendices II and III. The following section summarises the findings of these exploratory holes.

5.2 Ground Conditions

5.2.1 General

The general ground conditions encountered across the site comprise of asphalt over topsoil/made ground overlying predominantly reworked alluvium deposits. Table 6 summarises the findings of the machine excavated trial pits.

Table 6: Summary of Strata encountered in Trial Pits

Depth Range (mbgl)		Strata Encountered	Related Exploratory Holes
From	To		
GL	0.50	Asphalt/ Sub-Base	TP01
GL	1.00	Made Ground/ Demolition Fill	TP01, TP02, TP03, TP04, TP05, TP06, SA01, SA01(2), SA02, SA03, BH01 (CP), BH01A (CP), BH02 (CP)
GL	14.00	Granular Alluvium	TP01, TP02, TP03, TP04, TP05, TP06, SA01, SA01(2), SA02, SA03, BH01 (CP), BH01A (CP), BH02 (CP), SA04, SA05
13.00	25.10	South Wales Middle Coal Measures	BH01 (RC), BH02 (RC)

5.2.2 Detailed Summary

Made Ground was encountered in all boreholes located around the site location and comprised a range of granular/clayey soils (Gravel with abundant cobble/ boulder contents) with local occurrences of cohesive materials. Colours vary from a black grey and brown across all borehole/ trial pit locations. Granular particles typically consist of angular to sub-angular, fine to coarse siltstone sandstone brick and cobble/boulder (Alluvium/ Demolition Fill). Sands were found in proportions of slightly sandy to sandy.

Made Ground depth varies across the site from 0.00 to 1.00mbgl but generally to a depth of 0.50mbgl. The made ground present is brick and concrete content. Asphalt/ Sub-Base occupies one pit from ground surface to a maximum on 0.50mbgl where a limestone gravel sub-base underlies the asphalt.

Granular Alluvium was encountered in all the exploratory boreholes and trial pits across the site study area comprising both cohesive and non-cohesive soils. The general colour of the Granular Alluvial soil across the site is consistently yellow brown. Granular particles typically consist sub-angular to well-rounded siltstone

sandstone and high cobble/boulder content. Sands were found in proportions of slightly sandy to sandy fine to coarse.

Rockhead was struck at a depth of 14.00mbgl in BH01(RC) and 13.00mbgl in BH02(RC) resulting in rockhead deepening to the south of the phase III study area. The bedrock geology on-site is that of the South Wales Middle Coal Measures Formation with a driller's description of interbedded mudstone/ sandstone. There were no coal seam observations or voiding present during the investigative works.

5.2.3 Groundwater Conditions

Groundwater strikes were observed in both rotary boreholes at a depth of 14.10mbgl [BH01(RC)] and 13.50mbgl [BH02(RC)].

Artesian water was encountered limiting the extent of the rotary probe holes however, the boreholes were safely backfilled and sealed.

5.2.4 Previous Studies Ground Conditions

Using Report No. H4011-14/1 prepared by ESG a review of their ground conditions encountered are reproduced below as during that phase of investigation more investigatory techniques were used;

Table 7: Summary of Strata

Stratum Encountered (2014)	Range of Thickness(m) (2014)	Remarks (2014)	Quantum Phase II Strata Encountered (2017)	Range of Thickness (m) (2017)
TOPSOIL / MADE GROUND	0.20 to 1.20	Encountered in all exploratory holes	TOPSOIL / MADE GROUND	0.15 to 1.00
ALLUVIUM	0.20 > 0.75 (Where base not proved)	Encountered in RC01, ROH1, WS1, HD1, HD4, HD5 and HD6 with base depths of between 0.90 and at least 1.35m	ALLUVIUM	0.30 to 0.85
GLACIOFLUVIAL DEPOSITS	>0.35 to >28.90 (Base of stratum proved in two locations only)	Encountered in all exploratory holes with the exception of HD1, HD4, HD5 and HD6	GLACIOFLUVIAL DEPOSITS	0.35 to >2.40 (Base of stratum not proved)
SOUTH WALES MIDDLE COAL MEASURES	>2.40 to >31.30 (Base of stratum not proved)	Encountered in RC01 and RC02 only, at respective depths of 9.10m and 18.70m	- (Investigatory methods did not permit such depth to be reached)	-



5.2.5 Visual & Olfactory Evidence of Soil Contamination

No visual or olfactory evidence of soil contamination was observed/ recorded.

5.2.6 Visual & Olfactory Evidence of Groundwater & Surface Water Contamination

No visual or olfactory evidence of any groundwater contamination or surface water contamination during the investigation works was observed/ recorded.

6.0 GEOTECHNICAL ENGINEERING ASSESSMENT

6.1 General

The purpose of this Ground Investigation and subsequent reporting is to determine and assess the existing shallow ground conditions on site in preparation for the construction of a new proposed school building.

The main aims of the geotechnical investigation are to provide an assessment of the ground conditions to inform initial design of the foundations and determine chemical conditions in respect of below ground structures and confirm water soakaway rates.

6.2 Engineering Properties of Strata

In summary the ground conditions comprised Made Ground overlying variable Granular Alluvial deposits comprising dense clayey sandy Gravel with high cobble/ boulder content. Bedrock was revealed between 13.00 and 14.00m depth across the site, comprising interbedded Mudstone/. No coal, mine workings or indications of underground mining activity were encountered during the investigation.

A selection of basic classification tests were undertaken on both the granular soils to provide further information. The results of which are presented within V.

Particle Size Distribution tests undertaken on selected samples recorded results that reflect the Engineer's Logs within the Appendices, proving superficial deposits of granular material with the soil fraction dominating between 64 – 69% between 1.0-1.5m depth. There was an outlier within TP01 where Made Ground overlay a Clay/ Silt with a soil fraction of 65% between 0.50 and 1.50m. Plasticity Limit testing revealed that TP01 the Clay/ Silt material sampled on site is of an intermediate plasticity and as such will have a moderate to moderately high susceptibility to climatic change and potential therefore to be susceptible to shrinkage and swelling processes.

6.2 Earthworks

6.2.1 Site Preparation

Prior to commencing any earthworks / groundwork for the development, any live services on and in the vicinity of the site should be accurately located and protected, or if required, diverted.

Any exposed formations should be protected from the effects of the weather, site traffic, or water in order to prevent deterioration of this surface. It is recommended that any exposed formations be protected with a minimum thickness of 200mm of suitable granular material or a thin layer of blinding concrete, which should be placed immediately after excavation and exposure.

All topsoil shall be stripped and, where required for further use, stockpiled in an area provided by the Contractor and agreed by the Engineer. Any asphalt will require disposal/ recycling offsite.

6.2.2 Cutting and Filling

Cutting and filling is not envisaged to be required for this development.

6.2.3 Excavation Plant

Based on the observations made during the exploratory investigation, it is considered that excavations within the shallow soils (to 2.00m depth) can be undertaken by conventional excavation plant.

6.2.4 Stability of Excavation Sides

The hand excavated pits for borehole inspection and machine excavated trial pits for soakaway testing all remained stable, similarly the rotary probe boreholes remained open to full depth prior to being backfilled with Bentonite sealing pellets. However, it is advised that any open excavations are covered due to the clay content and likelihood for ground condition deterioration if exposed to inclement weather.

6.2.5 Foundation Concrete Class Designation

The Aggressive Chemical Environment for Concrete (ACEC) classification for the site has been assessed according to the guidelines within BRE Special Digest 1 (2005). For classification purposes, based on the BRE guidance, the groundwater must be classed as 'mobile' unless proven to be 'static' over a 24hr period. The pH values of the soil samples taken from across the site ranged from 7.4 to 9.6 indicating near neutral to alkaline conditions. The levels of water-soluble sulphate (SO_4) content of the tested soil samples in the Made Ground all recorded levels below 0.99g/l (990mg/l). The levels of water-soluble sulphate (SO_4) content of the tested soil samples in the Natural soils all recorded levels below 0.25g/l (250mg/l).

Based on the above, the Design Sulphate (DS) class for the site is DS-2 (Made Ground), and the Aggressive Chemical Environment for Concrete (ACEC) site classification is AC-2 (Made Ground), assuming mobile groundwater conditions. However, the Design Sulphate (DS) class for the site is DS-1 (Natural Soils), and the Aggressive Chemical Environment for Concrete (ACEC) site classification is AC-1 (Made Ground), assuming mobile groundwater conditions.

6.2.5 Drainage Considerations

Six separate soakaway test pits were excavated across the site as located and specified by the Scheme Engineer. Soakaway testing was undertaken in accordance with BRE Digest 365. Table 8 displays the soakaway test results.

Table 8: Summary of Soakaway Results

Exploratory Hole ID	Test No.	Test Depth (mbgl)	Permeability Result Recorded (m/sec)
SA01	1	1.60	Insufficient Outflow to determine permeability – test failed
	2	1.60	Insufficient Outflow to determine permeability – test failed

SA01(2)	1	2.30	F = 7.2581E-4
	2	2.30	F = 5.6145E-4
	3	2.30	F = 3.7815E-4
SA02	1	1.60	F = 1.5756E-4
	2	1.60	F = 2.0380E-4
	3	1.60	F = 9.3035E-5
SA03	1	1.00	F = 2.6144E-5
	2	1.00	Insufficient Outflow to determine permeability – test failed
SA04	1	1.50	F = 2.8188E-4
	2	1.50	F = 2.1550E-4
	3	1.50	F = 1.7913E-4
SA05	1	1.40	F = 1.9966E-4
	2	1.40	F = 1.4226E-4
	3	1.40	F = 1.2697E-4

Based on the above permeability calculations, conventional soakaways are considered feasible for this Phase III development.

6.3 Precautions Relating to Mine Workings

Ystalyfera School has been subject to two previous development phases (phase I and II). This report relates to Phase III. Each of the two previous phases have been subject to coal mining desk-based risk assessments followed by site based intrusive borehole mining investigations to assess ground conditions and any risk of underground historic mining activity to the proposed phased development.

On the two previous phases, it was concluded that the risk from underground mining was Low.

In relation to this current Phase III development, Quantum undertook a desk-based coal mining risk assessment in March 2020 concluding Shallow coal seams and as such, either recorded or unrecorded shallow mine workings are not anticipated to be present at shallow depths below the site. Therefore, on the balance of evidence, it is concluded the risk to the proposed Phase III development site from shallow mine workings is considered Low, however it is emphasized that the possibility of shallow depth mining having taken place beneath some parts of the site cannot be completely discounted. No mine entries were identified in the Coal Authority Mining Report for the site, nor has any evidence been revealed from our extended searches as to any unrecorded mining features that may affect the site.

This was followed up with 2No. rotary drilled mining investigation boreholes as part of this recent ground investigation, which revealed rockhead was struck at a depth of 14.00mbgl in BH01(RC) and 13.00mbgl in BH02(RC) resulting in rockhead deepening to the south of the phase III study area. The bedrock geology on-



site is that of the South Wales Middle Coal Measures Formation with a driller's description of interbedded mudstone/ sandstone. There were no coal seam observations or voiding present during the investigative works.

In summary, based on all information presented we conclude that the current Phase III development area is at a Low Risk from past underground mining activity

6.4 Foundation Appraisal

It is recommended that for the phase III development at Ystalyfera school that shallow pad and strip foundations be implemented into the granular dense alluvial deposits. Due to the shallow depth layers of the Made Ground that overlie the Granular Alluvial deposits which typically comprise compressible and variable materials, which for foundation purposes are not suitable.

The recommended foundations are to be placed in the Granular Alluvial deposits which typically comprise of sands, gravels, cobbles and boulders. Using the results from the 2014 and 2020 ground investigation the Alluvial deposits become dense as depth increases. Where the granular materials are at a sufficiently shallow depth (i.e. TP04 at 0.50mbgl) it is recommended that the foundations should be based at a minimum depth of 1.00m but a conservative depth of 2.00m is recommended particularly where poor ground conditions progress to depth e.g. former swimming pool area. The dense sands and gravels of the granular alluvial deposits, which with a 2m foundation width have an allowable bearing strength capacity of 300kN/m² which will be sufficient for the structure of the new development. But ground water levels need to be taken into consideration because if there is shallow ground water then bearing strength values are halved. Shallow excavations are unlikely to encounter groundwater however, should deeper foundations be opted for, such as piles, then at a depth of 13.50 – 14.10mbgl artesian water is likely to be present as represented in BH01 (RC) and BH02 (RC).

For the strip foundations supporting of the proposed wall loads, it is advised that the designs should allow for a bearing pressure of at least 250kN/m², that based upon a foundation width of up to 1.50m.

6.3 Soakaway

Four soakaway pits were conducted by Quantum Geotechnic (SA01, SA01(2), SA02, SA03, SA04 and SA05) with the tests being carried out a maximum of three times per pit depending on infiltration state. There were 16 tests carried out in total, with 13 tests successful, giving soil infiltration rates of 2.58x10⁻⁴, 2.04x10⁻⁴, 9.30x10⁻⁵, 7.26x10⁻⁴, 5.61x10⁻⁴, 3.78x10⁻⁴, 2.61x10⁻⁵, 2.82x10⁻⁴, 2.15x10⁻⁴, 1.79x10⁻⁴, 2.00x10⁻⁴, 1.42x10⁻⁴ and 1.27x10⁻⁴ (m/sec). The tests were carried out within the granular alluvial deposits, dominated with coarse granular material, and hence were anticipated to possess relatively high permeability characteristics.

For soakaway structures proposed to be within the area in which the soakaway tests were performed, it is recommended that the middle-bound value of 3.78x10⁻⁴m/sec be taken as an appropriate soil infiltration rate for design. This value was derived at the third test of SA01(2) upon saturating the ground. It should be noted



that variations in ground conditions will influence the drainage properties as well as the ground water levels due to seasonal changes.

7.0 GEO-ENVIRONMENTAL ENGINEERING ASSESSMENT

7.1 General

The proposed development entails the demolition of the buildings in the north-west quadrant of the school, followed by the construction of a new assembly hall, kitchen and dining room.

By adopting the CLEA approach to human health risk assessment as defined in CLR11, a human health risk assessment has been undertaken for the proposed development adopting the most sensitive model of Residential without plant uptake (1% Organic Matter) End use threshold values

The assessment criteria used in this assessment is that presented by LQM/CIEH in their publication *The LQM/CIEH S4ULs for Human Health Risk Assessment (2015)*. The S4ULs (Suitable for Use Levels) used have been derived in accordance with UK legislation, national as well as Environment Agency policy and using a modified version of the Environment Agency CLEA software and available guidance provided to the contaminated land practitioner community for the purpose of deriving Generic Assessment Criteria (GAC).

The LQM/CIEH S4ULs are intended for use in assessing potential risks posed to human health by contaminants in soil and as transparently derived and cautious 'trigger values' above which further assessment or remedial action may be necessary.

By using the LQM/CIEH S4AULs, Quantum Geotechnic acknowledges *Copyright Land Quality Management Ltd reproduced with permission; Publication Number S4AUL3409. All Rights Reserved.*

The test certificates are presented in Appendix VI along with summary tables of the respective results in the following Sections.

7.2 Potential Site Source, Pathway and Receptor for Contamination.

The Phase III development involves the demolition of the buildings in the north-west quadrant of the school, followed by the construction of a new assembly hall, kitchen and dining room and therefore site contamination is taken into consideration. During the development soil and groundwater contamination can be a major issue as pathways created during this phase can result in the distribution of contamination. Overpage in table 9 is a preliminary conceptual model identifying potential sources, pathways and receptors as derived from Quantum's March 2020 PRA desk-based study.

Source	Pathway	Receptor
On Site Activities- <i>Made Ground-</i> - Metals - Hydrocarbons (TPH,PAH) <i>Construction Materials-</i> - Asbestos <i>Macadam Surfacing-</i> - Hydrocarbon (PAH) <i>Landfill / Backfilled Canal-</i> - Hazardous Ground Gases <i>Railway-</i> - Metals - Asbestos - Sulphate - Polychlorinated Biphenyls (PCB) <i>Garage / Vehicle Service Workshop-</i>	Human Health- - Direct soil and Indoor Dust Ingestion - Dermal Contact with soils and indoor dust - Inhalation of indoor and outdoor dust Controlled Waters- - Rainfall infiltration - Seepage and vertical migration through permeable materials - Lateral migration through groundwater. Hazardous Gases- - Migration through permeable materials	Human Health- - Current site users - Site workers - Future site users/maintenance workers Controlled Waters- - Groundwater underlying and surrounding the site (Secondary (A) Aquifer) - Surface water Others- - Buildings, structures and services - Plants

Table 9: Conceptual Model indicating Source, Pathway and Receptor

7.3 Risk to Human Health

7.3.1 Heavy Metal and Inorganic Compounds

The results of levels of potential contaminants as listed in table 9 have been compared to generic assessment criteria as described above, for a residential end use without plant uptake (1% Organic Matter) as being considered the most appropriate threshold for human health relating to the school. The concentrations of heavy metal and inorganic compounds are summarised in the table below.

Table 9: Summary of Heavy Metals Soil Test Results

Determinant	Results Range (mg/kg)	LQM/CIEH S4ULs (2015) (mg/kg) Residential (1%) without Plant Uptake End Use ⁽¹⁾	Exceedances
Metals/Metalloids			
Arsenic	13 - 130	40	1
Boron	0.48 – 1.30	11,000	0
Cadmium	0.11 – 0.98	85	0
Chromium	11 - 18	-	0
Chromium VI	<0.50	6	0
Copper	22 - 840	7,100	0
Lead	23 - 210	310	0
Mercury	<0.10 – 0.27	56	0
Nickle	15 - 52	180	0
Zinc	65 - 520	40,000	0

7.3.2 Polycyclic Aromatic Hydrocarbons

The results of levels of potential polycyclic aromatic hydrocarbon contaminants have been compared to the generic assessment as described, for residential end use without plant uptake as being considered the most appropriate threshold human health related to the school.

The concentrations of speciated Polycyclic Aromatic Hydrocarbon are summarised and compared in the table below.

Table 10: Summary of Poly-aromatic Hydrocarbon Soils Test Results

Determinant	Results Range (mg/kg)	LQM/CIEH S4ULs (2015) (mg/kg) Residential (1%) without Plant Uptake End Use ⁽¹⁾	Exceedances
PAH Compounds			
Naphthalene	<0.10	2.3	0
Acenaphthylene	<0.10	2,900	0
Acenaphthene	<0.10	3,000	0
Fluorene	<0.10	2,800	0
Phenanthrene	<0.10	1,300	0
Anthracene	<0.10	31,000	0
Fluoranthene	<0.10 – 0.60	1,500	0
Pyrene	<0.10 – 0.83	3,700	0
Benzo (a) anthracene	<0.10	11	0
Chrysene	<0.10	30	0
Benzo (b) fluoranthene	<0.10	3.9	0
Benzo (k) fluoranthene	<0.10	110	0
Benzo (a) pyrene	<0.10	3.2	0
Indeno (1,2,3-cd) pyrene	<0.10	45	0
Dibenzo (ah) anthracene	<0.10	0.31	0
Benzo (g,h,i) perylene	<0.10	360	0

7.3.3 Petroleum Hydrocarbons

The results of levels of potential hydrocarbons contaminants (as aromatic and aliphatic compounds) have been compared to generic assessment criteria as described, for a residential end use without plant uptake as being considered the most appropriate threshold for human health related to the school.

The concentrations of speciated petroleum hydrocarbons are summarized and compared in the table over page.

Table 11: Summary of Petroleum Hydrocarbon Soil Test Results

Determinant	Results Range (mg/kg)	LQM/CIEH S4ULs (2015) (mg/kg) Residential (1%) without Plant Uptake End Use ⁽¹⁾	Exceedances
TPH-CWG Banding			
TPH-CWG – Aliphatic >EC5 – EC6	<0.10	42	0
TPH-CWG – Aliphatic >EC6 – EC8	<0.10	100	0
TPH-CWG – Aliphatic >EC8 – EC10	<0.10 - 28	27	1
TPH-CWG – Aliphatic >EC10 – EC12	<0.10 - 15	130	0
TPH-CWG – Aliphatic >EC12 – EC16	<0.10 - 13	1,100	0
TPH-CWG – Aliphatic >EC16 – EC21	<0.10 – 8.4	65,000	0
TPH-CWG – Aliphatic >21 – EC35	<0.10 - 85	65,000	0
TPH-CWG – Aliphatic >EC5 – EC35	-	-	-
TPH-CWG – Aromatic >EC5 – EC7	<0.10	370	0
TPH-CWG – Aromatic >EC7 – EC8	<0.10	860	0
TPH-CWG – Aromatic >EC8 – EC10	<0.10 – 4	47	0
TPH-CWG – Aromatic >EC10 – EC12	<0.10 - 5	250	0
TPH-CWG – Aromatic >EC12 – EC16	<0.10 – 7.2	1,800	0
TPH-CWG – Aromatic >EC16 – EC21	<0.10 - 18	1,900	0
TPH-CWG – Aromatic >EC21 – EC35	<0.10 - 270	1,900	0
TPH-CWG – Aromatic >EC5 – EC35	-	-	-

7.3.4 Asbestos and Other Compounds

None of the six samples of shallow soils tested were found to contain Asbestos

Table 12: Summary of Asbestos and Other Compounds Soil Test Results

Determinant	Results Range (mg/kg)	LQM/CIEH S4ULs (2015) (mg/kg) Residential (1%) without Plant Uptake End Use ⁽¹⁾
Other Compounds		
Asbestos	No Asbestos Detected	
Phenol	<0.30	440
Cyanide (Total)	<0.50	2,400
Sulphate (Water Soluble)	0.025 – 0.99	0.5 g/l

7.4 Risk to Controlled Waters

7.4.1 General

The risk to controlled waters, i.e. nearby watercourses or aquifer, is defined by the potential for any contaminants present on site to leach from soils beneath the site.

Once the leaching potential is known the risk from this can be assessed in terms of pathways by which it may migrate, impact on the receptors and, if need be, addressed by remedial actions.

As a preliminary Tier 1 screening tool two soil samples were tested for leachate and compared to UK Environmental Quality Standards (EQS), where these are published, in order to assess risks to local controlled waters. The Freshwater EQS is the most relevant in the threshold although World Health Organisation (WHO) acceptable levels have also been quoted to provide a more complete comparison of leachate test results.

The results of the samples analysis are shown below in Table 13 and 14 (below) along with the threshold levels given by the EQS as well as the WHO as guide figures for comparison.

Table 13: Summary of Soil Leachate Chemical Analysis - Organics

Determinant	Units	Results Range	Environmental Quality Standards – Freshwater ¹ (µg/l)	UK Drinking Water Standards ²
PAH Compounds				
Naphthalene	µg/l	<0.10	10	n/a
Acenaphthylene	µg/l	<0.10	-	n/a
Acenaphthene	µg/l	<0.10	-	n/a
Fluorene	µg/l	<0.10	-	n/a
Phenanthrene	µg/l	<0.10	-	n/a
Anthracene	µg/l	<0.10	0.02	n/a
Fluoranthene	µg/l	<0.10	0.02	n/a
Pyrene	µg/l	<0.10	-	n/a
Benzo (a) anthracene	µg/l	<0.10	-	n/a
Chrysene	µg/l	<0.10	-	n/a
Benzo (b) fluoranthene	µg/l	<0.10	-	n/a
Benzo (k) fluoranthene	µg/l	<0.10	-	n/a
Benzo (a) pyrene	µg/l	<0.10	0.03	n/a
Indeno (1,2,3-cd) pyrene	µg/l	<0.10	-	n/a
Dibenzo (ah) anthracene	µg/l	<0.10	-	n/a
Benzo (g,h,i) perylene	µg/l	<0.10	-	n/a

Table 14: Summary of Soil Leachate Chemical Analysis – Metals & In-Organics

Determinant	Units	Results Range	Environmental Quality Standards – Freshwater ¹ (µg/l)	WHO Guideline Values (µg/l)
Metals/Metalloids				
Arsenic	µg/l	13 – 130	50	10
Boron	µg/l	0.48 – 1.30	2000	0.3
Cadmium	µg/l	0.11 – 0.98	5	3
Chromium VI	µg/l	<0.50	4 – 20	50
Copper	µg/l	22 - 840	0.5 - 12	2000
Lead	µg/l	23 – 120	8 – 40	10
Mercury	µg/l	<0.10 – 0.27	1	1
Nickle	µg/l	14 – 52	8 – 40	70
Zinc	µg/l	65 – 520	8 – 50	3000
Cyanide	µg/l	<0.50	-	70

7.5 Recommendations on Contaminated Land

7.5.1 Human Health of Site End Users

Only one sample marginally exceeded Aliphatic >EC8 – EC10 by 1mg/ kg located at 0.20m in TP01 (ES1) within the shallow Made Ground. The Made Ground was predominantly reworked natural gravels with occasional man-made inclusions of brick, glass and slag (demolition material). One slightly raised Arsenic level in SA02 in the Made Ground is considered an isolated occurrence. No Asbestos was detected either.

With the end development being hardstanding the risk to the human health of site end users is negligible based on the above, as the pathway between the contaminant source (shallow lying made ground) and the site end user (pupils and staff) will be severed by the hardstanding. In addition, by excavating down to formation levels and disposing of the Made Ground offsite this would completely nullify the negligible risks posed by removing the source of the marginally raised contaminants, which Quantum are led to believe is the intention of the client in order to construct the desired formation/ levels.

With regards to offsite disposal, at time of writing no Waste Acceptance Criteria (WAC) tests have been undertaken as part of the scope of works, as discussed previously, however, the 'made ground' is predominantly reworked natural gravels with minor low amount of man-made inclusions such as glass, brick and occasional slag, which may be considered Inert based on the European Waste Catalogue description and classifications. It is best practice to pass on these soil test results along with the attached logs/ ground conditions to the proposed waste receiving facility prior to moving material offsite to ensure that the landfill operator will accept the material as Inert. WAC testing is also recommended.



7.5.2 Human Health Risks during Construction

The geo-environmental laboratory testing showed only marginal exceedances of raised contamination concentrations, therefore the risks posed to construction operatives from chemical contaminants within the shallow ground is considered negligible.

Operatives working with, or likely to come into contact with made ground with the potential to harness raised concentrations of contaminants, should observe particular precautions concerning personal hygiene. They should be issued with the appropriate personal protective equipment and should be instructed in safe working methods.

Instructions should be issued in the recognition of potentially hazardous materials including oily and odorous soil and water and any discoloured or fibrous substances for example. Operatives should be warned to avoid contact between hands and mouth before washing. The consumption of food must be confined to designated clean areas with suitable welfare including washing facilities should be provided.

7.5.3 Risk to the Environment and Controlled Waters

The risk to controlled waters, i.e. nearby water courses, is defined by the potential for any contaminants present on site to leach from the soils beneath the site.

Once the leaching potential is known the risk from this can be assessed in terms of pathways by which it may migrate, the impact on the receptors and if needs be, addressed by remedial actions.

The laboratory test certificates and as summarized in tables 13 and 14 show that the soil leachate samples tested recorded all results fell below the relevant EQS values for freshwater and referenced against WHO guidelines where no UK (DW) threshold are set. This indicates that there is a negligible risk posed to any nearby controlled waters. In addition, there is one water source east of the site a river system but with the collective chemical analysis results for soil leachates there no risk of leachates mitigating off site.

The results for soil leachate testing, which are used to determine level of risk to the immediate environment, particularly any controlled waterways i.e. streams/ rivers/ groundwater, all recorded values well within the Environmental Quality Standards published assessment criteria by NRW/EA.

7.5.4 Land Gas Assessment

No ground gas monitoring installations could be installed during Quantum's 2020 intrusive investigation due to artesian water. However, a gas membrane akin to the previous phase of development should be implemented into the design of the Phase III development. The rationale for this recommendation is set out below.

The 2014 ESG ground investigation involved the installation of 3No. ground gas monitoring wells/

standpipes which were subject to 6No. monitoring visits. The results were presented within Enclosure B of the ESG report. The results indicate carbon dioxide concentrations of up to 7.3% by volume and one record of methane, at a concentration of 0.5% by volume (no hydrogen sulphide was detected), together with oxygen concentrations as low as 9.6% by volume. A maximum gas flow rate of 0.1 l/h was recorded from the boreholes during the monitoring visits which were undertaken at atmospheric pressures ranging from 998 to 1014 mb.

The potential risks posed by any recorded presence of potentially harmful gases can be assessed on a semi-quantitative basis by reference to the guidance in documents CIRIA 665 and BS8485. The assessment comprises multiplying the maximum measured steady gas flow rate (expressed as litres per hour) by the maximum steady gas concentration (expressed as percentage-by-volume; divided by 100) to derive a Gas Screening Value (GSV).

The gas screening value is defined as a product of the gas concentration and gas flow, the worst case scenario being established from the highest of each. For a carbon dioxide value of 7.3%, and a gas flow value of 0.1 l/h, then the gas screening value would be 0.0073 l/hr. The maximum methane value was 0.5% and, again using a flow rate of 0.1 l/h, the gas screening value would be 0.0005 l/hr. Both of these results are within the range for Characteristic Situation 1 (after CIRIA R149), which is regarded as 'Very Low Risk'. However, as recommended in CIRIA C665, the adoption of Characteristic Situation 1 assumes that concentrations of methane are typically less than 1% by volume, and those of carbon dioxide typically less than 5% by volume. Should higher concentrations be present it is recommended that consideration be given to increasing the classification to Characteristic Situation 2.

The measurement of carbon dioxide at concentrations of up 7.3% (together with three other instances where the carbon dioxide values exceeded 5.0%) therefore indicates that it would be prudent to consider this site as Characteristic Situations 2 – same as the Phase I & Phase II scheme area. Should such an approach be adopted some kind of protection / remedial measures should be considered.

As per the earlier QGL PRA March 2020 report Radon protection measures are required.

7.6 Review of Conceptual site Model (CSM)

Based on the Phase I Desk Study and the findings of the Phase II Investigation, no potential source-pathway-receptor (S-P-R) linkages have been identified and as such no risk to human health or controlled waters have been identified.

8.0 REFERENCES

British Geological Survey:

- British Geological Survey Sheet 30 Ammanford: 1:50,000 scale, Bedrock and Superficial edition
- BGS Lexicon of Named Rock Units (www.bgs.ac.uk/lexicon)
- BGS Geology of Britain Viewer (www.bgs.ac.uk)

Specialist Publications:-

- British Code of Practice BS 5930:2015 '*Code of Practice for Site Investigations*'
- British Code of Practice BS 1377:1990 '*Methods of test for soils for civil engineering purposes*'.
- British Code of Practice BS EN ISO 14688-1:2002+A2:2013 Geotechnical investigation and testing. Identification and classification of soil. Identification and description
- British Code of Practice BS EN ISO 14688-2:2004+A2:2013 Geotechnical investigation and testing. Identification and classification of soil. Principles for a classification.
- British Code of Practice BS EN ISO 14689-1:2003 Ground Investigation and Testing – Identification and classification of rock
- Health and Safety Executive Guidance Note EH40/90
- *CIRIA Report 143* 'The Standard Penetration Test (SPT): Methods and Use', 1995.
- BRE (2005) Special Digest 1:2005, 3rd Edition, Concrete in aggressive ground. BRE, Garston.
- BS 6031: 2009 Code of Practice for Earthworks.
- Workmanship for excavation shall comply with BS 8000: 1989 Part 1, Sections 3.1, 3.2 and 3.3.

Previous Studies

- Land Adjacent to Ystalyfera School, Geotechnical and Geo-Environmental Desk Study (JACOBS)
- Document Reference Number: B1844758/01/R1 (December 2013)
- Ysgol Gyfun Ystalyfera, Nr Swansea Factual and Interpretative Report on Ground Investigation (ESG)
- Report Number: H4011-14/1 (September 2014)
- Ysgol Gyfun Ystalyfera School, Phase II Preliminary Risk Assessment/ Desk Study
- Report Number: G40035/PRA (Quantum Geotechnical Ltd – May 2017)
- Ysgol Gyfun Ystalyfera School, Phase II Ground Investigation Interpretative Report
- Report Number: G40035/IR (Quantum Geotechnical Ltd – May 2017)
- Ysgol Gyfun Ystalyfera School, Phase II Remediation Strategy Report
- Report Number: G40035/RS (Quantum Geotechnical Ltd – January 2018)
- Ysgol Gyfun Ystalyfera School, Phase II Remediation Validation Assessment Report
- Report Number: G40035/VR (Quantum Geotechnical Ltd – May 2018)
- Ysgol Gyfun Ystalyfera School, Phase III Preliminary Risk Assessment/ Desk Study
- Report Number: Q0229/PRA (Quantum Geotechnical Ltd – March 2020)