GroundSolve Ltd
Consulting Geotechnical Engineers

PHASE 2 GROUND INVESTIGATION: CONWY ACTIVE TRAVEL RSPB

GSL2996/R01

VERSION 1

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FINAL

Prepared for:

Conwy County Borough Council

Prepared by: A Bell

GroundSolve Ltd

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This report has been prepared by GroundSolve Ltd with all reasonable care and diligence, within the best practice and guidance current at the time of issue within the proposed redline boundary and proposed Site end use as presented by the Client.

This report is confidential to the Client and GroundSolve Ltd accepts no responsibility whatsoever to third parties to whom this report is presented.

Version No.	Description of Issue / Revision	Date of Issue	Author	Reviewed By	Approved By
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EXECUTIVE SUMMARY

Introduction	GroundSolve Ltd (GSL) was commissioned by Conwy County Borough Council. (CCBC / "the Client") to undertake a ground investigation to provide information on the ground conditions to aid in the construction of a cycle path and two associated bridges. This report presents the findings of the site investigation and makes recommendations based upon those findings.
Proposed land use	It is proposed to construct a cycle path along the outskirts of RSPB Conwy, with a bridge taking it over the Avon Ganol and a second bridge taking it over the railway to join with Conwy Road (A470).
Site location and surrounding land uses	The site is currently part of RSPB Conwy, with the North Wales Expressway to the north, a railway track adjacent to the east, the River Conwy and the RSPB Reserve to the south and to the west.
Site history	The RSPB nature reserve was constructed in 1991 from the settling lagoons which were use to help construct the Conwy Tunnel. The completion of the nature reserve was in 1995.
Geology, Hydrogeology and Hydrology	Likely made ground of reworked silts dredged from the Conwy Tunnel works. Alluvium (clay and silt) with Alluvium (sands and gravel) present offsite to the southwest. Bedrock Geology comprises Denbigh Grits Group (mudstones and sandstone) in the north and Lower Nantglyn Flags Group (mudstone) in the south. Several faults are present in the area with the Lower Nantlyn Flags in the centre of the site dipping 45° to the north and dipping 12-14° to the east in the south of the site. Groundwater likely tidally influenced.
Ground Gases	No significant thickness of putrescible made ground was encountered onsite. The proposed development is unlikely to involve confined spaces where gas could build up and pose a risk to site users.
Radon Requirements	10-30% maximum Radon potential. Should buildings or confined spaces be present as part of the proposed development then 'full' Radon protection measures will be required.
Potential contaminative features	No onsite potential contamination features. Recent substation onsite will have ongoing maintenance. Potential contamination in the form of made ground.
Mining and quarrying	There are no geotechnical hazards associated with mining or quarrying on or within influencing distance of the site.
Previous investigations	Previous investigation undertaken by Geotechnics in 2006 (Report No: PN050995)
Unexploded Ordnance	Low risk was noted across the site based on Zetica UXO Risk Mapping.
Contamination Assessment	The results of site investigation and laboratory analysis generally record negligible to zero concentrations of potential contaminants. Whilst unexpected contamination is not anticipated, the proposed development could encounter previously unrecorded hotspots of contaminants. These will be assessed and mitigated in accordance with current good practice.
Preliminary Geotechnical Assessment	Where present, bedrock will provide a suitable founding stratum. Where deep granular made ground is present, it may be possible to excavate the material and recompact it to a suitable specification to allow shallow spread foundations to be used. Where soft organic silts are present it is likely that piled foundations will be required.
Waste Soils Classification	The materials present onsite are not considered to be hazardous wate based on the sampling undertaken so far. No WAC testing was carried out as part of this investigation. WAC testing will have to be carried out to confirm the landfill waste classification and if any pre-treatment is required. This is best carried out once all material to be disposed of is stockpiled, and volumes can be accurately assessed. It should be noted that natural clay can be classified as Inert Waste 17 05 04: Soil and stones only (excluding topsoil, peat, soil and stones).
Materials re-use	Subject to volumetric fill requirements and a future assessment of suitability of re-use (both chemically and geotechnically), some materials *may* be considered for potential re-use in line with an appropriate end-of-waste protocol such as WRAP Quality Protocol for Aggregates from Inert Waste, U1 Exemption or a Materials Management Plan in accordance with the CL:AIRE Definition of Waste Code of Practice (DoWCoP).
Further works or other issues potentially restricting work	Services present that may require to be removed/rerouted should the proposed works be undertaken. Proximity of the railway to the proposed development. Potential for flooding and storm surges due to proximity to the sea. Proximity of the proposed works to the RSPB reserve.

1 INTRODUCTION

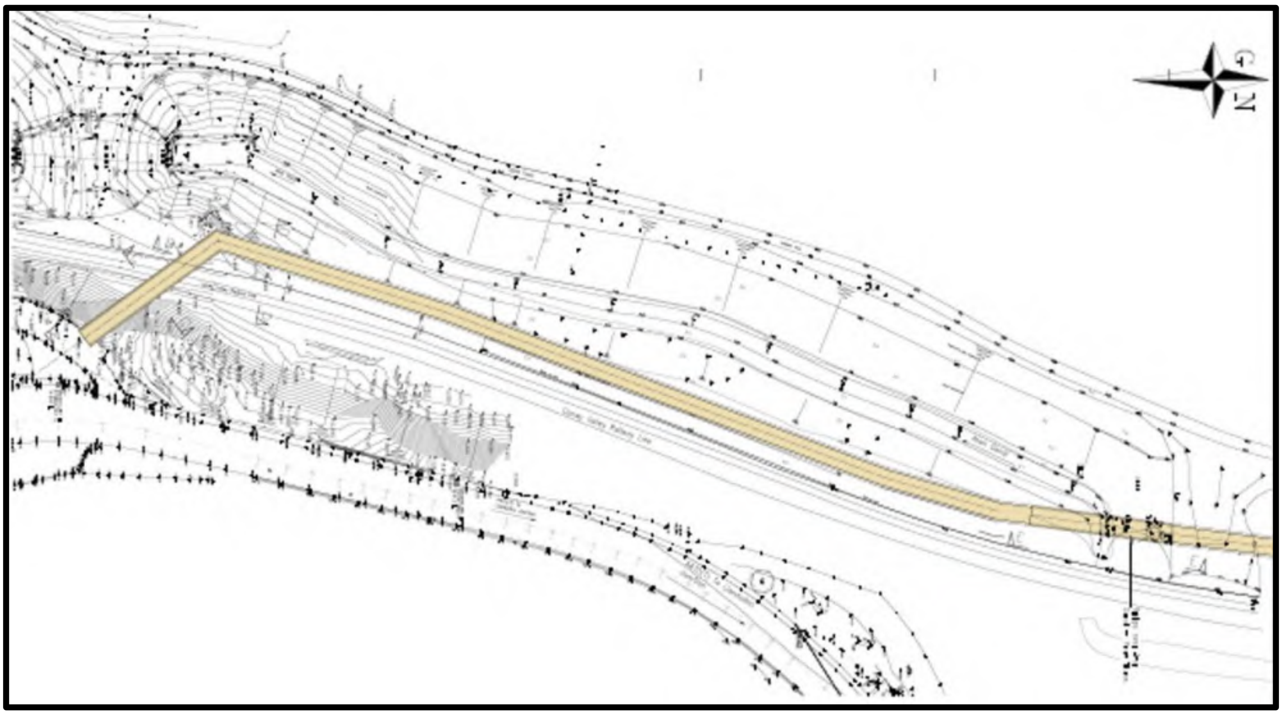
GroundSolve Ltd (GSL) was commissioned by Conwy County Council (CC/ "the Client") to undertake a second phase site investigation and contaminated land risk assessment for an area of land off at the RSPB site in Conwy off the A55 in North Wales (the "Site").

This report has been devised to generally comply with the relevant principles and requirements of a range of guidance including:

- Part IIA of the Environment Protection Act, 1990;
- BS5930:2015 +A1:2020: "Code of practice for site investigations";
- BS10175: 2011 +A2:2017 "Investigation of Potentially Contaminated Sites - Code of Practice";
- The Building Regulations 2010. Part C (HM Government 2013)
- Environment Agency: Land Contamination Risk Management (LCRM), Version 3, October 2020;
- Environment Agency (2017) "The Environment Agency's Approach to Groundwater Protection" November 2018 Version 1.2;

1.1 Proposed Development

The proposed development comprises of a new hardstanding footpath and bridge.



Extract from proposed development plan.

1.2 Objectives

The purpose of the report is to provide an assessment of the site using published information and information on conditions at the site in relation to the proposed Public Open Space (park) development.

The findings and conclusions of the risk assessments have been set out and recommendations given for the proposed school end use. If there is a subsequent change in the proposed land, the risk assessments and conclusions should be reviewed to determine whether they are still applicable for the revised end use.

This document is a working document and may need to be updated, in agreement with the relevant regulatory bodies, at any stage during development dependent on the conditions encountered. This version of this document is to be issued to regulators for approval (i.e., Conwy County Council).

1.3 Previous Investigations

A previous investigation was carried out by GroundSolve Ltd (GSL) in 2022 for an extension to the visitors centre.

Geotechnics produced a factual report for a ground investigation (Project No: PN050995) carried out in 2006 at the southern end of the site where the proposed bridge is located. This comprised 6no. Trial Pits, 2no. Cable Percussion boreholes following on with rotary drilling and 2no. Rotary Open Holes.

No Phase 1 Desk Study report was undertaken prior to GroundSolve undertaking a Phase 2 Site Investigation and Geotechnical Report.

1.4 Limitations

This report has been prepared for the sole use of Conwy County Borough Council. No other third party may rely upon or reproduce the contents of this report without the written approval of GroundSolve Ltd. If any unauthorised third party comes into possession of this report, they rely on it entirely at their own risk.

Access to part of the site was slightly restricted due to the Llandudno to Blaenau Ffestiniog railway line, a culvert with weight limit over the Afon Ganol and the River Conwy, therefore a particular rig had to be used to undertake the ground investigation works in this area.

2 SITE DETAILS AND DESCRIPTION

Table 2.1: Current Site Overview.

Site name	Conwy Active Travel RSPB
Site address	Llandudno Junction, N Wales Expressway, Conwy, LL31 9XZ.
National Grid Reference (NGR)	SH 79713 77382
Approximate Site area	5.02ha 
Site shape	Irregular
Current land use on the Site	The site is currently occupied by the RSPB.
Surrounding land uses	To the north is the A55 expressway, to the east are some agricultural fields, a residential property and commercial buildings and the A470. To the south and west is the River Conwy.
General topography and ground levels	General topography levels are between 6mAOD in the north east of the site and 10mAOD in the west of the site. The site is mainly at grade with dirt and gravel footpaths, grassed areas, and vegetation comprising trees and shrubs. There are also two large lakes at the centre of the site.

3 PREVIOUS INVESTIGATIONS

A summary of the findings from previous reports is given in **Table 3.1** below:

Table 3.1: Summary of Previous Investigations.

Summary of main findings from the previous reports	
Site History	In 1875 the site was occupied by the Conwy River, with the Blaenau Ffestiniog railway line located immediately north and east of the site. In 1898 there was a brick works at the north west corner of the site adjacent the railway. An old quarry was also located some 50m south east of the site until 1948. The RSPB nature reserve was constructed in 1991 from the settling lagoons which were use to help construct the Conwy Tunnel. The completion of the nature reserve was in 1995.
Geological Setting	• Geological Survey of England and Wales 1:63,360/1:50,000 geological map series, Sheet 94, Llandudno, 1989. • BGS GeoIndex (onshore). • There is made ground immediately northwest of the site. • Superficial Deposits comprise Tidal Flat Deposits comprising Sand and Gravel. • Bedrock comprises Denbigh Grits Formation – Mudstone, Siltstone and Sandstone and the Nantglyn Flags Formation – Mudstone and Siltstone. • The is one fault south of the site.
Mining	None
Hydrogeology	• Superficial Deposits are a Secondary Aquifer of medium to high groundwater vulnerability. • Bedrock is a Secondary Aquifer of medium groundwater vulnerability. • Groundwater is anticipated at depth of 1.0m below ground level.
Waste	• Historical Landfill 71m north of the site.
Contamination Sources	• No significant sources of onsite contamination identified with the exception of made ground onsite. • Onsite substation unlikely source of contamination due to ongoing maintenance. • Offsite sources include the train track adjacent to the which may be a source of Asbestos, PAHs and potentially heavy end hydrocarbons.

4 FIELDWORK

4.1 Introduction

The fieldwork was carried out 26th January 2024. GroundSolve personnel were present to supervise all work, describe the ground encountered, and take samples. Fieldwork procedures were undertaken in accordance with the relevant sections of:

- BS5930:2015 + A1:2020 "Code of Practice for Site Investigations;"
- BS10175:2011 + A2:2017 "Investigation of Potentially Contaminated Sites – Code of Practice."

The investigation included:

- 8 No. Windowless Sample boreholes to a maximum depth of 5.45mbgl (WS101-WS108),
- 2 No Dynamic Probe locations to a maximum depth of 2.80mbgl (DP103 and DP104),
- 14 No. ACSW Locations,
- 12 No. Dynamic Cone Penetrometer tests using the TRL method to a maximum depth of 1.00mbgl (DCP101-DCP112),
- Sampling for chemical and geotechnical testing of soils,
- Description of the ground encountered in accordance with BS5930:2015 + A1:2020, Code of Practice for Site Investigations.

Investigation locations are shown in **Figure 2** alongside the locations of the investigation works conducted by Geotechncis (2006). A more detailed view of the two potential bridge locations is given in **Figure 2A** (the culvert location) and **Figure 2B** (the 'piling mat' location).

Site Photographs are provided in **Appendix A**.

4.2 Dynamic (Window) Sample Boreholes

Eight windowless sampling boreholes (WS) were completed using a tracked windowless sample rig. The exploratory hole logs are presented in **Appendix B**.

4.3 Dynamic Probe

Two dynamic probe locations were completed due to shallow refusals at surface within the window sample boreholes. The rods were driven in with the number of blows recorded over 100mm increments to gather data at a greater depth and determine if bedrock was encountered. The logs are presented in **Appendix B**.

4.4 Advanced Continuous Surface Wave (ACSW)

Fourteen Advanced Continuous Surface Wave (ACSW) locations were undertaken using a non-intrusive in-situ testing method. The full report is presented in **Appendix C**.

4.5 CBR Values from Dynamic Cone Penetration Tests

Dynamic Cone Penetration Tests were carried out using the TRRL method from surface to a maximum depth of around 1.00m. The results are presented in **Table 4.1** below, and **Appendix D**.

Table 4.1: CBR values derived from DCP testing.

Location:	Depth (mm):	Estimated CBR value (%):
DCP101/WS104	0 – 364	37
	364 – 582	31
	582 – 698	61
DCP102/WS106	0 – 430	19
DCP103/WS107	0 – 530	6
	530 – 830	13
DCP106	0 – 535	4
	535 – 640	31
DCP107	0 – 266	13
	266 - 435	41
DCP108	0 – 266	26
	266 – 306	133
DCP109/WS108	0 – 236	17
	236 – 305	234
DCP110	0 – 150	51
	150 – 250	109
	250 – 525	67
DCP111	0 – 260	28
	260 – 290	68
DCP112	0 – 530	7
	530 – 700	28
	700 – 895	31
	Min	4
	Max	>100
	Average	40

4.6 Samples and Sample Containers

Soil samples for chemical analysis each comprised a pair of samples: a plastic tub for metals and inorganics and an amber glass jar for organics.

Soil samples were stored in cool boxes with ice packs and dispatched directly to the testing laboratory, for all phases of the investigation.

Samples for physical testing comprised of a tubs and bulk bags and were dispatched to the testing laboratory.

5 LABORATORY TESTING

5.1 Chemical Laboratory Testing

Chemical samples were submitted to a UKAS accredited laboratory in accordance with ISO17025 and are also MCERTS accredited for soil analysis in accordance with the Environment Agency's scheme. The laboratory carries out Quality Assurance and Quality Control in accordance with BS ISO 17025 and participate in external laboratory comparison and quality control schemes. Details of the accreditation and the methods of analysis are provided on the relevant test reports.

The selection of samples for laboratory testing and analytes to be determined were made based on historic mapping and relevant observations during the investigations. The sample selection rationale is as follows:

- To gain a good coverage across the Site of the various material types and strata encountered;
- To fully characterise the potential made ground materials within the identified higher-risk areas.
- To identify aggressive ground with regards to potential future infrastructure.

The selected soil samples were tested for a range of typical contamination indicators including specific tests for contaminants suspected as being present from historic mapping and observations made on-site. Tests were also performed which were used to support the modelling of contaminant transport and impacts (e.g. TOC) and for waste classification purposes.

Each of the soil samples were analysed for the 'total' concentration of a suite of potential contaminants.

The results of the laboratory analysis are presented in **Appendix E**. The various suites of analysis for the soil are presented in **Table 5.1** below:

Table 5.1: Suites of Analysis for Environmental Soil Samples

Determinand	Soil Suite 1
Number of Samples	13
Index Tests	
Asbestos Screen / Quantification	✓
pH	✓
Metals	
As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Zn (all totals)	✓
Inorganics	
Acid Soluble Sulphate	✓
Cyanide - Total	✓
Sulphate (2:1 extract on soil samples)	✓

Determinand	Soil Suite 1
Organics	
Phenols - Total (monohydric)	✓
Total Organic Carbon (TOC)	✓
PAH (Speciated USEPA 16)	✓

5.2 Physical Laboratory Testing

Samples were submitted to Professional Soils Laboratory (PSL) who are UKAS accredited in accordance with ISO17025. The following geotechnical testing was undertaken with the results of this testing presented in are presented in **Appendix F**. The various suites of analysis for the soil are presented in **Table 5.1**:

Table 5.2: Summary of Physical Testing

Determinant	Samples Used in Testing
Index Tests	
Atterberg	**5**
Moisture Content	**7**
PSD (Particle Size Distribution	**10**

6 GROUND CONDITIONS

6.1 General

The site investigations have allowed the site-specific ground conditions to be described and this information was used to provide an improved conceptual ground model. The geology encountered during the site investigations was generally consistent with existing publicly available information online on the British Geological Survey (BGS) GeoIndex (onshore) viewer. A summary of the general strata encountered across the site is provided in **Table 6.1** below, with more detailed description given in the following sub sections.

Table 6.1: Summary of Strata Encountered

Exploratory Hole Ref No.	Topsoil (mbgl)	Made Ground (mbgl)	Superficial Deposits (mbgl)	Bedrock (mbgl)
WS101	0.00 – 0.30	-	-	0.30 – 0.70
WS102	-	0.00 – 0.30	-	-
WS103	-	0.00 – 0.80	-	-
WS104	-	0.00 – 1.00	-	-
WS105	-	-	0.00 – 5.45	-
WS106	-	-	0.00 – 5.45	-
WS107	-	0.00 – 1.00	1.00 – 5.45	-
WS108	0.00 – 0.50	-	0.50 – 1.00	-
DCP04	0.00 – 0.70	-	0.70 – 0.80	-
DCP06	0.00 – 0.40	-	0.40 – 0.93	-
DCP07	0.00 – 0.30	-	0.30 – 0.42	-
DCP08	-	0.00 – 0.20	-	-
DCP10	-	0.00 – 1.00	-	-
DCP11	0.00 – 0.20	0.20 – 0.40	-	-
DCP12	0.00 – 0.50	-	0.50 – 1.00	-

6.2 Ground Surface / Topsoil

Topsoil was encountered within seven exploratory hole locations to a maximum depth of 0.70m bgl. The topsoil were generally described as;

- Soft black slightly sandy silty clay
- Loose dark brown sandy gravelly silt
- Loose sandy slightly clayey silt

6.3 Anthropogenic Materials

Made Ground and/or re-worked ground were encountered within seven of the exploratory holes across the site to a maximum depth of 1.00m bgl, and were generally described as;

- Loose brown sandy angular fine to coarse gravel of limestone.
- Loose grey sandy angular fine to coarse gravel of crushed slate.
- Loose brown sandy angular fine to coarse gravel.
- Brown clayey sandy gravel with cobbles of limestone and basalt.

6.4 Natural Deposits

Natural deposits were encountered within eight exploratory holes between from ground level and proven to 5.45mbgl. Superficial deposits were generally recorded as;

- Loose sandy silty clay.
- Black organic silty sand
- Loose gravelly fine to coarse sand.
- Dark grey silty sand
- Soft dark grey organic clay.

Organic rich strata were encountered from depths between 2.50mbgl and 3.60mbgl.

Soil classification tests were carried out on the Till samples which revealed all such samples to be a clay of intermediate plasticity, with liquid limits ranging from 40% to 60%, plastic limits ranging from 22% to 28%, a plasticity index between 18% and 32%, and a moisture content ranging from 20% to 53%. A classification test carried out on a sample from the sand encountered in WS105 and WS106 revealed a moisture content of 26% and 41% respectively. All results are presented in **Appendix F**.

6.5 Bedrock

Bedrock was encountered from 0.30mbgl in WS101 to a depth of 0.70mbgl, comprising grey weathered mudstone.

7 GENERIC QUANTITATIVE RISK ASSESSMENT

7.1 Assessment for the Protection of Human Health

The results of the soil analyses are presented below, where they have been compared to suitable generic assessment criteria (GACs), in order to allow a generic quantitative risk assessment (GQRA) to be carried out for the site and the proposed development.

The Category 4 Screening Levels (C4SLs) published by DEFRA (2014) have been adopted in the first instance, which have been published for six substances to date. Where a C4SL is unavailable, the “Suitable 4 Use Levels” (S4ULs) published by LQM/CIEH (2015) have been adopted.

These criteria have been derived using the CLEA model for a range of standard end-use scenarios and a range of soil organic matter (SOM) contents. It should be noted that the C4SL values are derived on the basis of a “low level of toxicological concern”, while the S4UL values are based on a “tolerable” or “minimal” level of risk. As such, the S4ULs describe a lower level of risk than the C4SLs, and are equivalent to the former Soil Guideline Values (SGVs, published by the Environment Agency) and the previous editions of the LQM/CIEH GAC values.

The GQRA is based on a soil with a Soil Organic Matter of 1.0%, for a public open space (residential) end use.

A full summary of the chemical test results is presented in **Appendix E**.

7.2 Restrictions

Areas were difficult to access due to dense vegetation and soft ground conditions along the proposed cycle track, as such several hand dug pits were undertaken along this length.

7.3 Results

All analysis sheets are presented in **Appendix E**.

Asbestos

Asbestos can be present in soil as fragments of bulk Asbestos Containing Materials (ACMs) (e.g., asbestos cement sheeting) and also as discrete asbestos fibres within the soil matrix.

This investigation has carried out assessments to determine whether both bulk fragments of asbestos and discrete fibres are present in the soil at the site. The asbestos assessment commenced on site with inspection of the Made Ground by our site staff for the presence of bulk ACMs. During the fieldwork no suspected ACMs were identified.

Laboratory assessments were carried out in order to confirm the site assessment that ACMs were absent, and no asbestos was detected in any of the samples retrieved from site.

Metals and PAHs

When compared to stringent assessment criteria for residential with home grown produce, no elevations were encountered in any of the 13 soil samples taken for metals or PAHs. As such the risk posed to ground workers and future site users is considered to be low.

Hydrocarbons

No visual or olfactory evidence of hydrocarbon contamination has been identified onsite. As such the risk posed to ground workers and future site users is considered to be low.

7.4 Assessment for the Protection of Controlled Waters

No evidence of significant mobile contamination was identified onsite.

7.5 Permanent Ground Gases

No significant thickness of putrescible made ground was encountered onsite.

It should also be noted that the proposed development is unlikely to involve confined spaces where gas could build up and pose a risk to site users.

7.6 Risks to Human Health (Construction Phase)

During the construction works there will be a risk from dust to on-site workers and people occupying adjacent properties. Appropriate risk assessments should be carried out by the contractor to allow appropriate controls for the mitigation of risk to health of construction workers to be put in place. This risk can be controlled to within acceptable limits by:

- Method statement for site activities including control of dust generation;
- Having adequate site hygiene facilities allowing staff to keep a good level of personal hygiene;

- The method statement shall have a contingency plan which should be implemented if the presence of significantly elevated levels of lead is suspected in groundworks; and
- Only permitting smoking or eating on site in appropriate pre-designated areas.

Given the location of the proposed works adjacent to the RSPB reserve, control of fugitive dust will be a priority. As a minimum it is anticipated the works will be undertaken in accordance with BRE best practise guidance, and that the following measures will be introduced to assist with control of dust generation during the groundworks phase of the works:

- Access roads and any stockpiles created during groundworks should be regularly damped down with water;
- Vehicles used to transport materials/wastes and aggregates should be enclosed or tarpaulined;
- Vehicle movements and speed should be kept to a minimum within the site ;
- Dust generating equipment (e.g., mobile crushing and screening equipment) should be located to minimise potential nuisance impacts to receptors as far as practicable; and
- Minimising drop heights of all loading and unloading activities that involve the transfer of soils and demolition materials.

7.7 Conceptual Site Model

The proposed development comprises a new hardstanding footpath and bridge.

The conceptual site model has been created from the findings of the Phase 2 site investigation, which revealed the following general downward succession:

- Site surface: topsoil/made ground (some locations);
- Tidal Flat Deposits: Encountered in eight locations, comprising Loose sandy clayey silt, black organic silty sand, loose gravelly fine to coarse sand, medium dense dark grey silty sand, soft dark grey organic clay.
- Bedrock: Encountered in a single location comprising weathered mudstone recovered as dense dark grey slightly clayey slightly sandy angular fine to coarse gravel.

The potential contamination at the site has been assessed using the contaminant-pathway-receptor linkage approach.

The results of site investigation and laboratory analysis generally record negligible to zero concentrations of potential contaminants.

Whilst unexpected contamination is not anticipated, the proposed development could encounter previously unrecorded hotspots of contaminants. These will be assessed and mitigated in accordance with current good practice.

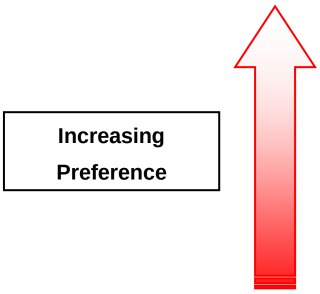
Hazard Identification				Hazard Assessment			
Link	**Contaminant**	**Pathway**	**Receptor**	**Probability**	**Consequence**	**Risk**	**Hazard Assessment**
1	Contaminated soil/groundwater Potential for Made Ground associated with existing structures. Metals, PAHs, TPHs, ACMs	Ingestion (via soil dust) and inhalation (via soil dust and vapours), ingestion through dirty hands, dermal contact with soil/water.	Humans using the site during construction.	Unlikely	Mild	Very Low	No history of polluting land use onsite. No elevated levels of contaminants present. **Recommendation:** Watching brief should be maintained during site works and GSL informed should contamination be identified.
2		Ingestion (via soil dust) and inhalation (via soil dust and vapours), ingestion through dirty hands, dermal contact with soil/water.	Humans using the site after development completion. No change of use.	Unlikely	Medium	Low	No history of polluting land use onsite. No elevated levels of contaminants present. **Recommendation:** No further works required.
3		Via service pipes	Humans using the site after construction. Building structures.	Unlikely	Mild	Very Low	No contamination present at pipeline depth (0.75-1.35mbgl). **Recommendation:** Should water pipes be installed a Risk Assessment should be undertaken. It is unlikely that barrier pipe will be required.
4		Migration of contaminated groundwater (vertical/lateral).	Surface water (Afon Ganol)	Low	Medium	Moderate / Low	No history of polluting land use onsite. No elevated levels of contaminants present. **Recommendation**: No further works required. Care must be taken during construction works to prevent hydrocarbon spillages.

Hazard Identification				Hazard Assessment			
Link	**Contaminant**	**Pathway**	**Receptor**	**Probability**	**Consequence**	**Risk**	**Hazard Assessment**
5	Potential hazardous gases from onsite made ground and potential offsite infilled features.	Migration and accumulation of hazardous ground gasses and vapours (vertical/lateral) leading to asphyxiation (carbon dioxide) and explosion (methane, hydrocarbons).	Humans using the site during construction and after development completion.	Unlikely	Severe	Moderate / Low	No putrescible made ground encountered during site investigation works but organic/alluvium deposits identified. No confined spaces in the proposed development. **Recommendation**: No further works required.
6	Radon	Migration and accumulation of hazardous ground gasses and vapours (vertical/lateral) leading to asphyxiation (carbon dioxide) and explosion (methane, hydrocarbons).	Humans using the site after development completion.	Likely	Severe	**High**	Radon risk is 10-30% of estimated properties affected. No confined spaces in the proposed development. **Recommendation:** Radon protection required should confined spaces and buildings be constructed.
7	Aggressive ground conditions	Direct contact with infrastructure.	Building structures	Likely	Medium	Moderate	No elevated levels of Sulphate or low pH encountered across the majority of the site. Elevated sulphate within the organic Silts and potential brackish environment. **Recommendation:** Sulphate resistant concrete DS-3 AC-2 required where infrastructure in contact with the organic Silts. DS-1 AC-1s acceptable elsewhere onsite.

8 WASTE ASSESSMENT

8.1 Waste Hierarchy

In accordance with government guidance, it is required that the production and disposal of waste is managed in accordance with the following hierarchy of preference:



AVOIDANCE

REDUCTION

RE- USE

RECOVER (including RECYCLING)

DISPOSAL (the final option)

8.2 Waste Characterisation and Classification

If there is a portion of excess soil this will then have to be sent to a suitable landfill site. A two-phase approach is required comprising:

- Waste Characterisation; and
- Waste Classification (Waste Acceptance Criteria).

Waste Characterisation

The results of the total concentrations from the chemical testing on soil samples have been assessed to determine whether or not they are hazardous in terms of waste classification. The results of this assessment indicate that the materials encountered during the investigation can be classified as non-hazardous.

Waste Classification

In order to determine whether soils can be sent to a licensed landfill for disposal further testing is required comprising landfill Waste Acceptance Criteria (WAC) analysis for both total concentrations for certain chemicals and for leachate analysis. No WAC testing was carried out as part of this investigation. WAC testing will have to be carried out to confirm the landfill waste classification and if any pre-treatment is required. This is best carried out once all material to be disposed of is stockpiled, and volumes can be accurately assessed. It should be noted that natural clay can be classified as Inert Waste 17 05 04: Soil and stones only (excluding topsoil, peat, soil and stones).

Testing Frequency

There are also set requirements for the required sampling and testing frequencies for materials being sent for disposal at landfills. The required testing frequencies for each different waste type are summarised in **Table 8.1** below.

Table 8.1: Laboratory Sampling Testing Frequencies

Testing Level	Quantity of Waste	Number of Samples	
		Homogeneous	Heterogeneous & New Wastes
Level 1 Characterisation (Description, Total Concentrations & Leaching)	<100T	2	5
	<500T	3	8
	<1000T	5	14
	10,000 T	11	22
	Per additional 10,000T	+5 pro rata	+10 pro rata
Level 2 Compliance For Regularly Generated Wastes (Total Concentrations & Leaching)		1 per defined waste sub-population per year	3 per defined waste sub-population per year
Level 3 Verification Delivery document & visual check Chemical testing as per Level 2 suite		Visual – Each Load	Visual – Each Load
		1 per year per waste stream	3 per year per waste stream

Further information is provided in **Appendix G.**

9 GEOTECHNICAL ASSESSMENT AND RECOMMENDATIONS

9.1 Fieldwork and Laboratory Data Review

The proposed development includes the construction of a cycle path and two bridges.

No loading information has been provided for this report.

The shallow ground conditions predominantly comprise topsoil and made ground to a maximum depth of between 0.70m and 1.00mbgl.

Topsoil were generally recorded as dark brown sandy gravelly clayey silt topsoil varying in thickness from 0.20m to 0.70m. Made Ground were generally recorded as brown sandy gravel varying in thickness from 0.20m to 1.00m.

The drift deposits have been confirmed to comprise loose to dense brown fine to coarse sand proven to 5.45m.

The natural clay should prove suitable for the proposed development foundations. However, due to the presence of a range of trees, the depth of desiccation and the volume change potential of the clays will have to be considered in the design. The classification test results on the clay strata are summarised below:

Table 9.1: Summary of Classification Testing

Hole	Depth (m)	Moisture Content (%)	% passing 425um sieve	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Modified Plasticity Index	Plasticity	Volume Change Potential
WS105	0.00-1.00	45	100	40	22	18	18	CI	Low
WS105	1.00-2.00	53	100	46	25	21	21	CI	Medium
WS105	2.00-3.00	51	100	45	25	20	20	CI	Medium
WS105	3.00-4.00	41	100	60	28	32	32	CH	Medium
WS106	0.00-1.00	20	83	48	26	22	18.26	CI	Low
Minimum		20	83	40	22	18	18	-	-
Average		42	96.6	47.8	25.2	22.6	21.85	-	-
Maximum		53	100	60	28	32	32	-	-

Testing shows that the clay strata has a medium volume change potential. It is recommended that, should shallow foundations be employed as part of these works, that foundations are suitably deepened to take into account trees within influencing distance in line with NHBC Chapter 4.

In total 11no. tests using the ACSW were undertaken and a range of data was gathered.

In CSW01 and CSW01B, poor results were recorded where the combination of shallow bedrock, traffic vibrations of a nearby road and several shallow water pipes were present. WS101 undertaken in this area suggests that competent bedrock is present at 0.70mbgl. Sections of the shaley Mudstone can be seen at the surface, at the base of the nearby drystone wall.

In CSW02, CSW02A, CSW02B, CSW02C and CWS04 poor data was obtained, likely due to the presence of the armour stone along the Afon Ganol.

High quality data was acquired in CSW10, 11, 11A and 12.

The relationship between the Shear Wave Velocity and the Undrained Shear Strength (S_u) is shown in the equation below (Wair, DeJong and Shantz, 2015):

$V_s = 23\ S_u^{\ 0.475}$

The approximate relationship between the Sear Wave Velocity and the corrected SPT 'N' Value (N_{60}) is shown in the equation below (Wair, DeJong and Shantz, 2015):

$V_s = 131\ N_{60}^{\ 0.205}$

Using these equations, and the average shear wave velocity with depth, the following parameters have been calculated and presented in **Table 9.2**.

Table 9.2: Summary of ACSW Values

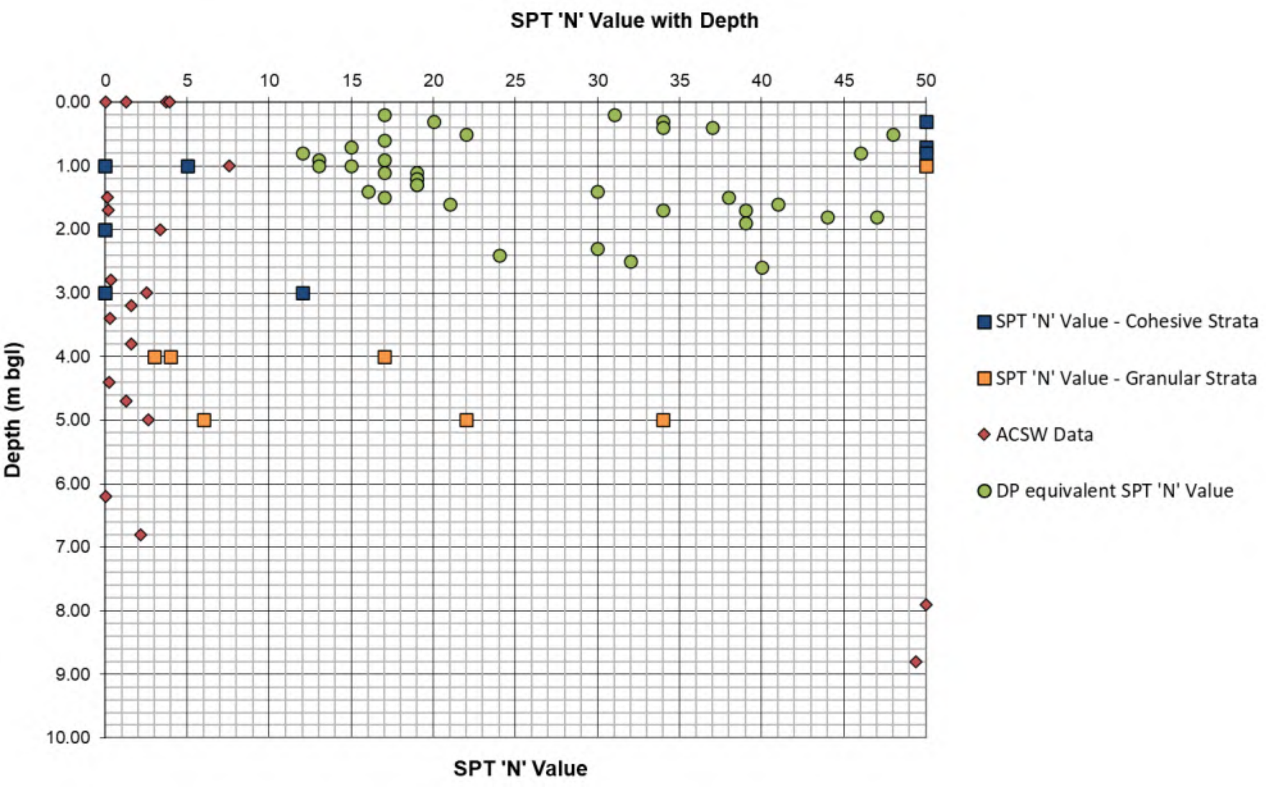
Location	Depth (m bgl)	Vs (m/s)	Strain Softened Youngs Modulus (MPa)	Equivalent Undrained Shear strength (kPa)	Equivalent SPT 'N' Value	Likely Strata
CSW10	0.00-1.50	138	29.5	43.58	1.30	MG: Rock armour
	1.50-3.40	90	12.5	17.61	0.16	SILT
	3.40-4.40	103	16.3	23.27	0.30	SILT
	4.40-5.30	97	14.4	20.50	0.23	SILT
CSW11	0.00-1.00	171	45.4	68.60	3.71	MG: Granular pile mat
	1.00-3.00	198	60.8	93.32	7.57	MG?
	3.00-5.00	158	38.7	58.01	2.52	SILT
	5.00-6.80	160	39.4	59.15	2.63	SILT
	6.80-8.80	153	36.3	54.26	2.15	SILT
	8.80-10.6	291	131.2	209.67	49.38	Bedrock
CSW11A	0.00-2.00	174	46.5	70.46	3.95	MG: Granular pile mat
	2.00-3.20	168	43.7	65.93	3.38	MG?
	3.20-4.70	144	32.1	47.64	1.59	SILT
	4.70-6.20	138	29.2	43.15	1.27	SILT
	6.20-7.90	68	7.2	9.94	0.04	SILT
	7.90-9.50	564	490.8	840.97	50.00+	Bedrock

Location	Depth (m bgl)	Vs (m/s)	Strain Softened Youngs Modulus (MPa)	Equivalent Undrained Shear strength (kPa)	Equivalent SPT 'N' Value	Likely Strata
CSW12	0.00-1.70	70	7.5	10.34	0.05	SILT
	1.70-2.80	92	13.0	18.34	0.17	SILT
	2.80-3.80	104	16.7	24.01	0.33	SILT
	3.80-4.60	144	32.0	47.41	1.58	SAND

SPT 'N' values were recorded throughout each borehole and are summarised in **Table 9.3** below for the material encountered.

Equivalent 'N' values have also been added for the Dynamic Probe data and for the ACSW.

Table 9.3: Summary of SPT 'N' Values



The SPT 'N' values vary within the silt/clay from 0 to 12 with an average of 10, and in the gravel with a value of 50. There is no general trend to the SPT N values.

Generally where the natural silt is encountered the 'N' values are low which matches the consistencies encountered and the ACSW data. At a depth of around 4.00m to 5.00m below ground level slightly stronger sand is encountered, however this may not be a particularly thick strata based on both the ACSW data and the Geotechncics report (Ref: PN050995, dated January 2006).

Both the granular ‘pile mat’ and the rock armour surrounding the Afon Ganol appear to be a significant thickness. This is confirmed by the investigation works presented in the Geotechncics report. Where the ‘rock armour’ was encountered at the surface along the sides of the Afon Ganol and in the ‘piling mat’ area, it was attempted in two locations to drive the Dynamic Probe rods through this. Data from these locations suggests that the material is at least 2.50m thick. Two rotary holes were undertaken by Geotechncics show the ‘rock armour’ to be 4.00m thick.

9.2 Trees

A number of mature trees and bushes are located on or adjacent to the field boundaries. A comprehensive tree survey of those trees within the site boundary, and up to 20m beyond the site boundary (assuming mature high water demand trees are not present along the boundary) will be required to determine the effect of existing trees to proposed properties and also to assess the condition of trees which are to remain.

Any proposed felling or removal of trees or hedgerows should be agreed with the Local Authority as part of the pre-planning discussions for development and should be carried out outside the bird nesting season (it may be possible that tree felling can be carried out during the bird nesting season under the direction of an ecologist).

Care must be taken to ensure that any existing trees scheduled for retention are not adversely affected by construction operations. Further guidance on this aspect of site works is given in the British Standards “Guidance for Trees in Relation to Constructions”, BS5837.

9.3 Foundation Recommendations

While loads of the proposed bridge structures have not been given, the ground conditions in the vicinity of the two bridge structures shall be assessed and, based on the information available, likely bearing capacities and foundation solutions shall be recommended.

It is anticipated that, where shallow bedrock is present, traditional shallow strip foundations directly onto the bedrock should be suitable. Based on visual identification of the rock present onsite, and Annex G of BS EN 1997-1:2004+A1:2013, the shaley mudstone present onsite would be classed as a Group 3 rock which even with a moderately weak strength and closely spaced discontinuities should provide a bearing capacity of around 500kPa for a pad foundation with settlement of less than 0.5% of the foundation width. Where encountered the depth of bedrock in mAOD has been shown in **Figure 3A** and **Figure 3B**.

Where deep soft organic silts are present, a piled solution is recommended.

In order to limit the potential for differential settlement it is recommended that foundations should not bridge two differing strata.

When footings have been initially sized then full design of these should be carried out in accordance with BS EN 1997-1: 2004+A1 2013: Eurocode 7 – Geotechnical Design – Part 1: General rules (including UK National Annex of November 2007) and BS8004:2015: Code of practice for foundations.

9.4 Reuse of Materials

It may be possible to reuse the materials present onsite in the proposed development. The granular made ground could be excavated, processed and recompacted in line with a suitable specification in order to provide either a suitable development platform for spread foundations or a piling mat.

9.5 Groundwater Conditions

It is assumed that all groundwater in the site area is likely to be tidally influenced and may, depending on the current sea level, range significantly. It is unlikely that traditional sump and pump methods will be effective in these conditions.

9.6 Groundwater & Excavations

Should deep excavations be required additional temporary works may be required to help prevent water ingress and stabilise the sides of any excavation.

Excavations through the soils to a depth of about 2.0m should be stable in the short term (up to 3 to 4 hours). However, it is anticipated that these will gradually collapse into excavations, leading to instability of the sides of excavations. All excavations should be carried out in accordance with CIRIA Report 97 “Trenching Practice” and BS6031: 2009: Code of Practice for Earthworks. Further guidance on this aspect of site works is given in the British Standards for “Workmanship on Building Sites”, BS 8000, Parts 1 and 14, and in the Construction Industry Training Board’s Site Safety Note 10.

Excavation depths should generally be readily achieved using conventional hydraulic plant (e.g. wheeled JCB or similar) although larger plant will have higher excavation rates.

Care will need to be required if excavations are to be undertaken in the areas of large bounders (armour stone) along the Afon Ganol and excavations in this material are likely to become wider rather than deeper and may negatively affect nearby features such as the river or the railway line.

9.7 Buried Concrete and Pipework

An assessment of the soil and groundwater data (following the protocol established in BRE Special Digest 1, 2005) indicates that ACEC Class AC-1 conditions prevail across the majority of the site.

However, 1.78g/l of sulphate was encountered in WS105 at 1.00-2.00mbgl. While this is only one location it is recommended that, should infrastructure be installed at this location or within the organic silt strata, DS-3 AC-2 sulphate resistant concrete is used.

Any concrete to be used in this development should be designed with the potential for brackish water to be present. The less resistant a type of cement is to salt-water aggression the more important it is that the permeability of the concrete is low. Standard Portland cement concrete can exhibit satisfactory resistance to salt-water attacks if made sufficiently impermeable. One of the main problems is the attack on the steel reinforcement within the concrete by chloride ions. Generally minimum concrete cover for reinforcement is generally given as 55mm for a design life of 100 years, however a minimum of 120mm is recommended for a maritime structure within the tidal zone. It is recommended that this later more conservative thickness is used where concrete may be submerged in groundwater that is in continuity with the sea and tidally influenced.

9.8 Soakaways

While no soakaway or permeability testing has been undertaken onsite it is unlikely that soakaways will be a viable form of drainage onsite due to the high recorded water levels encountered in investigation locations and the tidally influenced groundwater.

9.9 Road Design

The results of in situ CBR tests range between 4% to >50%. Topsoil will be removed as part of the site strip and preparation so the upper 350mm has been discounted. Values in the underlying clays showed significant variation, however, it is anticipated the exceptionally high values are more likely as a result in encountering gravel or cobble sized material rather than indicative of the overall subgrade condition and the lower CBR values are more indicative of the formation materials. The performance of any hard standing will be determined by the weaker areas, therefore based upon the nature of the ground conditions encountered during the site investigations undertaken, it is recommended that a lower bound CBR value of 4% is adopted for design purposes. All exposed formations should be proof rolled and any soft spots revealed should be excavated and replaced with suitable compacted granular fill.

10 CONCLUSIONS AND RECOMMENDATIONS

10.1 Environmental Risk Assessment

A Phase 2 intrusive investigation was carried out to develop a comprehensive conceptual ground model of the site. This detailed the characteristic ground conditions and elements of the surrounding environment and has assisted with identifying the potential contaminants of concern, the potential receptors of the contaminations and the pathways between them.

The results of site investigation and laboratory analysis generally record negligible to zero concentrations of potential contaminants.

Whilst unexpected contamination is not anticipated, the proposed development could encounter previously unrecorded hotspots of contaminants. These will be assessed and mitigated in accordance with current good practice.

It should be noted that the Radon potential in this area is high. Should the proposed development change and buildings be constructed, ‘full’ Radon Protection measures would need to be installed.

Due to the proximity of the Afon Ganol it is recommended that care is taken during the proposed works to ensure that no hydrocarbon contamination enters the water course. This can be mitigated by good environmental practices and the use of spill kits .

10.2 Geotechnical Design

Where competent bedrock is encountered traditional spread foundations are likely suitable for the proposed development.

Where the granular made ground ‘armour rock’ is present along the Afon Ganol and the ‘piling mat’ location, it may be possible to excavate and recompact these granular materials to a suitable specification in order to allow the use of spread foundations. This will be dependent on the proposed loads of the new structure.

Where the organic Silt deposits are present it is likely that piled foundations will be required to transfer the load to bedrock.

An assessment of the soil and groundwater data (following the protocol established in BRE Special Digest 1, 2005) indicates that ACEC Class AC-1 conditions prevail. However, in one location (WS105 at 1.00-2.00m) high levels of sulphate were encountered. Should infrastructure be installed at this location or within the organic silt strata is it recommended that DS-3 AC-2 sulphate resistant concrete is used.

Due to the brackish conditions, and likely continuity of the groundwater and the sea, special precautions may be required at the site for the design of concrete in terms of the durability and structural performance.

10.3 Regulatory Liaison

Any proposals to remediate or develop the site should be agreed with the relevant authorities (e.g., local authority environmental health officer, Environment Agency etc) to obtain Planning Permission prior to commencement of the works and should be agreed with the NHBC or similar, or with the local authority building control officer prior to commencement of the works. Where remediation works are required, a verification report should be submitted to the relevant authorities for approval in accordance with relevant Planning Conditions.

10.4 Health and Safety

As outlined within the HSE publication “Successful Health and Safety Management – HSG65” this report should inform your development of safe systems of work and information as an input into the safety management system. The contents of this report may be used to supplement the contents of the Health and Safety File as required under the Construction Design and Management (CDM) Regulations 2015. All risk control measures should be in accordance with the guidelines laid down within the Management of Health and Safety at Work Regulations 1999.

In accordance with the Construction Design and Management (CDM) Regulations 2015, Groundsolve has acted in the role of Principal Contractor and as Principal Designer for the works as described in this report. With issue of this report, GroundSolve has discharged and completed all contractual and legal requirements for these positions, and we have no further involvement with the project.

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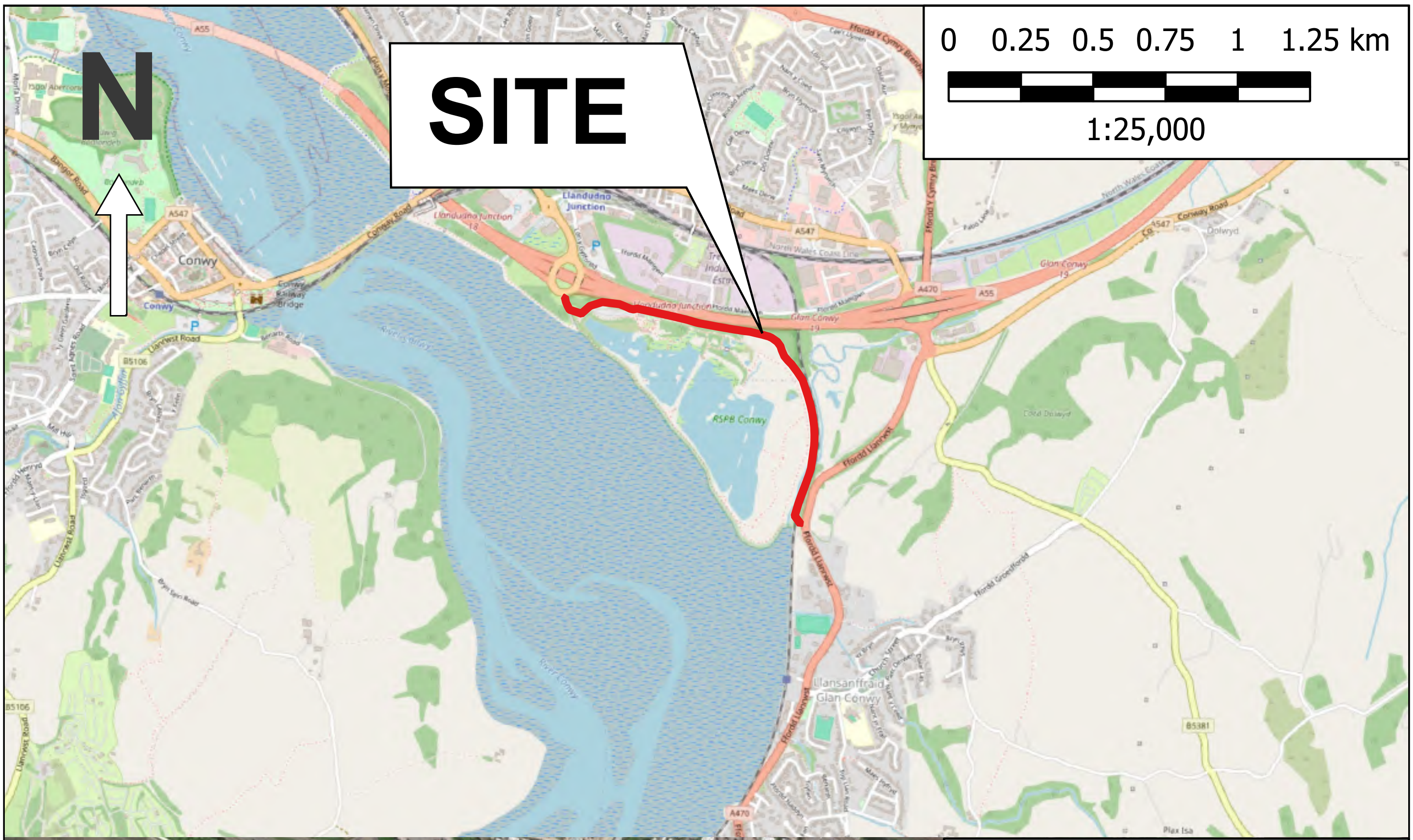
12 DEFINITIONS

AOD	Above Ordnance Datum
bgl	Below ground level
BGS	British Geological Survey
BRE	Building Research Establishment
CBR	California Bearing Ratio (test)
COMAH	Control of Major Accident Hazards (regulations)
DQRA	Detailed Quantitative Risk Assessment
DWS	Drinking Water Standard
EQS	Environmental Quality Standard
GAC	Generic Assessment Criterion
GQA	General Quality Assessment (Environment Agency)
GQRA	Generic Quantitative Risk Assessment
GSV	Gas Screening Value
HCV	Health Criteria Value
IPPC	Integrated Pollution Prevention and Control (regulations)
NGR	National Grid Reference
NIHHS	Notification of Installations Handling Hazardous Substances (regulations)
OS	Ordnance Survey
ppm	Parts per million
ppmv	Parts per million by volume
SAC	Special Area of Conservation
SPZ	Source Protection Zone (see **Error! Reference source not found.**)
SSAC	Site-Specific Assessment Criterion
SSSI	Site of Special Scientific Interest

FIGURES



KEY

🟥 Site Location

(C) OpenStreetMap Contributors

Sampling locations and features annotated are approximate and are based upon observed measurements unless otherwise stated. Do not scale from this drawing and work from marked dimensions only. All dimensions and features should be confirmed on site by the Contractor.

Client: Conwy County Borough Council

Site: RSPB Conwy

Title: Site Location and Boundary Plan

Job No.: GSL 2996

Drawn By: PW

Checked By: SF

Drawn: Mar 2024

Scale (see scale bar):
1:25,000 @ A4
1:1,000 @ A4

Figure: 1

Revision:

GroundSolve Ltd
Consulting Geotechnical Engineers

KEY

▭ Proposed Route

● Window Sample Location

● DCP Location

● ACSW Location

◆ Trial Pit (2006)

◆ Bore Hole (2006)

(C) OpenStreetMap Contributors

Sampling locations and features annotated are approximate and are based upon observed measurements unless otherwise stated. Do not scale from this drawing and work from marked dimensions only. All dimensions and features should be confirmed on site by the Contractor.

Client: Conwy County Borough Council

Site: RSPB Conwy

Job No.: GSL 2996

Drawn By: PW

Checked By: SF

Drawn: Mar 2024

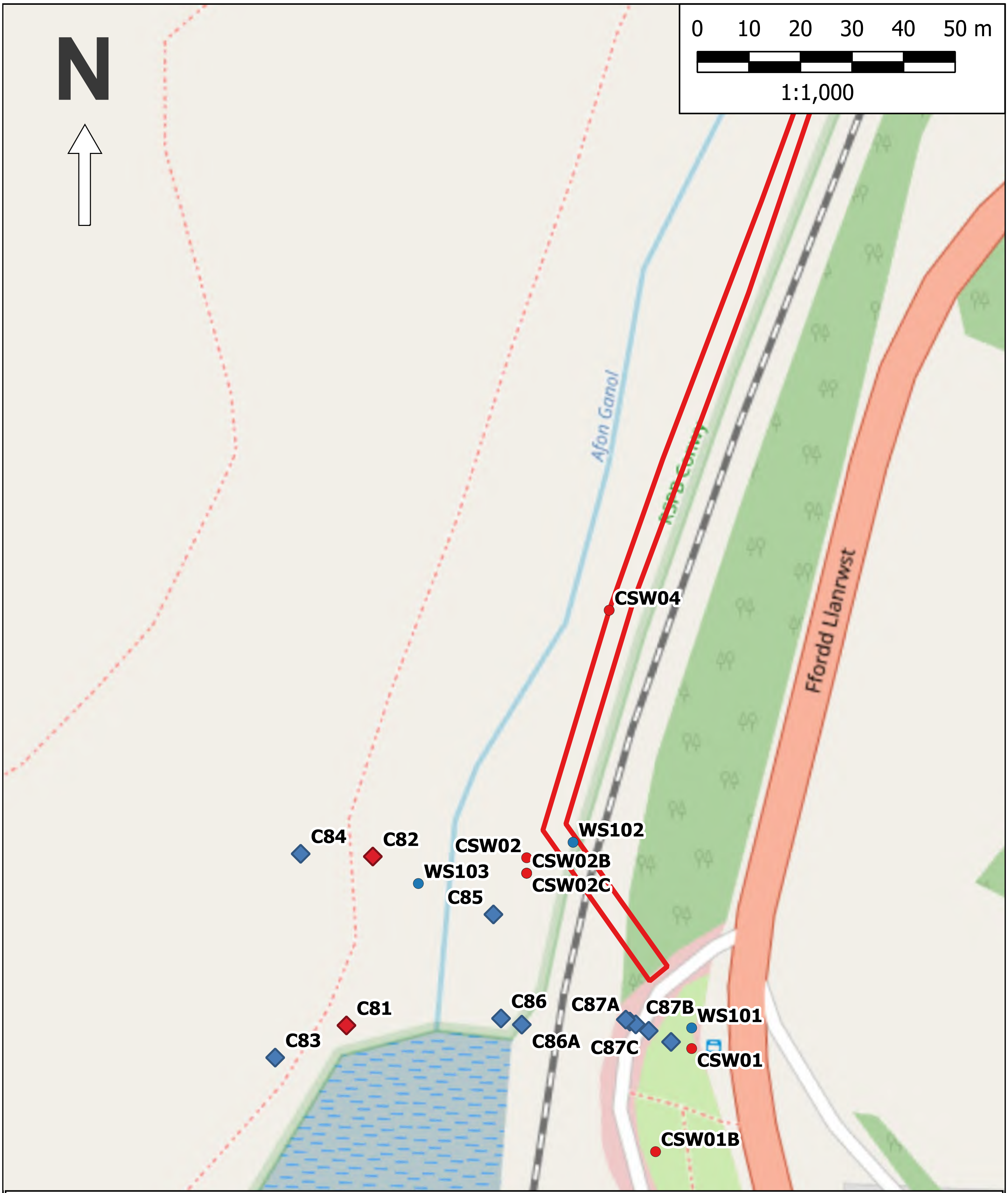
Title: Sampling Location Plan

Scale (see scale bar): 1:5,000 @ A4

Figure: 2

Revision:

GroundSolve Ltd
Consulting Geotechnical Engineers



KEY

▭ Proposed Route

🔵 Window Sample Location

🟢 DCP Location

🔴 ACSW Location

🔷 Trial Pit (2006)

♦ Bore Hole (2006)

(C) OpenStreetMap Contributors

Sampling locations and features annotated are approximate and are based upon observed measurements unless otherwise stated. Do not scale from this drawing and work from marked dimensions only. All dimensions and features should be confirmed on site by the Contractor.

Client: Conwy County Borough Council

Title: Sampling Location Plan

Site: RSPB Conwy

Job No.: GSL 2996

Drawn By: PW

Checked By: SF

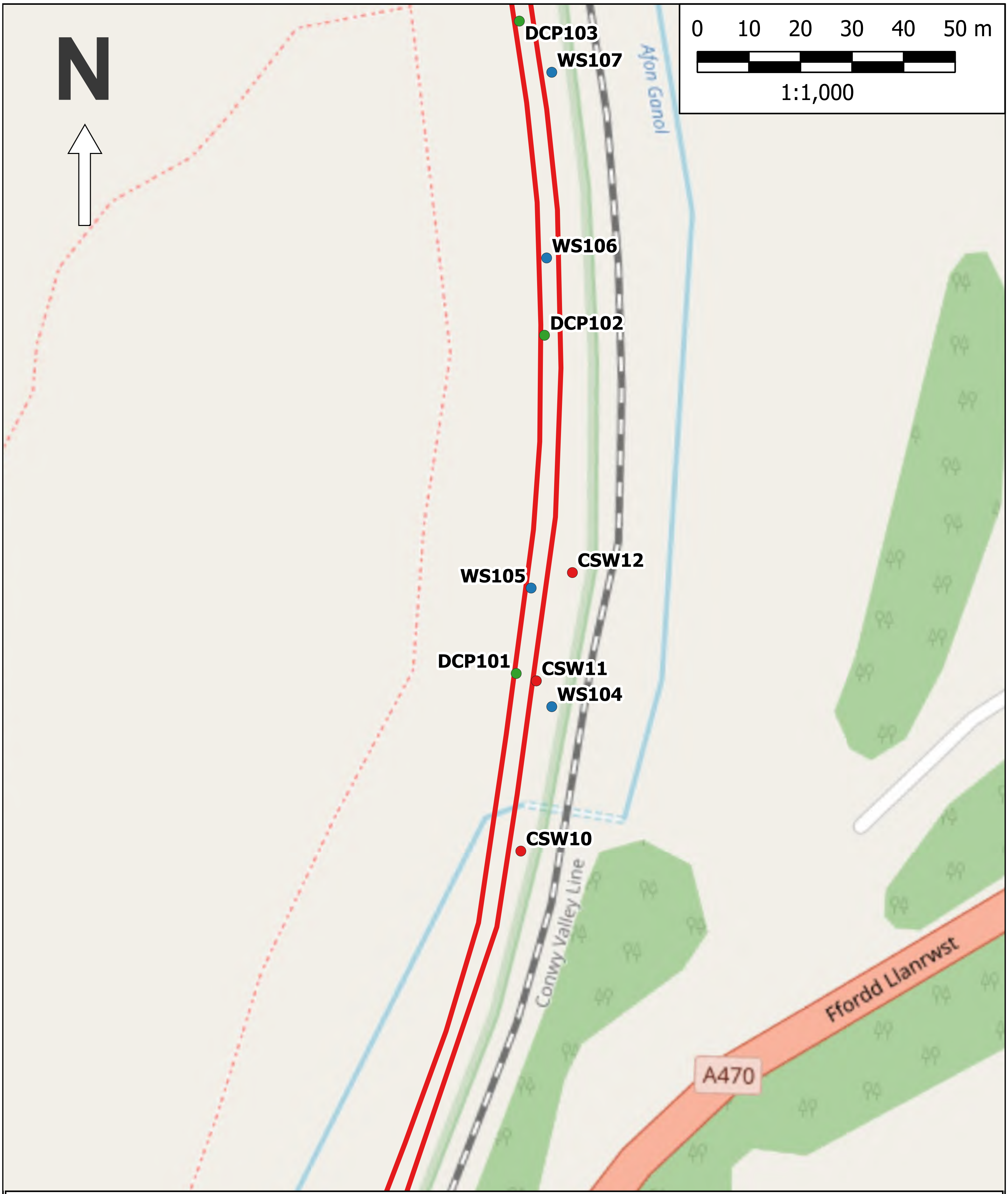
Drawn: Mar 2024

Scale (see scale bar): 1:1,000 @ A4

Figure: 2A

Revision:

GroundSolve Ltd
Consulting Geotechnical Engineers



KEY

● Window Sample Location

● DCP Location

● ACSW Location

◆ Trial Pit (2006)

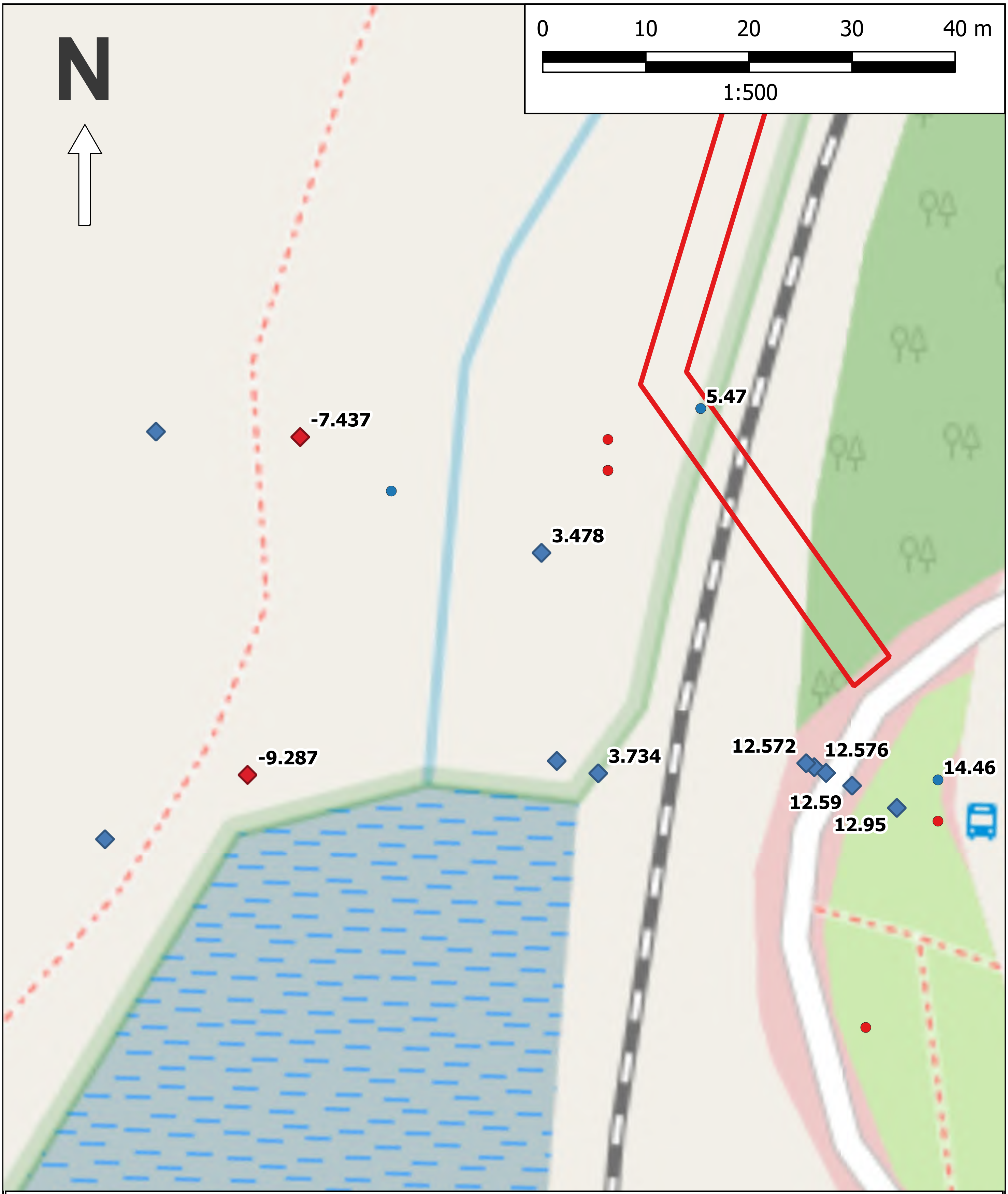
◆ Bore Hole (2006)

▭ Proposed Route

(C) OpenStreetMap Contributors

Sampling locations and features annotated are approximate and are based upon observed measurements unless otherwise stated. Do not scale from this drawing and work from marked dimensions only. All dimensions and features should be confirmed on site by the Contractor.

Client: Conwy County Borough Council				Title: Sampling Location Plan			GroundSolve Ltd Consulting Geotechnical Engineers
Site: RSPB Conwy							
Job No.: GSL 2996	Drawn By: PW	Checked By: SF	Drawn: Mar 2024	Scale (see scale bar): 1:1,000 @ A4	Figure: 2B	Revision:	



KEY

▭ Proposed Route

● Window Sample Location

● DCP Location

● ACSW Location

◆ Trial Pit (2006)

◆ Bore Hole (2006)

Sampling locations and features annotated are approximate and are based upon observed measurements unless otherwise stated. Do not scale from this drawing and work from marked dimensions only. All dimensions and features should be confirmed on site by the Contractor.

Client: Conwy County Borough Council

Site: RSPB Conwy

Job No.: GSL 2996

Drawn By: PW

Checked By: SF

Drawn: Mar 2024

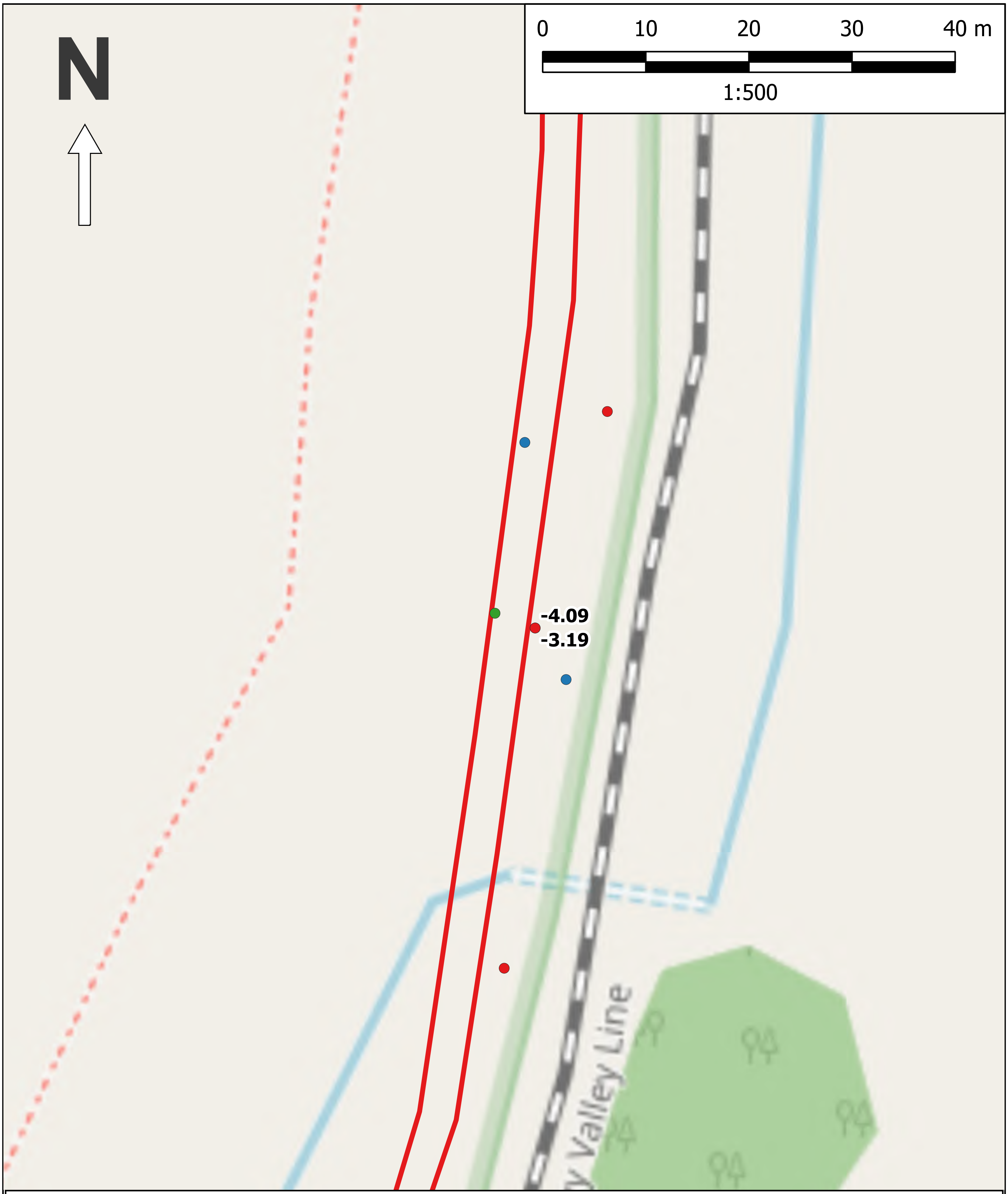
Title: Depth to Bedrock mAOD

Scale (see scale bar): 1:500 @ A4

Figure: 3A

Revision:

GroundSolve Ltd
Consulting Geotechnical Engineers



KEY

▭ Proposed Route

● Window Sample Location

● DCP Location

● ACSW Location

◆ Trial Pit (2006)

◆ Bore Hole (2006)

(C) OpenStreetMap Contributors

Sampling locations and features annotated are approximate and are based upon observed measurements unless otherwise stated. Do not scale from this drawing and work from marked dimensions only. All dimensions and features should be confirmed on site by the Contractor.

Client:
Conwy County Borough Council

Site:
RSPB Conwy

Job No.: GSL 2996
Drawn By: PW
Checked By: SF
Drawn: Mar 2024

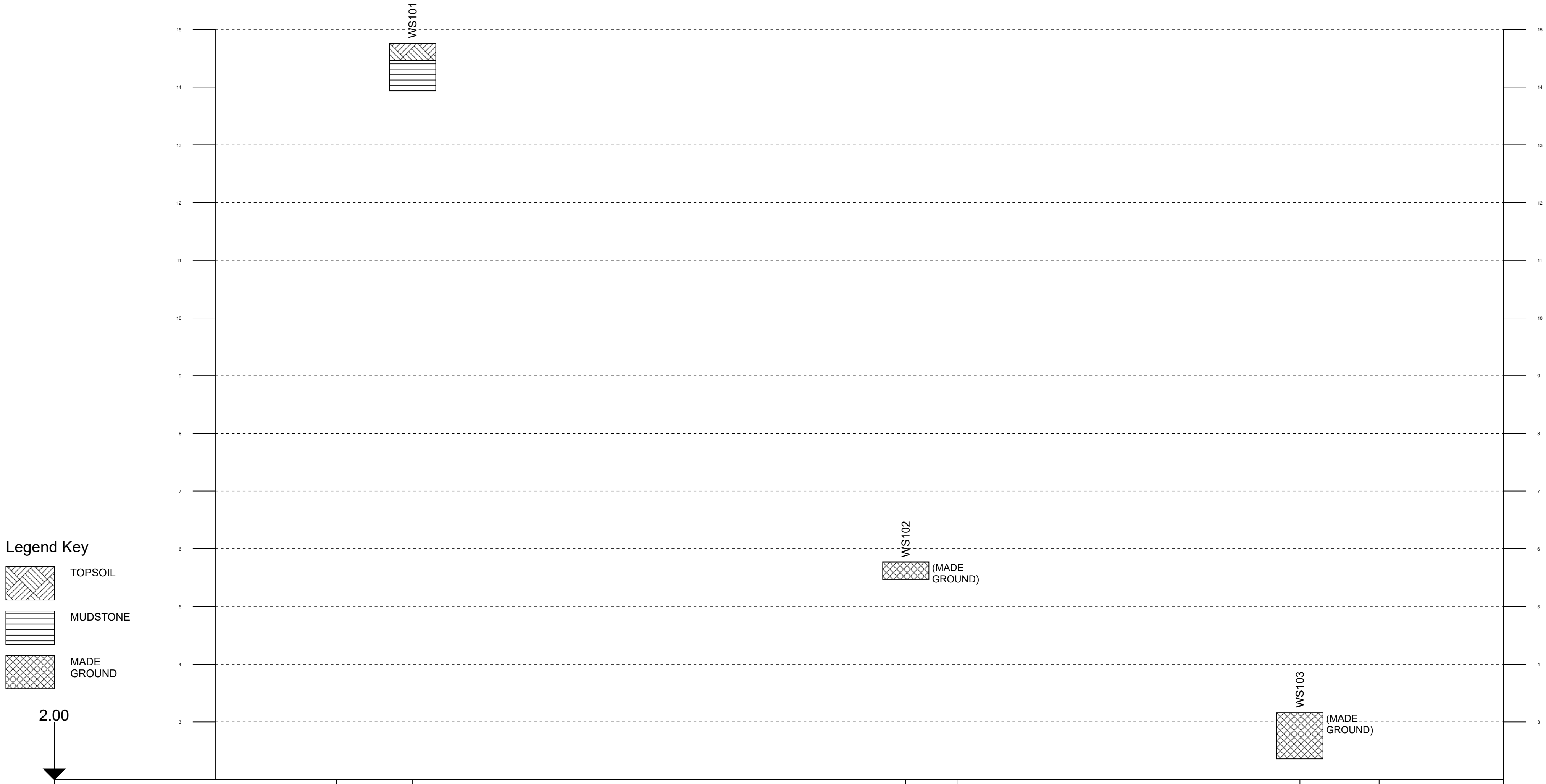
Title:
Depth to Bedrock mAOD

Scale (see scale bar): 1:500 @ A4
Figure: 3B
Revision:

GroundSolve Ltd
Consulting Geotechnical Engineers

Project Id: 2996
Project Title: Conwy active travel
Location: RSPB Conwy
Client: Conwy CBC

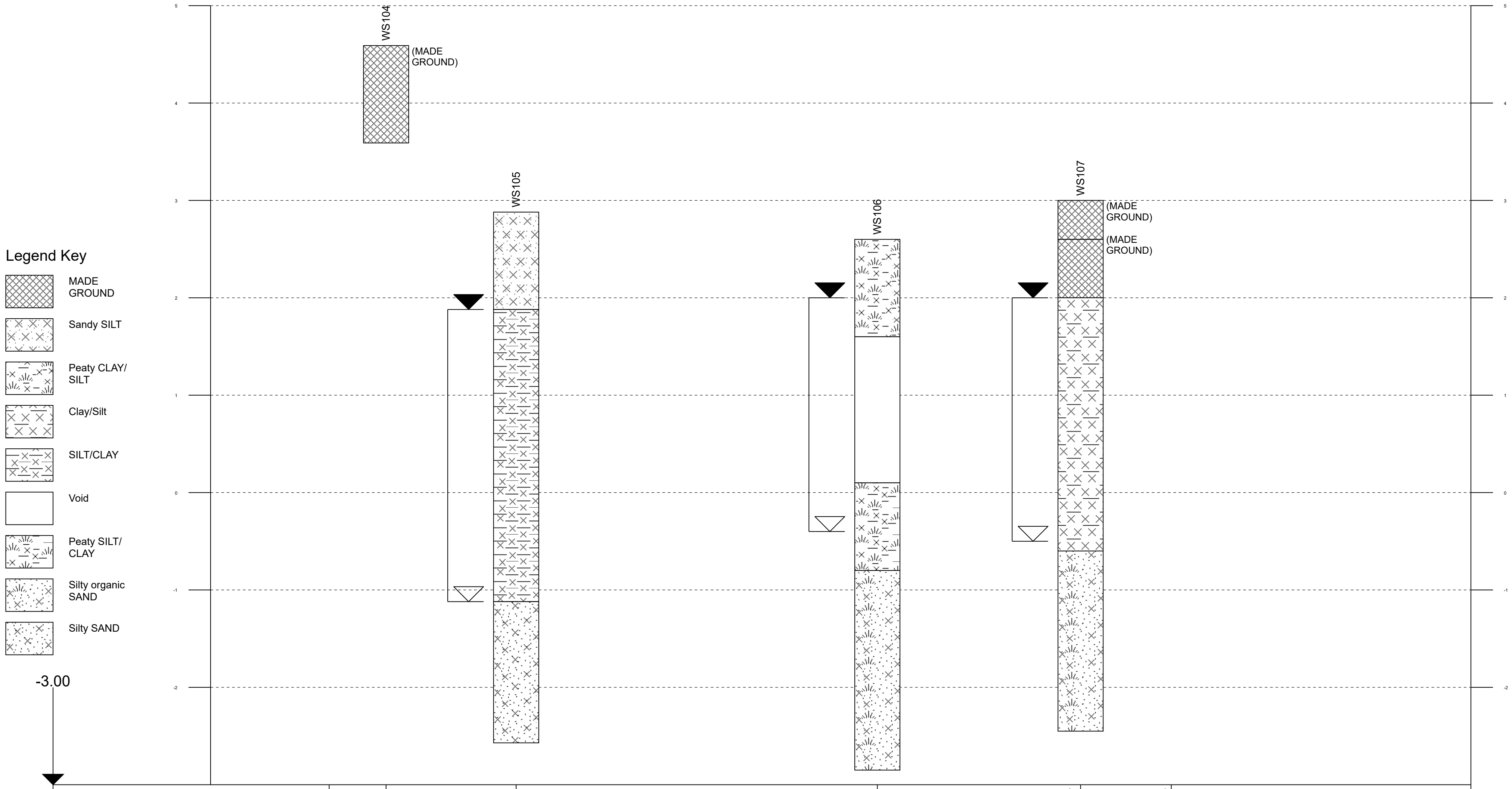
Title: Section Line
Vertical Scale: 1:100
Horizontal Scale: 1:500
Engineer:



Chainage (m)	0.00	6.60	49.31	53.75	83.46	90.31
Elevation (mAOD)		14.76	5.77		3.16	
Offset (m)		0.61	0.21		0.97	

Project Id: 2996
Project Title: Conwy active travel
Location: RSPB Conwy
Client: Conwy CBC

Title: Section Line
Vertical Scale: 1:58
Horizontal Scale: 1:1000
Engineer:



Chainage (m)	0.00	10.08	33.12	97.08	133.07	149.14
Elevation (mAOD)		4.59	2.88	2.60	3.00	
Offset (m)		1.32	5.11	1.50	0.16	

APPENDIX A – SITE PHOTOGRAPHS

Photo Locations

Photo 1

Photo 2

SITE PHOTOGRAPHS

Photo 3

Photo 4

Photo 5

APPENDIX B – EXPLORATORY HOLE RECORDS

GroundSolve Ltd

Machine Dug Trial Pit Record

DCP104

Project Name: Conwy active travel	Client: Conwy CBC	Date: 26/01/2024
Location: RSPB Conwy	Contractor: D and I Drilling	Co-ords: E280268.00 N377150.00
Project No. : 2996	Crew Name:	Equipment: Hand Tools

Location Number	Location Type	Level	Logged By	Scale	Page Number
DCP104	TP	3.58m AoD	AB	1:25	Sheet 1 of 1

Backfill/ Instal'n	Water Strikes	Sample and In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
▨	▼						▨	Soft black slightly sandy slightly silty CLAY. Sand is fine.
								Becomes gravelly from 0.65m to 0.75m
					0.75	2.83	⁘	Medium dense greyish brown silty SAND. Sand is fine to coarse.
					0.80	2.78		End of Trial Pit at 0.800m

Dimensions		Trench Support and Comment			Pumping Data		
Pit Length	Pit Width	Pit Stability	Shoring Used	Remarks	Date	Rate	Remarks
0.50	0.50	Stable					

Remarks

Groundwater encountered at 0.65m.
Hole terminated at 0.80m due to collapse below water level.

GroundSolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton
CH4 0DH

DCP104

DCP104

GroundSolve Ltd

Machine Dug Trial Pit Record

DCP106

Project Name: Conwy active travel	Client: Conwy CBC	Date: 26/01/2024
Location: RSPB Conwy	Contractor: D and I Drilling	Co-ords: E280166.00 N377301.00
Project No. : 2996	Crew Name:	Equipment: Hand Tools

Location Number	Location Type	Level	Logged By	Scale	Page Number
DCP106	TP	6.54m AoD	AB	1:25	Sheet 1 of 1

Backfill/ Instal'n	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
▨					0.40	6.14	▩	Grass over loose dark brown sandy gravelly SILT. Sand is fine to coarse. Gravel is angular fine to coarse of limestone. (MADE GROUND)
▨					0.93	5.61	░	Medium dense brown gravelly fine to coarse SAND. Gravel is angular fine to coarse with cobbles of limestone.
								End of Trial Pit at 0.930m

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Dimensions		Trench Support and Comment			Pumping Data		
Pit Length	Pit Width	Pit Stability	Shoring Used	Remarks	Date	Rate	Remarks
0.50	0.50	Stable					

Remarks

Hole terminated at 0.93m due to obstruction/possible bedrock.

GroundSolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton
CH4 0DH

DCP106

DCP106

GroundSolve Ltd

Machine Dug Trial Pit Record

DCP107

Project Name: Conwy active travel	Client: Conwy CBC	Date: 26/01/2024
Location: RSPB Conwy	Contractor: D and I Drilling	Co-ords: E280080.00 N377334.00
Project No. : 2996	Crew Name:	Equipment: Hand Tools

Location Number	Location Type	Level	Logged By	Scale	Page Number
DCP107	TP	6.50m AoD	AB	1:25	Sheet 1 of 1

Backfill/ Instal'n	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
▨					0.30	6.20	▨	Grass over loose sandy slightly clayey SILT with frequent rootlets. Sand is fine to coarse.
▨					0.42	6.08	░	Medium dense brown fine to coarse SAND.
								End of Trial Pit at 0.420m

1
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Dimensions		Trench Support and Comment			Pumping Data		
Pit Length	Pit Width	Pit Stability	Shoring Used	Remarks	Date	Rate	Remarks
0.50	0.50	Stable					

Remarks

Hole terminated at 0.42m due to large obstruction/possible bedrock.

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DCP107

DCP107

GroundSolve Ltd

Machine Dug Trial Pit Record

DCP108

Project Name: Conwy active travel	Client: Conwy CBC	Date: 26/01/2024
Location: RSPB Conwy	Contractor: D and I Drilling	Co-ords: E279930.00 N377359.00
Project No. : 2996	Crew Name:	Equipment: Hand Tools

Location Number	Location Type	Level	Logged By	Scale	Page Number
DCP108	TP	6.38m AoD	AB	1:25	Sheet 1 of 1

Backfill/ Instal'n	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
▨		0.20	ES		0.20	6.18	▩	Thin layer of topsoil over loose brown sandy GRAVEL. Sand fine to coarse. Gravel angular fine to coarse of limestone. (MADE GROUND)
								End of Trial Pit at 0.200m

Dimensions		Trench Support and Comment			Pumping Data		
Pit Length	Pit Width	Pit Stability	Shoring Used	Remarks	Date	Rate	Remarks
0.50	0.50	Stable					

Remarks

Hole terminated due to obstruction or possible bedrock at 0.20m

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Bretton
CH4 0DH

PROJECT NAME RSPB CONWY
PROJECT NO 2996
DATE 26-01-24
TP NO DCP8
FINAL DEPTH 0.32
CLIENT

DCP108

PROJECT NAME RSPB CONWY
PROJECT NO 2996
DATE 26-01-24
DCP8
FINAL DEPTH 0.32

DCP108

GroundSolve Ltd

Machine Dug Trial Pit Record

DCP110

Project Name: Conwy active travel	Client: Conwy CBC	Date: 26/01/2024
Location: RSPB Conwy	Contractor: D and I Drilling	Co-ords: E279682.00 N377407.00
Project No. : 2996	Crew Name:	Equipment: Hand Tools

Location Number	Location Type	Level	Logged By	Scale	Page Number
DCP110	TP	6.66m AoD	AB	1:25	Sheet 1 of 1

Backfill/ Instal'n	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
▨		0.10	ES				▨	Loose grey sandy GRAVEL. Sand fine to coarse. Gravel fine to coarse angular of crushed slate. (MADE GROUND)
					0.30	6.36	▨	Loose to medium dense dark brown grey slightly silty gravelly SAND with rare cobbles of brick. Sand fine to coarse. Gravel is fine to coarse angular of crushed slate. (MADE GROUND)
	▼	0.50 0.50	B ES					
					1.00	5.66		End of Trial Pit at 1.000m

Dimensions		Trench Support and Comment			Pumping Data		
Pit Length	Pit Width	Pit Stability	Shoring Used	Remarks	Date	Rate	Remarks
0.50	0.50	Stable					

Remarks

Target Depth Reached.
Groundwater encountered at 0.50m.

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Unit 1 Well House Barns
Chester Road
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CH4 0DH

DCP110

DCP110

GroundSolve Ltd

Machine Dug Trial Pit Record

DCP111

Project Name: Conwy active travel	Client: Conwy CBC	Date: 26/01/2024
Location: RSPB Conwy	Contractor: D and I Drilling	Co-ords: E279574.00 N377437.00
Project No. : 2996	Crew Name:	Equipment: Hand Tools

Location Number	Location Type	Level	Logged By	Scale	Page Number
DCP111	TP	6.58m AoD	AB	1:25	Sheet 1 of 1

Backfill/ Instal'n	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
▨					0.20	6.38	▦	Grass over loose dark brown slightly clayey sandy SILT with frequent rootlets. Sand is fine to medium. (MADE GROUND)
⁘		0.30	ES		0.40	6.18	▦	Loose brown sandy GRAVEL. Sand fine to coarse. Gravel fine to coarse, angular of limestone. (MADE GROUND)
								End of Trial Pit at 0.400m

Dimensions		Trench Support and Comment			Pumping Data		
Pit Length	Pit Width	Pit Stability	Shoring Used	Remarks	Date	Rate	Remarks
0.50	0.50	Stable					

Remarks

Hole terminated due to obstruction.

GroundSolve Ltd
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Chester Road
Bretton
CH4 0DH

DCP111

DCP111

GroundSolve Ltd

Machine Dug Trial Pit Record

DCP112

Project Name: Conwy active travel	Client: Conwy CBC	Date: 26/01/2024
Location: RSPB Conwy	Contractor: D and I Drilling	Co-ords: E279479.00 N377405.00
Project No. : 2996	Crew Name:	Equipment: Hand Tools

Location Number	Location Type	Level	Logged By	Scale	Page Number
DCP112	TP	9.14m AoD	AB	1:25	Sheet 1 of 1

Backfill/ Instal'n	Water Strikes	**Sample and In Situ Testing**			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
▨		0.10	ES				▨	Grass over loose dark brown slightly gravelly clayey SILT with frequent rootlets. Gravel fine to coarse angular with rare cobbles of limestone. (MADE GROUND)
▨		0.60	ES		0.50	8.64	░	Loose brown fine to coarse SAND.
					1.00	8.14		End of Trial Pit at 1.000m

Dimensions		Trench Support and Comment			Pumping Data		
Pit Length	Pit Width	Pit Stability	Shoring Used	Remarks	Date	Rate	Remarks
0.50	0.50	Stable					

Remarks

Target depth reached.

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Chester Road
Bretton
CH4 0DH


GroundSolve Ltd
PROJECT NAME RSPB CONWY
PROJECT NO 2996
DATE 26-01-24
TP NO. DCP12
FINAL DEPTH 1.0
CLIENT
0.0m
0.1m
0.2m
0.3m
0.4m
0.5m

DCP12


GroundSolve Ltd
PROJECT NAME RSPB CONWY
PROJECT NO 2996
DATE 26-01-24
TP NO. DCP12
FINAL DEPTH
CLIENT

DCP12

GroundSolve Ltd

Windowless Sample Record

WS101

Project Name: Conwy active travel	Client: Conwy CBC	Date: 26/01/2024
Location: RSPB Conwy	Contractor: D and I Drilling	Co-ords: E280264.00 N376659.00
Project No. : 2996	Crew Name: D & I Drilling	Drilling Equipment: Premier Compact 110

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WS101	WLS	14.76m AoD	AB	1:25	Sheet 1 of 1

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
▨		0.20	ES				▨	Grass over loose dark brown slightly sandy slightly clayey SILT with frequent rootlets. Sand fine to coarse.
▨					0.30	14.46		
▨		0.40 0.40	B ES				▤	Weathered bedrock recovered as medium dense to dense dark grey slightly clayey slightly sandy GRAVEL with occasional cobbles of mudstone. Sand fine to coarse. gravel fine to coarse angular of mudstone.
▨		0.70	SPT	50 (10,10/50 for 125mm)			▤	
					0.83	13.94		
								End of Borehole at 0.825m

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation
0.83	200										

Remarks

Borehole terminated due to refusal against bedrock.
No groundwater encountered.

GroundSolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton
CH4 0DH


GroundSolve Ltd
RSPB CONWY
2996
26-01-24
WS01
0.7

WS101


GroundSolve Ltd
RSPB CONWY
2996
26-01-24
WS01
0.7

WS101

GroundSolve Ltd

Windowless Sample Record

WS102

Project Name: Conwy active travel	Client: Conwy CBC	Date: 26/01/2024
Location: RSPB Conwy	Contractor: D and I Drilling	Co-ords: E280241.00 N376695.00
Project No. : 2996	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WS102	WLS	5.77m AoD		1:25	Sheet 1 of 1

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
▨		0.00 0.00	B ES				▨	Reddish brown clayey sandy GRAVEL with frequent boulders of mudstone and limestone. Sand fine to coarse. Gravel fine to coarse, angular. (MADE GROUND)	
		0.30	SPT	50 (25 for 36mm/50 for 275mm)	0.30 0.30	5.47 5.47		MUDSTONE	
								End of Borehole at 0.300m	
									1
									2
									3
									4
									5

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

Refusal against possible bedrock. Attempted to get down the side with DP rods but were unable. Possible bedrock.

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Bretton
CH4 0DH


Old Rectory, Colwyn Bay LL28 5LG, UK
2°N (T) • 53.273674, -3.79738 ±2m ▲ 64m
26 Jan 2024, 9:13:59 am

WS102


NW
330
N
0
30
NE
60
E
90
120
33°N (T) • 53.27366, -3.797295 ±3m ▲ 68m
26 Jan 2024, 9:14:06 am

WS102

GroundSolve Ltd

Windowless Sample Record

WS103

Project Name: Conwy active travel	Client: Conwy CBC	Date: 26/01/2024
Location: RSPB Conwy	Contractor: D and I Drilling	Co-ords: E280211.00 N376687.00
Project No. : 2996	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WS103	WLS	3.16m AoD		1:25	Sheet 1 of 1

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
▨		0.00 0.00	B ES				▨	Dense brown clayey sandy GRAVEL with occasional boulders of mudstone and limestone. Sand fine to coarse. Gravel fine to coarse, angular. (MADE GROUND)
		0.80	SPT	50 (25,/50 for 20mm)	0.80	2.36		End of Borehole at 0.800m

1
2
3
4
5

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

Refusal against cobbles. DP undertaken, refusal at 2.90mbgl, likely cobbles.

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CH4 0DH

GroundSolve Ltd	Windowless Sample Record	WS104

Project Name: Conwy active travel	Client: Conwy CBC	Date: 26/01/2024
Location: RSPB Conwy	Contractor: D and I Drilling	Co-ords: E280306.00 N376904.00
Project No. : 2996	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WS104	WLS	4.59m AoD		1:25	Sheet 1 of 1

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
▨		0.00 0.00	B ES				▨	Dense brown clayey sandy GRAVEL with occasional cobbles of limestone and basalt. Sand fine to coarse. Gravel fine to coarse, angular. (MADE GROUND)	
		1.00	SPT	N=50 (6,7/50 for 240mm)	1.00	3.59		End of Borehole at 1.000m	1
									2
									3
									4
									5

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

Refusal against cobbles. DP undertaken, refusal at 1.90mbgl, likely cobbles.

GroundSolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton
CH4 0DH

GroundSolve Ltd — Windowless Sample Record — WS105

Project Name: Conwy active travel	Client: Conwy CBC	Date: 26/01/2024
Location: RSPB Conwy	Contractor: D and I Drilling	Co-ords: E280302.00 N376927.00
Project No. : 2996	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WS105	WLS	2.88m AoD		1:25	Sheet 1 of 2

Sample and In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m)	Stratum Description
0.00	B				Firm brown slightly sandy clayey SILT. Sand fine to medium.
0.00	ES				
0.50	PP	58.9 kPa			
1.00	B		1.00	1.88	Soft very low strength dark brown sandy clayey SILT. Sand fine to medium.
1.00	ES				
1.00	SPTLS				
1.00	SPT	N=0 (0,0/0,0,0,0)			
1.50	PP	2.4 kPa			
2.00	B				
2.00	SPTLS				
2.00	SPT	N=0 (1,0/0,0,0,0)			
3.00	B				
3.00	SPTLS				
3.00	SPT	N=0 (1,0/0,0,0,0)			
4.00	B		4.00	-1.12	Loose brownish grey silty SAND. Sand fine to coarse.
4.00	ES				
4.00	SPTLS				
4.00	SPT	N=4 (0,0/0,0,2,2)			

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

GroundSolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton
CH4 0DH

GroundSolve Ltd	Windowless Sample Record	WS105

Project Name: Conwy active travel	Client: Conwy CBC	Date: 26/01/2024
Location: RSPB Conwy	Contractor: D and I Drilling	Co-ords: E280302.00 N376927.00
Project No. : 2996	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WS105	WLS	2.88m AoD		1:25	Sheet 2 of 2

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
▨		5.00	SPTLS					Loose brownish grey silty SAND. Sand fine to coarse.
		5.00	SPT	N=6 (3,2/2,2,1,1)				
					5.45	-2.57		End of Borehole at 5.450m

6

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Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

GroundSolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton
CH4 0DH


A470, Colwyn Bay LL28, UK
23°N (T) ◉ 53.27581, -3.796376 ±2m ▲ 60m
GroundSolve Ltd
DATE 26-01-24
RSPB CONWY
PROJECT NO
CLIENT
BOREHOLE NO. WS105
BOX NO.
DEPTH FROM 0·00 M TO 5·45 M
Unit 1 Well House Barns
Chester Road
Bretton, CH4 0DH
01244 661361
www.groundsolve.com
enquiries@groundsolve.com
0.0m
0.1m
0.2m
0.3m
0.4m
0.5m
0.6m
0.7m
0.8m
0.9m
1.0m
26 Jan 2024, 11:3

WS105

GroundSolve Ltd

Windowless Sample Record

WS106

Project Name: Conwy active travel	Client: Conwy CBC	Date: 26/01/2024
Location: RSPB Conwy	Contractor: D and I Drilling	Co-ords: E280305.00 N376991.00
Project No. : 2996	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WS106	WLS	2.60m AoD		1:25	Sheet 1 of 2

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
		0.00 0.00	B ES					Firm very low strength brownish grey slightly sandy organic clayey SILT. Sand fine to medium.
		1.00	SPTLS		1.00	1.60		NO RECOVERY.
		1.00	SPT	N=0 (1,0/0,0,0,0)				
		2.00	SPTLS					
		2.00	SPT	N=0 (1,0/0,0,0,0)				
					2.50	0.10		Soft medium strength dark grey organic SILT/ CLAY.
		3.00	SPTLS					
		3.00	SPT	N=12 (0,1/2,3,3,4)				
		3.40 3.40	B ES		3.40	-0.80		Medium dense dark grey silty SAND. Sand fine to medium.
		4.00	SPTLS					
		4.00	SPT	N=17 (2,3/4,4,4,5)				

1
2
3
4
5

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

GroundSolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton
CH4 0DH

GroundSolve Ltd	Windowless Sample Record	WS106

Project Name: Conwy active travel	Client: Conwy CBC	Date: 26/01/2024
Location: RSPB Conwy	Contractor: D and I Drilling	Co-ords: E280305.00 N376991.00
Project No. : 2996	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WS106	WLS	2.60m AoD		1:25	Sheet 2 of 2

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
▨		5.00 5.00	SPTLS SPT	 N=22 (5,5/5,5,6,6)	5.45	-2.85	▨	Medium dense dark grey silty SAND. Sand fine to medium.
								End of Borehole at 5.450m

6
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9
10

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

GroundSolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton
CH4 0DH


A470, Colwyn Bay LL28, UK
GroundSolve Ltd
Consulting Geotechnical Engineers
64°NE (T) 53.276334, -3.796503 ±2m ▲ 55m
RSPB CONWY
DATE 26-01-24
PROJECT NO. 2996
CLIENT
BOREHOLE NO. WS106
BOX NO. N/A
DEPTH FROM 0·00 M TO 5.45 M
Unit 1 Well House Barns
Chester Road
Bretton, CH4 0DH
01244 661361
www.groundsolve.com
enquiries@groundsolve.com
0.0m
0.1m
0.2m
0.3m
0.4m
0.5m
0.6m
0.7m
0.8m
0.9m
1.0m
26 Jan 2024, 1

WS106

GroundSolve Ltd

Windowless Sample Record

WS107

Project Name: Conwy active travel	Client: Conwy CBC	Date: 26/01/2024
Location: RSPB Conwy	Contractor: D and I Drilling	Co-ords: E280306.00 N377027.00
Project No. : 2996	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WS107	WLS	3.00m AoD		1:25	Sheet 1 of 2

Depth (m)	Type	Results	Depth (m)	Level (m)	Stratum Description
					Soft brownish grey sandy clayey SILT. Sand fine to medium. (MADE GROUND)
			0.40	2.60	Orangish brown gravelly SAND. Sand fine to coarse. Gravel fine to coarse, subangular of slate. (MADE GROUND)
1.00	SPT	N=5 (8,3/2,1,1,1)	1.00	2.00	Soft very low strength sandy clayey SILT. Sand fine.
2.00	SPTLS				
2.00	SPT	N=0 (1,0/0,0,0,0)			
3.00	SPTLS				
3.00	SPT	N=0 (1,0/0,0,0,0)			
			3.60	-0.60	Loose black organic silty SAND. Sand fine to coarse.
4.00	SPTLS				
4.00	SPT	N=3 (0,0/0,1,1,1)			

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

GroundSolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton
CH4 0DH

GroundSolve Ltd	Windowless Sample Record	WS107

Project Name: Conwy active travel	Client: Conwy CBC	Date: 26/01/2024
Location: RSPB Conwy	Contractor: D and I Drilling	Co-ords: E280306.00 N377027.00
Project No. : 2996	Crew Name:	Drilling Equipment:

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WS107	WLS	3.00m AoD		1:25	Sheet 2 of 2

Well	Water Strikes	**Sample and In Situ Testing**			Depth (m)	Level (m)	Legend	Stratum Description	
		Depth (m)	Type	Results					
▨		5.00	SPTLS				▨	Loose black organic silty SAND. Sand fine to coarse.	
		5.00	SPT	N=34 (1,2/6,7,9,12)					
					5.45	-2.45		End of Borehole at 5.450m	
									6
									7
									8
									9
									10

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation

Remarks

GroundSolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton
CH4 0DH


A470, Colwyn Bay LL28, UK
45°NE (T) 53.276621, -3.796605 ±3m ▲ 57m
GroundSolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton, CH4 0DH
01244 661361
www.groundsolve.com
enquiries@groundsolve.com
PROJECT NAME RSPB CONWY
DATE 26-01-24
BOREHOLE NO. WS107
DEPTH FROM 0·00 M TO 5·45 M
0.0m
0.1m
0.2m
0.3m
0.4m
0.5m
0.6m
0.7m
0.8m
0.9m
1.0m
26 Jan 2024, 2:

WS107

GroundSolve Ltd

Windowless Sample Record

WS108

Project Name: Conwy active travel	Client: Conwy CBC	Date: 26/01/2024
Location: RSPB Conwy	Contractor: D and I Drilling	Co-ords: E279791.00 N377394.00
Project No. : 2996	Crew Name: D & I Drilling	Drilling Equipment: Premier Compact 110

Borehole Number	Hole Type	Level	Logged By	Scale	Page Number
WS108	WLS	6.94m AoD	AB	1:25	Sheet 1 of 1

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
		Depth (m)	Type	Results				
							▩	Thin layer of topsoil over loose brown gravelly SAND. Sand fine to coarse. Gravel fine to coarse, angular of limestone. (MADE GROUND)
		0.30	ES					
					0.50	6.44	░	Loose brown fine to coarse SAND.
		0.60	B					
		1.00 1.00	D SPT	 N=50 (9,7/50 for 245mm)				
					1.25	5.70		End of Borehole at 1.245m

Hole Diameter		Casing Diameter		Chiselling				Inclination and Orientation			
Depth Base	Diameter	Depth Base	Diameter	Depth Top	Depth Base	Duration	Tool	Depth Top	Depth Base	Inclination	Orientation
1.25	200										

Remarks

Borehole terminated at 1.00m due to refusal.
No groundwater encountered.

GroundSolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton
CH4 0DH


GroundSolve Ltd
Consulting Geotechnical Engineers
PROJECT NAME
RSPB CONWY
PROJECT NO.
2996
DATE
26-01-24
TP NO.
WS08 + DCP09
FINAL DEPTH
1.00m
CLIENT
0.0m
0.1m
0.2m
0.3m
0.4m
0.5m

WS108


GroundSolve Ltd
PROJECT NAME
RSPB CONWY
PROJECT NO.
2996
26-01-24
TP NO.
WS08 + DCP09
FINAL DEPTH
1.00m
CLIENT

APPENDIX C – ADVANCED CONTINUOUS SURFACE WAVE REPORT

Advanced Continuous Surface Wave Ground Stiffness Profiling

RSPB Conwy
Advanced Continuous Surface Wave Testing Report

Report ref.:	P-1084	**Date of issue:**	14/03/2024
		Prepared	**Checked**
Status	FINAL	27/02/2024	14/03/2024

SoilSafe Ltd
54 Oak Street,
Manchester,
M4 5JA
www.soilsafe.co.uk

Contents

Abbreviations

C-DAS	GSS ACSW data acquisition & analysis software
ACSW	GSS Advanced Continuous Surface Wave testing system
E	Young's Modulus
$E_{X\%}$	Young's Modulus softened to X% strain
GSS	Ground Stiffness Surveys Limited
SoilSafe	SoilSafe Limited
f	Frequency
G	Shear Modulus
G_0	Small-strain Shear Modulus
V_r	Rayleigh Wave velocity
V_s	Shear Wave velocity
λ	Wavelength
ν	Poisson’s Ratio
ρ	Soil density
S/N	Signal to noise (ratio)

1 Project details

Project title	RSPB Conwy
Client	GroundSolve Ltd
Site location	Conwy
Scope of report	SoilSafe Limited (SoilSafe) has been commissioned to undertake Advanced Continuous Surface Wave (ACSW) testing to provide ground stiffness profiles in accordance with the details listed below. This report provides ACSW testing data generated using GSS's C-DAS data acquisition & analysis software. Assumptions and testing standards are listed in Section 4. Average shear wave velocity (V_s) *simple inversion* profiles are provided in Appendix A. Where appropriate *advanced inversion* of the data to generate a layered shear wave velocity (V_s) profile has been undertaken, with data presented as equivalent small-strain Shear Modulus (G_0) in Appendix B. Illustrative strain-softened values of E are provided in Appendix C and separately in an MS Excel spreadsheet with the facility for client adjustment of strain level and other default values. ***A commentary on results for design review purposes is provided as Section 5.***
Report conditions	Numbers and locations of ACSW testing have been determined by the client. The standards under which testing was completed are listed in Section 4. *This report is produced solely for the benefit of the client identified in this report and in accordance with the brief and associated conditions identified below.* No liability is accepted for any reliance placed on this report by any other party. The report is intended for use solely by a suitably qualified and experienced geotechnical engineer in conjunction with other appropriate information on ground conditions. *No design or consultancy advice is offered as part of this report.* Where provided, strain-softened stiffness values are for illustration and information only. Appropriate skill and care by a suitably qualified geotechnical engineer is required in the assessment of ground stiffness or shear wave velocity profile data for design use, including the selection of appropriate strain levels for strain-softening and the applicability of strain-softening functions. Design of ACSW testing, including the suitability of ACSW data for the design, numbers and locations of tests should be determined by a suitably qualified geotechnical engineer. A general description of the terminology, test methodology and analysis techniques used to provide stiffness and shear wave velocity profiles from ACSW test data, including references, is provided as Appendix D. Further information and guidance is available via the GSS website: www.groundstiffnesssurveys.com .
Commercial	Testing was undertaken in accordance with SOILSAFE Standard Terms & Conditions. Reference should be made to the relevant ACSW testing proposal. *The report has been produced for and on behalf of SoilSafe Limited and no responsibility for information or opinions included is attached to any individual or implied.*

2 Testing details

<table>
<tr><td>Attendances</td><td colspan="2">Yes</td></tr>
<tr><td>Setting out</td><td colspan="2">GroundSolve Ltd</td></tr>
<tr><td>SOILSAFE seismic sources</td><td colspan="2">Standard Shaker – GSS Standard 80kg Shaker - 8 to 91Hz
EM Shaker – GSS EM high frequency shaker - 50 to 400Hz
Heavy Shaker – GSS high energy 80kg ‘Heavy’ Shaker – 4 to 50Hz
<i>Unless otherwise noted below, the GSS Standard Shaker source has been used with a 3m long standard test array.</i></td></tr>
<tr><td rowspan="2">ACSW test equipment</td><td>Shaker Serial No.</td><td>Data Acquisition Unit Serial No.</td></tr>
<tr><td>SS05</td><td>DA06</td></tr>
<tr><td rowspan="2">C-DAS software versions</td><td>Data capture</td><td>Reporting</td></tr>
<tr><td>2.9.5.0 'Cashew'</td><td>2.9.4.0 'Cashew'</td></tr>
<tr><td>Project notes</td><td colspan="2">The client requested the use of ACSW testing as part of a non-intrusive investigation which aimed to provide ground condition information.
The investigation was carried out within the proposed site area as requested by the client.
Testing on site was undertaken on 26th January 2024 using a tracked ACSW delivery system. In total 11 No. ACSW tests were undertaken. The ACSW tracked delivery system was deployed in an area which was completely inaccessible using traditional ground investigation techniques.</td></tr>
</table>

3 Project testing summary

Test	Acceptable Data Quality?	Easting	Northing	Level (mAOD)	Notes
CSW01	Poor quality data due to combination of shallow bedrock and noise due to proximity of road.	280264	376655	14.69	No sandbag under shaker. Geophone with metal spikes used. Retests undertaken with change of data box and removal of geophone extension cable. Test runs N-S. W3W: hurray.graduated.allowable No advanced inversion ran due to poor quality of data.
CSW01B	Possible interference of traffic vibrations due to combination of proximity of road and shallow bedrock.	280257	376635	14.12	No sandbag under shaker. Geophone with metal spikes used. Test runs E-W W3W: listings.journals.consonant Possible interference of traffic vibrations due to combination of proximity of road and shallow bedrock. Model Fit = 13.514m/s: Fair model fit, indicates acceptable level of model confidence.
CSW02	Poor quality data due to combination of shallow bedrock and noise due to proximity of road.	280232	376692	5.58	No sandbag under shaker Geophone with metal spikes used. Test runs N-S. W3W: skid.propelled.rope Poor data throughout. Changed to ceramic bag geophones in CSW02A. No advanced inversion ran due to poor quality of data.
CSW02A	Poor quality data due to combination of shallow bedrock and noise due to proximity of road.	280232	376689	5.43	No sandbag under shaker. Geophone with ceramic bases used. Test runs N-S. W3W: forced.different.laws No advanced inversion ran due to poor quality of data.
CSW02B	Poor quality data due to combination of shallow bedrock and noise due to proximity of road.	280232	376689	5.43	Sandbag under shaker. Geophone with ceramic bases used. Test runs N-S. W3W: forced.different.laws No advanced inversion ran due to poor quality of data.

Test	Acceptable Data Quality?	Easting	Northing	Level (mAOD)	Notes
CSW02C	Possible interference of traffic vibrations due to combination of proximity of road and shallow bedrock.	280232	376689	5.43	Sandbag under shaker. Geophone with ceramic bases used. Test runs N-S. W3W: forced.different.laws Geophones spacing reduced to 0.3m Model Fit = 10.263m/s: Fair model fit, indicates acceptable level of model confidence.
CSW04	Possible interference of traffic vibrations due to combination of proximity of road and shallow bedrock.	280248	376740	2.72	Sandbag under shaker. Geophone with ceramic bases used. Test runs N-S. W3W: ecologist.shield.engaging Model Fit =6.903m/s: Good model fit, indicates high level of model confidence.
CSW10	Good quality data, enough fines within the rock armour for data to be obtained.	280300	376876	4.05	Sandbag under shaker. Geophone with ceramic bases used. Test runs N-S. W3W: concerts.amplified.until Model Fit = 9.812m/s: Good model fit, indicates high level of model confidence.
CSW11	Good quality data, enough fines within the rock armour for data to be obtained.	280303	376909	4.71	Sandbag under shaker. Geophone with ceramic bases used. Test runs W-E. W3W: snowstorm.halt.remaining Model Fit = 14.129m/s: Fair model fit, indicates acceptable level of model confidence.
CSW11A	Good quality data, enough fines within the rock armour for data to be obtained.	280303	376909	4.71	Sandbag under shaker. Geophone with ceramic bases used. Test runs S-N. W3W: snowstorm.halt.remaining Model Fit = 16.405m/s: Fair model fit, indicates acceptable level of model confidence.
CSW12	Good quality data, enough fines within the rock armour for data to be obtained.	280310	376930	3.20	Sandbag under shaker Geophone with metal spikes used. Test runs N-S. W3W: library.sting.finer Model Fit = 2.617m/s: Excellent model fit, indicates very high level of model confidence.

Note that unless otherwise stated:

1. *Test positions are as set-out on site by SoilSafe Ltd.*
2. *Test location co-ordinates shown are approximate as-built positions as recorded on site using hand-held GPS at the centre of the test array (typical accuracy ±3m) to National Grid Reference.*
3. *Levels of the test locations have been provided by the Client.*

4 ACSW data

4.1 Data acquisition

Data acquisition was undertaken using GSS's C-DAS data acquisition & analysis software which automatically controls testing, assesses data quality and provides field outputs.

C-DAS automatically identifies frequencies where there is inconsistency in velocities and frequencies measured between geophones. Outlying data or very scattered data which may not be reliable has also been excluded from the analyses undertaken but is still presented for transparency using a different symbol.

4.2 Data plots

Data plots generated using GSS's C-DAS data acquisition and analysis software are presented in Appendices A & B. For each test the following plots, including an appropriate smoothed best fit curve, are provided:

- The *field dispersion curve* – measured Rayleigh Wave velocity (V_r) against measured frequency (Appendix A)
- The *simple inversion* – average V_s against approximate depth based on the dispersion curve data (Appendix A)
- The *synthetic dispersion curve* (where appropriate) - generated by the advanced inversion process (Appendix B)
- The *advanced inversion* results (where appropriate) – layered V_s profile with depth (Appendices A & B)

Deleted invalid, scattered or outlying data not used in the analyses is shown on the field dispersion plots only. Commentary on data quality is given in Section 3 (individual test notes) and in Section 5 (commentary on all results), including any tests where advanced inversion was not deemed appropriate.

Advanced inversion results are converted to G_0 and E_0 stiffness profiles in Appendix C using the relationships and soil density and Poisson's ratio values shown. Softened Young's Modulus (E) values are also provided using a published strain softening model and default strain level. This data is provided separately in MS Excel format to allow any of the default parameters to be adjusted to reflect site specific conditions for design purposes. Note that the strain softened stiffness values provided may not be appropriate for some ground conditions (e.g. in rock) or design applications. Further guidance on use of ACSW data is available at www.groundstiffnesssurveys.com.

A key to data plots presented is given in Appendix D. *All data should be assessed in conjunction with the notes on use of ACSW data provided in Appendix D.*

4.3 Data inversion

Simple (average with depth) and advanced (layered) inversion shear wave velocity (V_s) profiles have been generated by C-DAS in accordance with the procedures and references set out in Appendix D and the default model constraints below. Unless otherwise stated, an effective dispersion curve modelling approach using the WAVe model (Leung & Aung, 2013) is used. Model defaults are reviewed as part of initial inversion and taking into account available site information; *any modifications from the default analysis settings below are set out in Section 5.*

C-DAS model constraint	**Value**	**Basis**
Poisson's ratio	0.5	Conservative for natural range (has very small impact on derivation of V_s from V_r)
Soil density	1.8 Mg/m^3	Conservative for natural range (has only limited impact on inversion)
Simple inversion depth	wavelength/ 2.5	Foti *et al* 2017
Minimum V_s	50m/s	Minimum natural value for soils; Foti et al 2017
Maximum V_s	1500m/s	Maximum value for non-crystalline rock; Foti *et al* 2017
Minimum layer thickness	1m (Standard & Heavy Shaker sources) 0.5m (EM Shaker source)	Practical minimum layer resolution. May be adjusted to the *minimum* value which meets stiff-soft-stiff layer and layer thickness resolution checks or in line with available site information.
Maximum layer thickness	1m to 10m	Adjusted to the *minimum* value which meets stiff-soft-stiff layer and layer thickness resolution checks or in line with available site information.
Minimum number of model layers	10	Adjusted to ensure approximately 1 layer per 1m of profile (Foti *et al* 2017).
Maximum model depth validity	Simple inversion maximum depth for site	Foti *et al* 2017
Top layer thicknesses	No shallower than depth of first simple inversion point	Foti *et al* 2017
Simple inversion weighting	0.05 (Normally Dispersive profiles) 0.1 (Inversely Dispersive profiles)	Standard calibrated value providing an appropriate degree of constraint to the simple inversion as prescribed by Foti *et al* 2017. Adjusted if required based on available site information.
Numbers of stiff-soft-stiff layers check	1 or 2	Foti *et al* 2017; where greater numbers generated by the inversion the number of layers and layer thicknesses are adjusted.
Layer thickness resolution check	Max 0.5m at shallow depth (typical minimum resolution); min 1m to 2m at base of profile (minimum practical resolution at 10 Hz).	Foti *et al* 2017; where thinner layers generated by the inversion the number of layers and layer thicknesses are adjusted.

Guidance and relevant standards on data inversion are listed in Section 4.5. Notes on the inversions undertaken for each test are given in Section 3. A commentary on the inversions completed is provide in Section 5.

4.4 Conversion of shear wave velocity to stiffness

Advanced inversion layered shear wave velocity profile results are presented in Appendix C as equivalent values of G & E using the parameters and relationships set out.

Default parameters can be changed by the user based on other site data or design requirements in the MS Excel version of the Appendix C data issued with this report - *see GSS website for guidance.*

4.5 Testing standards

ACSW testing has been undertaken in accordance with the following GSS standard guidance documents:

GSSGN010	Description & limitations of ACSW technique
GSSSPEC01	ACSW Standard Specification
GSSMS01	Method Statement: ACSW Stiffness Profiling
GSSDWG001	ACSW Test Layout

The documents above and further guidance on ACSW testing practice and application are available at www.groundstiffnesssurveys.com.

Key references are listed in Appendix D.

5 Commentary on results

5.1 Notes on results commentary

The qualitative assessment and observations below are based on available ACSW test data only and should be read in conjunction with the limitations set out in Appendix D.

For simplicity, higher shear wave velocity values are described qualitatively as ‘stiff’ or ‘stiffer’ and lower shear wave velocity values ‘soft’ or ‘softer’. Guidance for preliminary interpretation of shear wave velocity data in conjunction with available information on ground conditions is provided in Appendix C.

Where appropriate the total range of data quality is indicated as well as the typical range within this through the use of light (total range) and dark blue (typical range) shading (*see example below*).

Example key for qualitative assessment of results

Very poor		
Poor	Total range of data quality observed in results	
Fair		Typical range
Good		
Excellent		

Appropriate interpretation of data presented, based on available geotechnical information and scheme design criteria, should be undertaken by a suitably qualified and experienced geotechnical engineer when assessing and utilising this data. Notes on individual tests are provided in Section 3.

In reviewing the results reference should be made as necessary to the testing standards listed in Section 4.5, the references listed in Appendix D and guidance available via the GSS website.

5.2 Data & results assessment

Review element	Class	Description	Typical impact
Available ground investigation information *Qualitative assessment of extent of site ground investigation information available to constrain modelling.* *See project notes in Section 2 and Observations section.*	**None**	No reliable site-specific ground investigation data available.	No reliable check on modelled results against ground investigation data possible; further review/remodelling may be required once ground investigation data available.
	Poor	Some site-specific ground investigation data available but soil types and/or variation in layer boundaries could vary significantly across site.	Limited assessment of results of modelling possible against ground investigation data.
	Fair	Soil types and/or range of variation in layer boundaries across site well defined.	Accuracy of V_s modelling enhanced by constraints on layer boundaries allowing reliable assessment of model results against ground investigation data.
	Good	Soil types well-understood and layer boundaries known or very well defined at each test location.	Highest degree of accuracy of V_s modelling possible where layer boundaries well defined.

Review element	Class	Description	Typical impact
Data quality *Qualitative assessment within normal valid data frequency range for source or sources used.*	**Very poor**	Most of the data does not meet data quality requirements and/or is multi-modal.	Data unlikely to be reliably analysable but may provide qualitative evidence of variable ground conditions.
	Poor	Many data points not meeting data quality requirements and/or significant multi-modal data.	Data might not be reliably analysable unless supported by the results of other nearby tests but may provide qualitative evidence of variable ground conditions.
	Fair	Some data points not meeting data quality requirements and/or some multi-modal data.	Normal minimum standard for data analysis.
	Good	Few data points not meeting data quality requirements and little multi-modal data.	Data likely to support reliable analysis.
	Excellent	Very few data points not meeting data quality requirements and very little to no multi-modal data.	Data highly likely to support reliable analysis.

Review element	Class	Description	Typical impact
Advanced inversion model fit *Confidence level subject to comparison with other adjacent tests and available geotechnical data prior to use.* *Notes on individual tests are provided in Section 3.*	**Very poor**	Average fit of synthetic dispersion curve to field dispersion curve data >30m/s.	Indicates very low level of model confidence, well below normally acceptable levels; *if reported, results should only be used with caution.*
	Poor	Average fit of synthetic dispersion curve to field dispersion curve data >20m/s and <30m/s.	Indicates low level of model confidence, results may be acceptable if comparable with other similar tests; *caution in use of results required.*
	Fair	Average fit of synthetic dispersion curve to field dispersion curve data >10m/s and <20m/s.	Indicates acceptable level of model confidence.
	Good	Average fit of synthetic dispersion curve to field dispersion curve data >5m/s and <10m/s.	Indicates high level of model confidence.
	Excellent	Average fit of synthetic dispersion curve to field dispersion curve data <5m/s.	Indicates very high level of model confidence.

Review element	Class	Description	Typical impact
Strain value used for adjustment of small strain stiffness (G_0, E_0) *Reporting uses a well-established soil softening model applicable to a wide range of soil types. However, this model may not be applicable to rock and problematic soils such as collapsible ground or peat which may exhibit strain hardening behaviour – see Appendix D.* *Applicability to be reviewed by Designer against scheme design criteria and available geotechnical information.*	**0%**	Unadjusted very small strain value.	Seismic strain level value. Upper bound value for most soils which typically strain soften. Provides a lower bound estimate of stiffness for geomaterials which strain harden.
	0.01%	Small strain value	Typical upper bound value of strain around propped excavations, anchored walls and machine base foundations.
	0.1%	Moderate strain value	Typical upper bound value of strain associated with typical geotechnical schemes. Provided as the default value in the MS Excel output spreadsheet.
	1%	Large strain value	Typical upper bound value associated with standard field (e.g. Plate Load Test) and laboratory (e.g. oedometer) testing.

Review element	Class	Description	Typical impact
Overall assessment of results – *see Observations section for more detail.* *Qualitative assessment, to be reviewed by Designer based on scheme geotechnical categorisation, against available site information and in relation to design objectives as part of assessment of suitability for use.*	**Poor**	Data quality and analysis results variable and not consistent with available information.	Data not normally issued and if reported may be indicative or qualitative only. *To be used with caution only.*
	Fair	Data quality and analysis results generally consistent with each other and/or available information, though some variation in individual test results may be present.	Additional design review required for some or all data prior to use; as appropriate, conservatism to be applied on outliers or for selection of design values. *Some results to be used with caution or qualitatively only.*
	Good	Data quality and analysis results consistent with each other and/or available information.	Standard level of design review appropriate for scheme required before use.

5.3 Observations

5.1.1 General

Simple inversion profiles generated extend to between 2m and 9m depth.

Advanced inversion was undertaken using an effective dispersion curve (WAVe) model with a maximum of 9 layers and a minimum 1m and maximum 2m layer thickness. Advanced inversion profiles generated reflect the simple inversion profiles and have been reported to simple inversion profile depths.

The advanced inversion profiles give a layered representation of the stiffness and strength of the soils. Each layer represented is the anticipated strength of the material *at that depth* and therefore becomes much more useful for further design and analysis of the study area.

Throughout the ACSW tests undertaken, several tests recorded higher mode / poor quality data, possibly due to testing on rock armour with limited fines between the larger rock clasts. This data has been ignored from the tests as would affect the quality of the data used and may result in an over-estimation of ground stiffness of the shallow material.

5.1.2 Geology of Site Area from BGS Records

Published geology shows the site to comprise Tidal Flat Deposits and Denbigh Grits Formation. BGS Geoindex, also notes the presence of a fault at rockhead to the south-west of site.

The Tidal Flat Deposits are described as including mud flat and sand flat deposits, form extensive nearly horizontal marshy land in the intertidal zone that is alternately covered and uncovered by the rise and fall of the tide. They consist of unconsolidated sediment, mainly mud and/or sand. They may form the top surface of a deltaic deposit.

5.1.3 ACSW Tests

ACSW testing undertaken at RSPB Conwy was conducted using the Tracked ACSW Delivery System. In total 11 No. ACSW tests were undertaken (excluding retests due to equipment checking following the recorded poor data quality), the location plan of these ACSW tests can be found in the appendices.

Several ACSW tests have recorded poor quality data to an extent at which advanced inversions would not be useful or representative of actual ground conditions. The following reasons for poor data quality have been surmised:

- Testing on rock armour which lines the Afon Ganol with limited fines between rock clasts, resulting in poor transmission of seismic waves through the soil skeleton
- Testing across possible buried services (CSW01 area) which could possibly create higher mode data at shallow depth

- The CSW01 area is located upon shallow bedrock and is within close proximity to the highway. This shallow but very stiff medium may have a resultant effect that vibrations from the highway were efficiently transmitted to the testing location, resulting in significant “noise” from the geophones.

The following figures contain screenshots of the data from the CDAS programme for the ACSW tests conducted at RSPB Conwy and screenshots of WS logs, as provided by the Client.

Due to the good quality of the data demonstrated in ACSW tests CSW10, 11, 11A & 12, it was deemed suitable to undertake advanced inversions of the simple inversions . The advanced inversions have been undertaken to the depths of the simple inversions.

5.1.4 CSW01-04

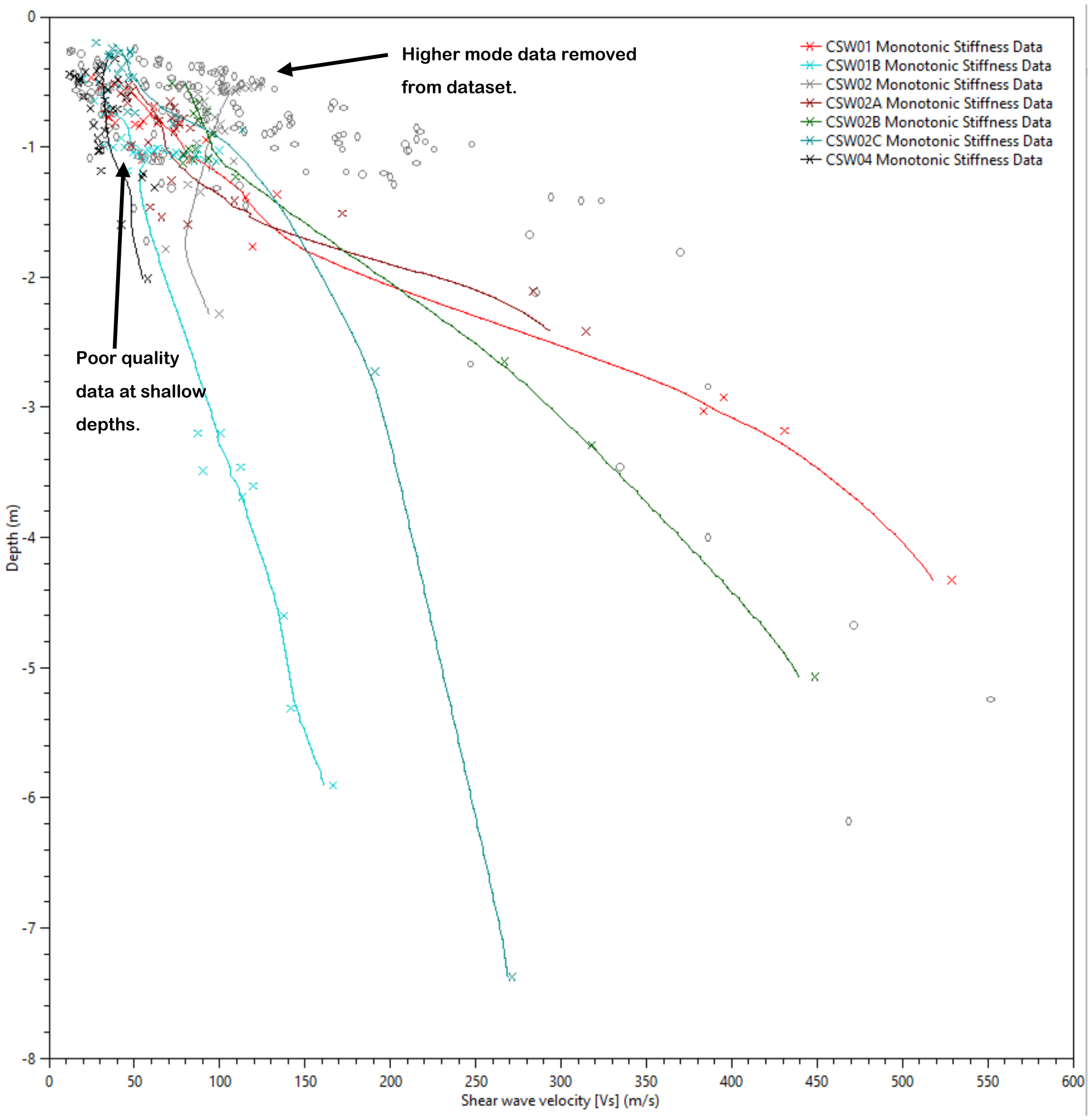


Figure 5-1: Superimposed graph showing simple inversions of ACSW tests CSW01, 01B, 02, 02A, 02B, 02C & 04.

Figure 5-1 indicates a large proportion of ACSW tests contain poor quality data at shallow depths. This poor quality data has been ignored (as shown by the grey circles in Figure 5-1). Due to the poor quality of the data recorded, the ACSW equipment was replaced on site with spare equipment in order to rule out any equipment errors or failure. It was deemed that there were no issues with the testing equipment and that the poor quality data recorded was due to difficult ground conditions.

5.1.5 CSW10

CSW10 was undertaken within an area close to the northern end of a proposed new footbridge across the existing railway line. This area of site is inaccessible for a drilling rig therefore there are no close boreholes to compare the ACSW tests to. This area of site is considered by the BGS and by SoilSafe to be underlain with rock armour and tidal flat deposits at depth.

The ACSW test data shows higher mode data at shallow depths, with a stiffer medium up to a~1.5m bgl depth (~2.5mAOD). The testing area is located ~1.5m above the water table, which could suggest why the top ~1.5m of material is of a higher strain softened stiffness of around 29MPa, which equates to a shear wave velocity of 138m/s and an undrained shear strength of around 43kPa.

There is a gradual reduction in stiffness with depth, shown in Figure 5-2, to ~3.5m bgl (0.5mAOD). This is shown by the decrease in values of strain softened stiffness and shear wave velocity. This geological layer equates to a shear wave velocity of 90m/s, a strain softened stiffness of 13MPa and an undrained shear strength of 18kPa. The closest window sample log suggests the likely presence of a cohesive tidal flat material.

There is a slight increase in stiffness with depth at ~4.0m bgl, showing an increase in shear wave velocity to 103m/s, which equates to a strain softened stiffness of 16MPa and an undrained shear strength of 24kPa.

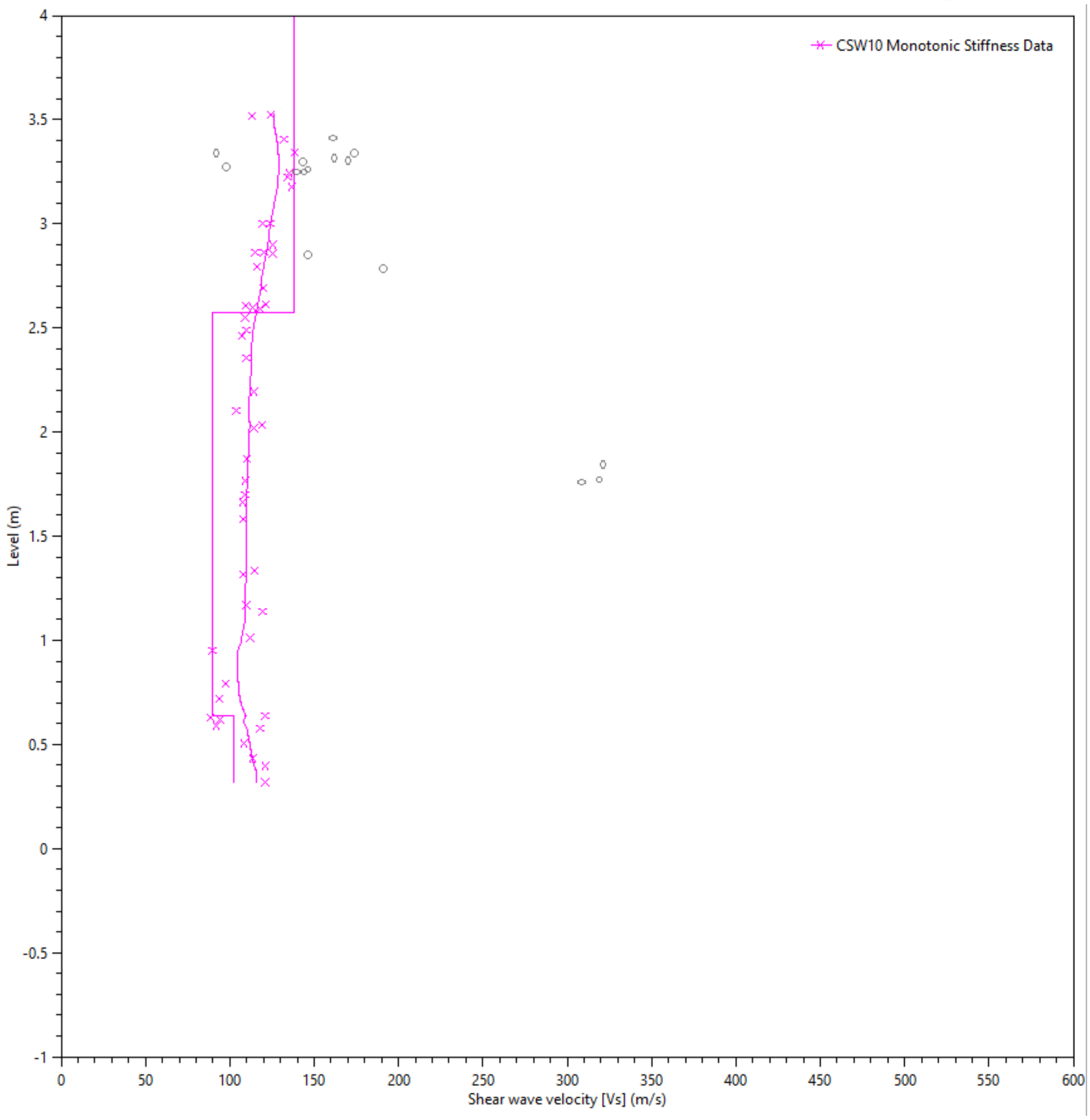


Figure 5-2: Simple and Advanced Inversions of CSW10.

5.1.6 CSW11/11A

2 No. ACSW tests were undertaken at the same location, but in different orientations in order to provide an overview of the area. Within the location of the tests an old pile mat has been built up over anticipated Made Ground.

The ACSW tests are in a similar location to WS104, recently undertaken by the Client. WS104, however, was terminated at 1.0m bgl depth due to obstructions within the Made Ground soils. SoilSafe were able to achieve good ASCW data to ~ -4.0mAOD.

The proposed footbridge is anticipated to cross the Afon Ganol, starting roughly at the location of CSW10 and ending roughly at the location of CSW11.

It is anticipated that the stiffer Made Ground stops at ~1.7mAOD and soils at ~2.7mAOD are less stiff than the anthropogenic soils and could possibly represent the tidal flat deposits at depth.

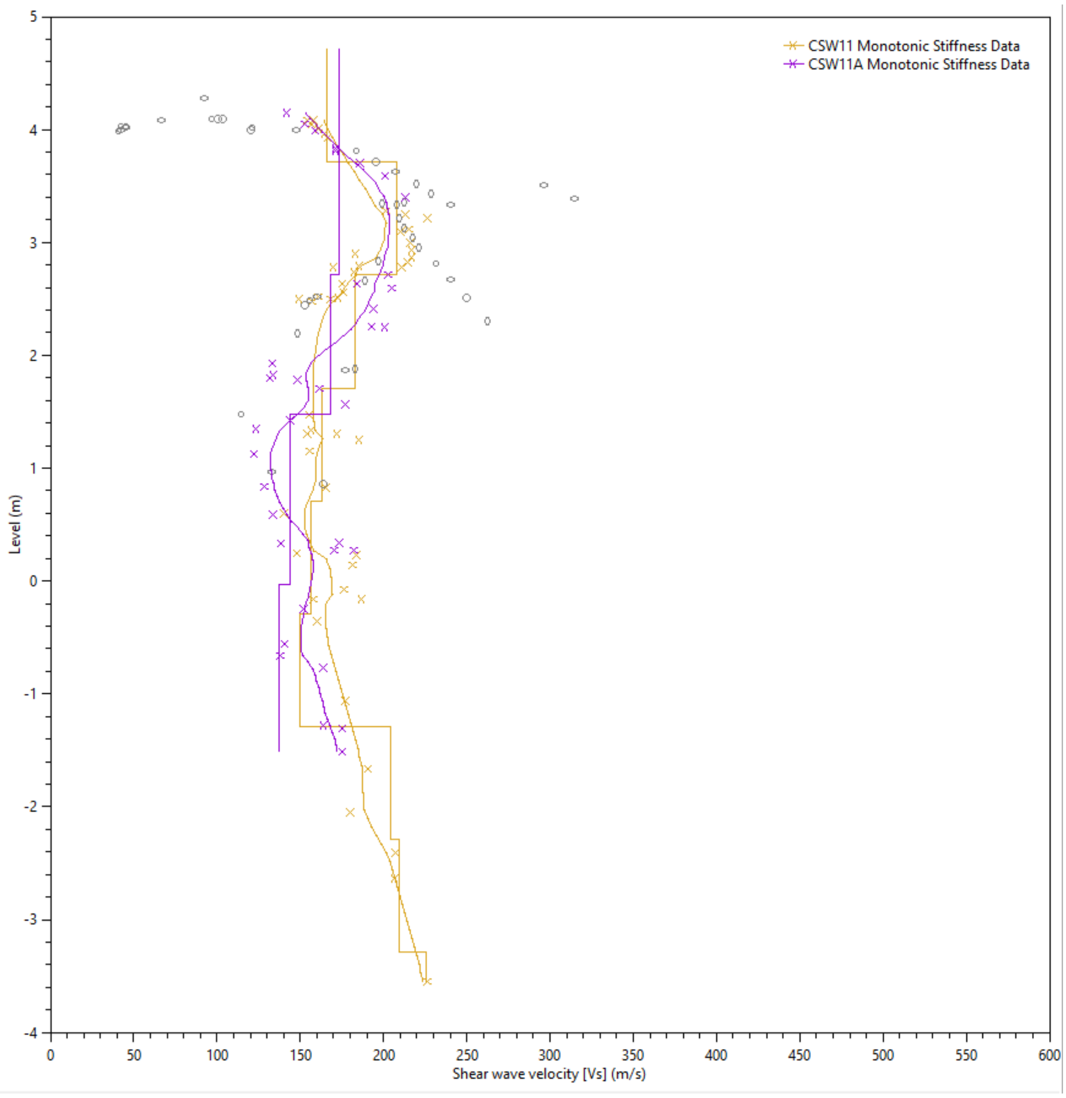


Figure 5-3: Simple and Advanced inversions for CSW11 and CSW11A.

5.1.7 CSW12

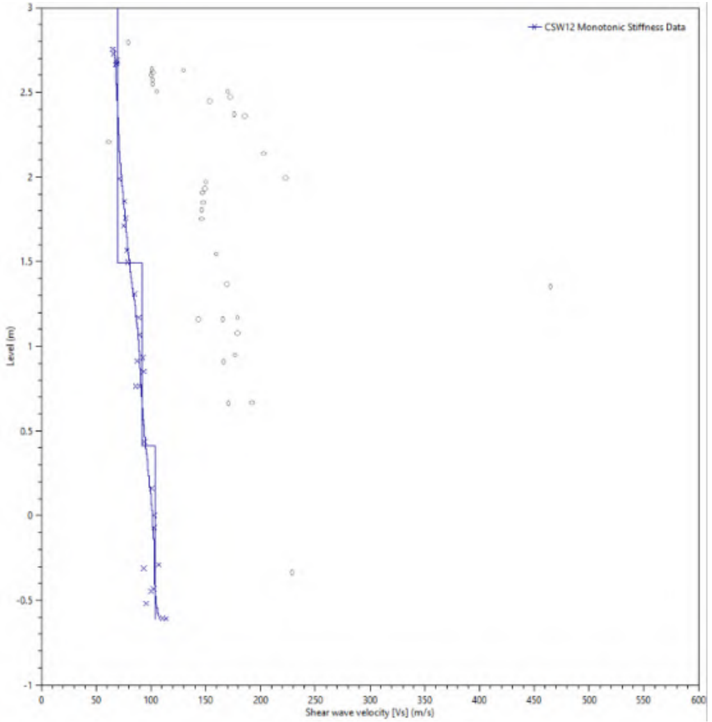
CSW12 is located further north of the previous tests and north of the working platform at CSW11. WS105 is within close proximity to CSW12 and shows similar results. CSW12 shows very soft material throughout the test, with a shear wave velocity range between 70 and 104m/s which equates to strain softened stiffness between 8 and 17MPa and a shear strength between 10 and 24kPa. The very soft material shown in the ACSW test coincides with the low SPT N values that have been recorded during WS105. Due to the low stiffness of the material, the ACSW test only reached a 4.0m depth.

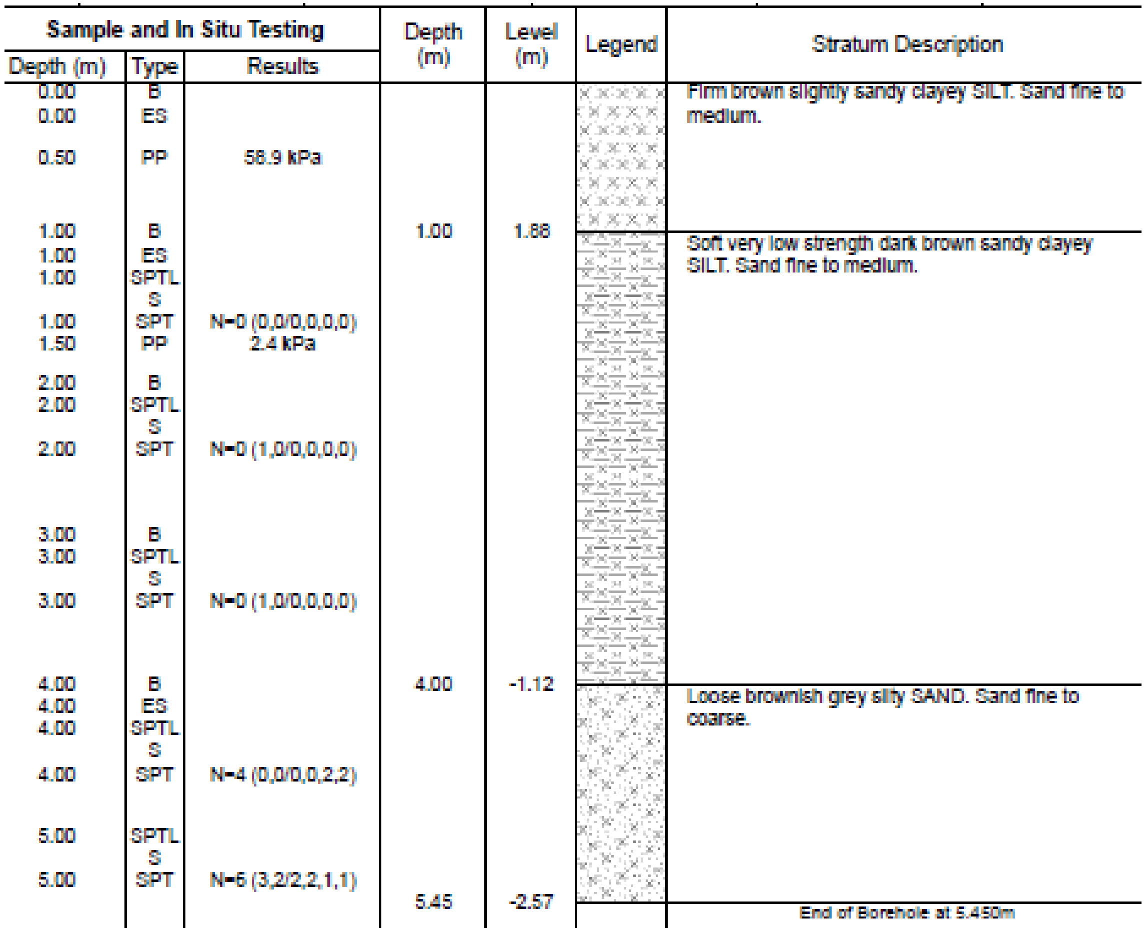
Based upon the SPT N values that were obtained during WS105, it has been demonstrated that the silty sand layer has a higher SPT N value at depth than the soft sandy clayey silt layer at shallow depths, suggesting an increase in stiffness with depth. This increase in ground stiffness at ~4.0m depth is also demonstrated in the ACSW test CSW12.

According to WS105 the following layered profile is present:

- firm slightly sandy clayey silt down to 1.0m depth,
- soft sandy clayey silt down to 4.0m depth,
- silty sand down to 5.45m depth.

A screenshot of the WS105 log is provided in Figure 5-5, and has been placed adjacent to the CDAS superimposed simple and advanced inversions graph of CSW12 in order to provide a comparison between the WS log data and the ACSW data. Both results show soft material, that increase in stiffness at ~4.0m depth. CSW12 was taken at 3.20mAOD compared to WS105 which was taken at 2.88mAOD, therefore the results are recorded at slightly different levels but the results are similar with depth.



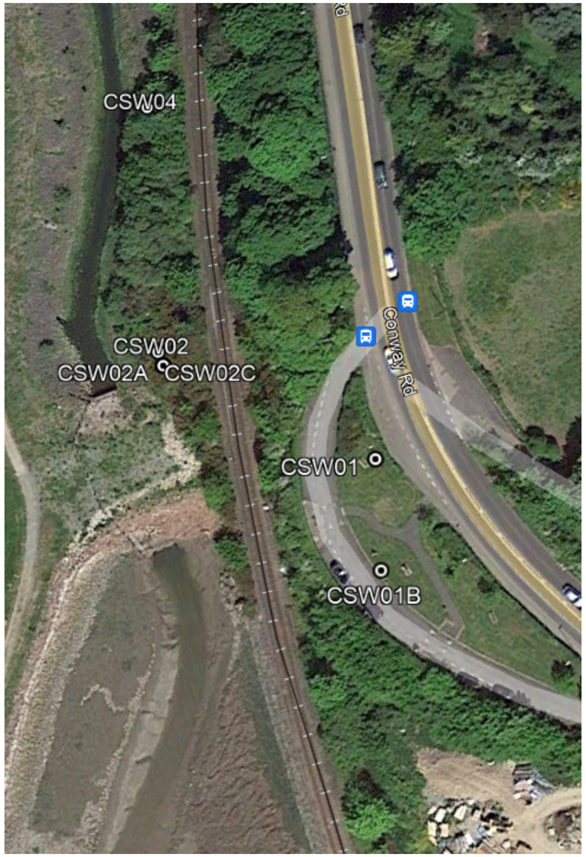


Sample and In Situ Testing			Depth (m)	Level (m)	Legend	Stratum Description
Depth (m)	Type	Results				
0.00	B					Firm brown slightly sandy clayey SILT. Sand fine to medium.
0.00	ES					
0.50	PP	58.9 kPa				
1.00	B		1.00	1.88		Soft very low strength dark brown sandy clayey SILT. Sand fine to medium.
1.00	ES					
1.00	SPTLS					
1.00	SPT	N=0 (0,0/0,0,0,0)				
1.50	PP	2.4 kPa				
2.00	B					
2.00	SPTLS					
2.00	SPT	N=0 (1,0/0,0,0,0)				
3.00	B					
3.00	SPTLS					
3.00	SPT	N=0 (1,0/0,0,0,0)				
4.00	B		4.00	-1.12		Loose brownish grey silty SAND. Sand fine to coarse.
4.00	ES					
4.00	SPTLS					
4.00	SPT	N=4 (0,0/0,0,2,2)				
5.00	SPTLS					
5.00	SPT	N=6 (3,2/2,2,1,1)				
			5.45	-2.57		End of Borehole at 5.450m

Figure 5-4: Simple and Advanced inversions for CSW12.

Figure 5-5: Screenshot of WS105 log, provided by the client.

ACSW test location plan



LEGEND:

REV	DATE	BY	DESCRIPTION	CHK	APD
A	29/02/2024	IB	FIRST ISSUE	JB	JB

DRAWING STATUS: FIRST ISSUE

SoilSafe Ltd
54 Oak Street
Manchester
M4 5JA

CLIENT: Ground Solve Ltd

ARCHITECT: TBC

PROJECT: RSPB Conwy

TITLE: ACSW Location Plan

SCALE @ SIZE: NTS	CHECKED: JB	APPROVED: JB
CAD FILE: N/A	DESIGN/DRAWN: IB	DATE: 29/02/2024
PROJECT No: P-1084	DRAWING No: P-1084DWG1	REV: A

Appendix A: Field dispersion curves & combined simple and advanced inversion plots

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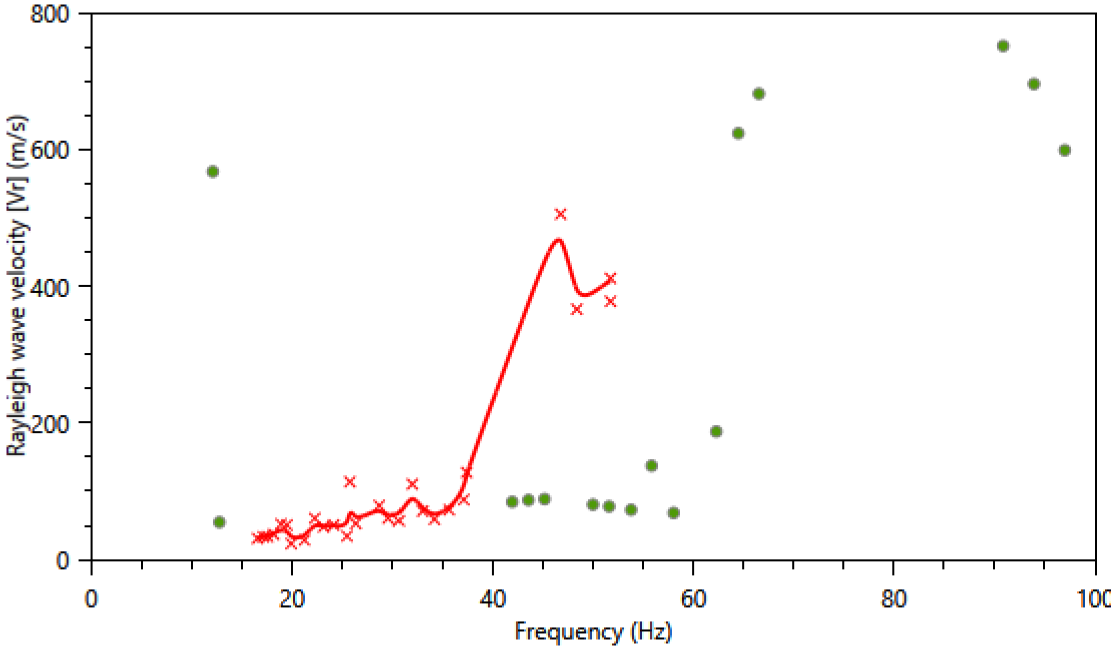
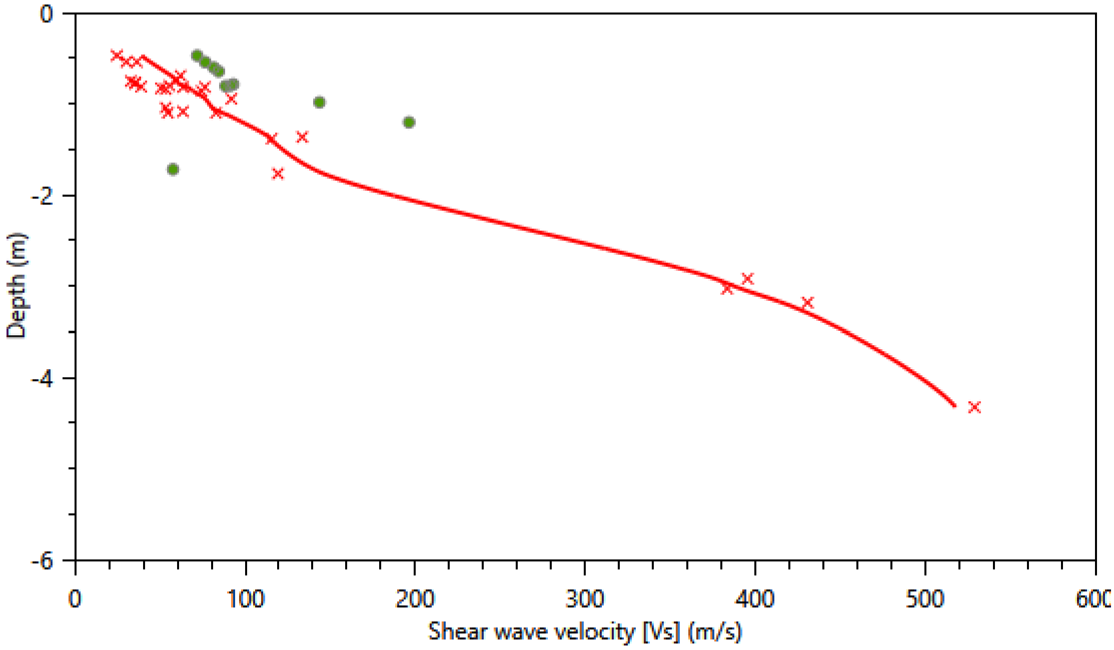
See Appendix D for key

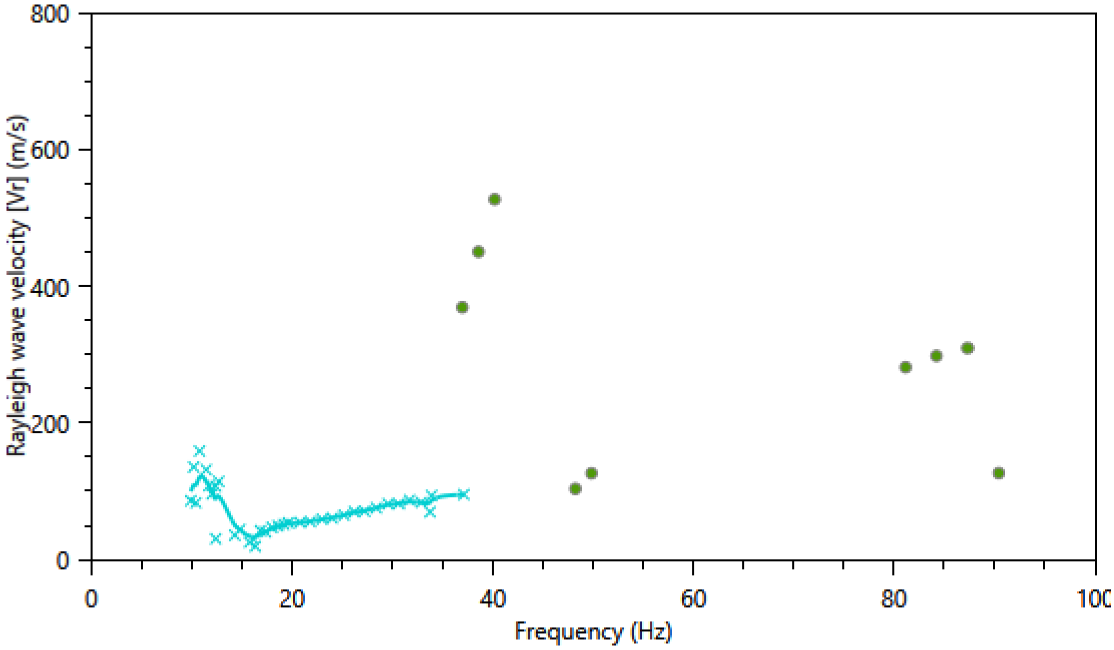
CSW01 Field dispersion curve



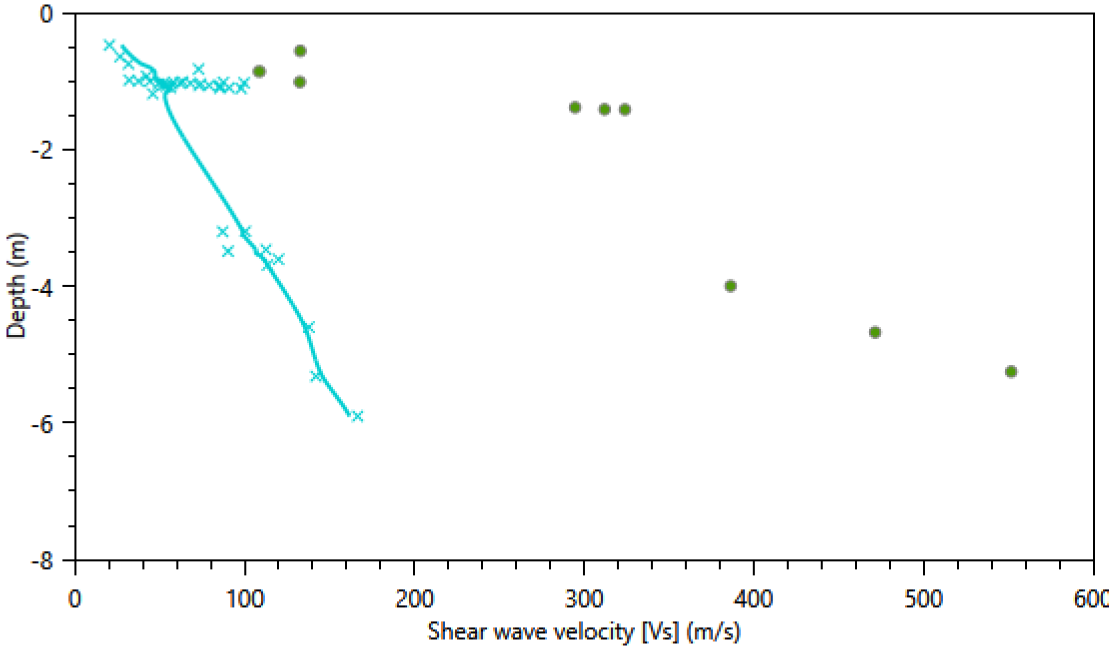
CSW01 Simple & advanced inversion



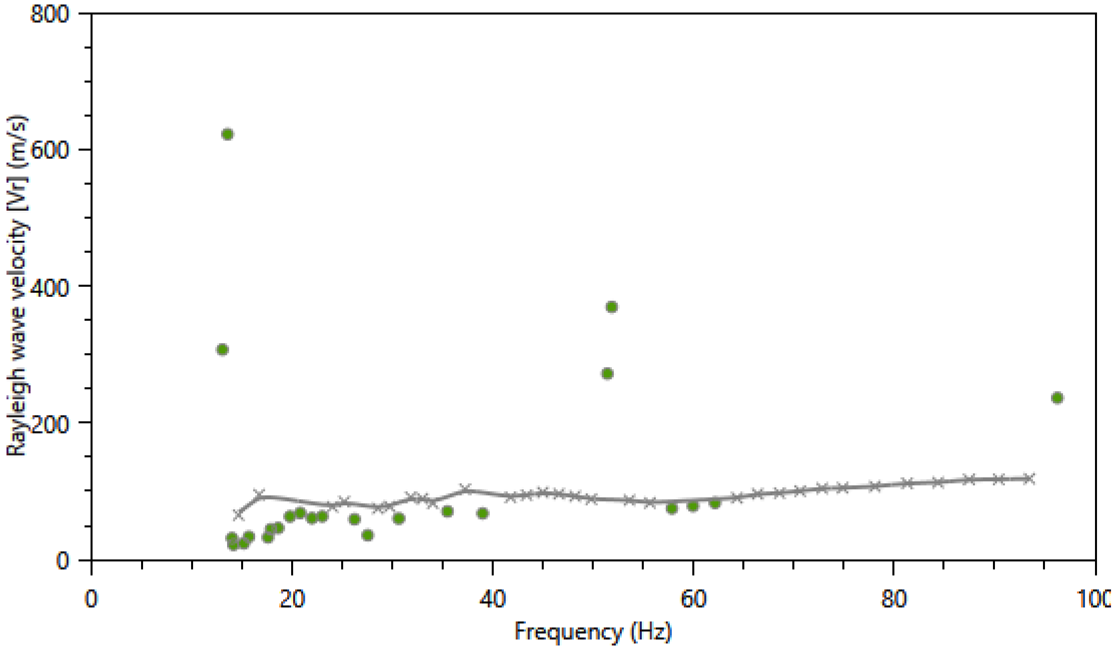
CSW01B Field dispersion curve



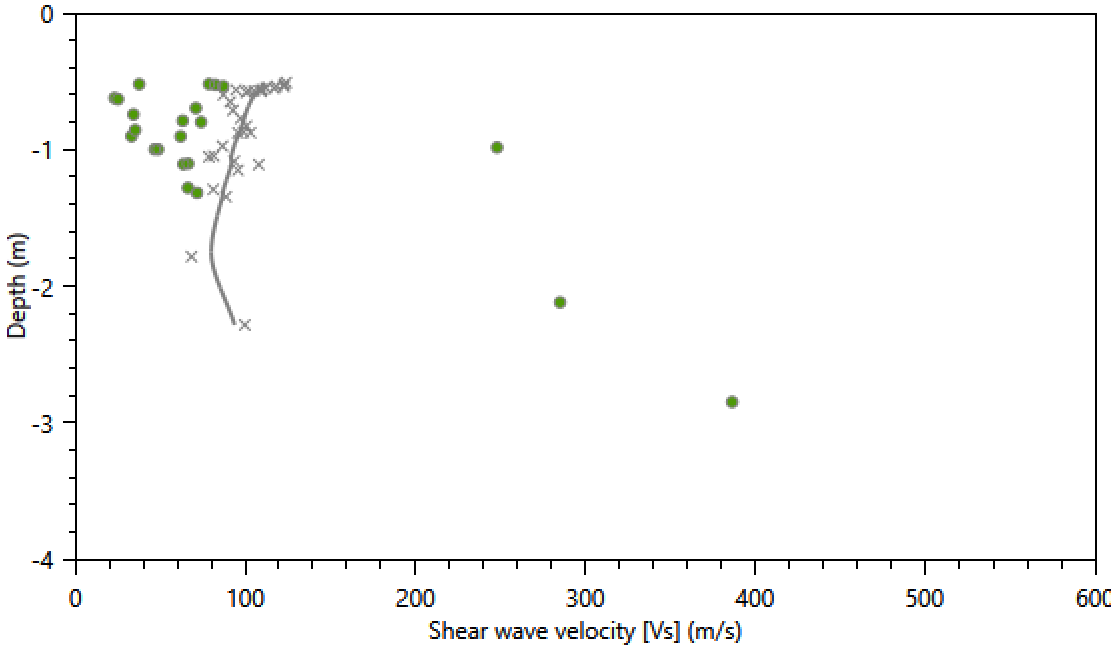
CSW01B Simple & advanced inversion



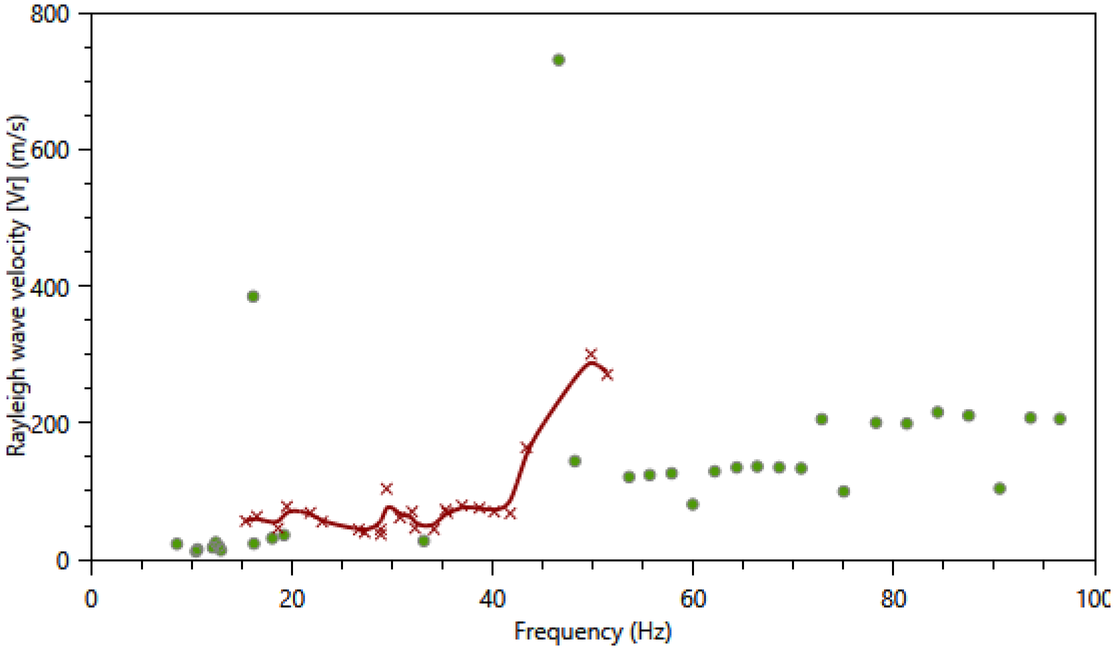
CSW02 Field dispersion curve



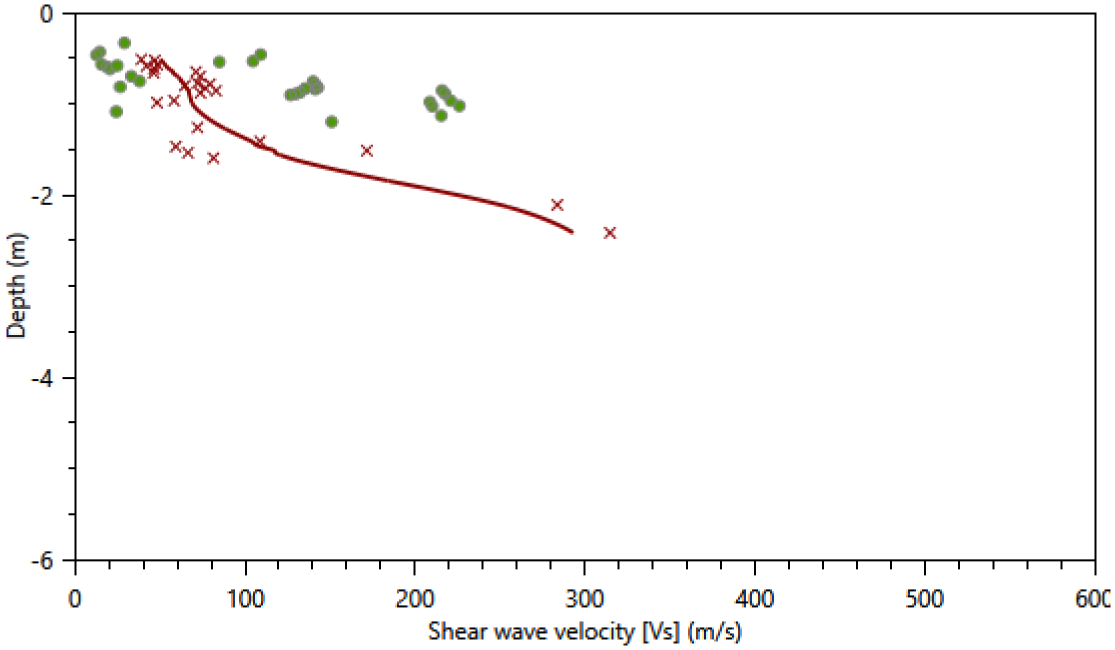
CSW02 Simple & advanced inversion



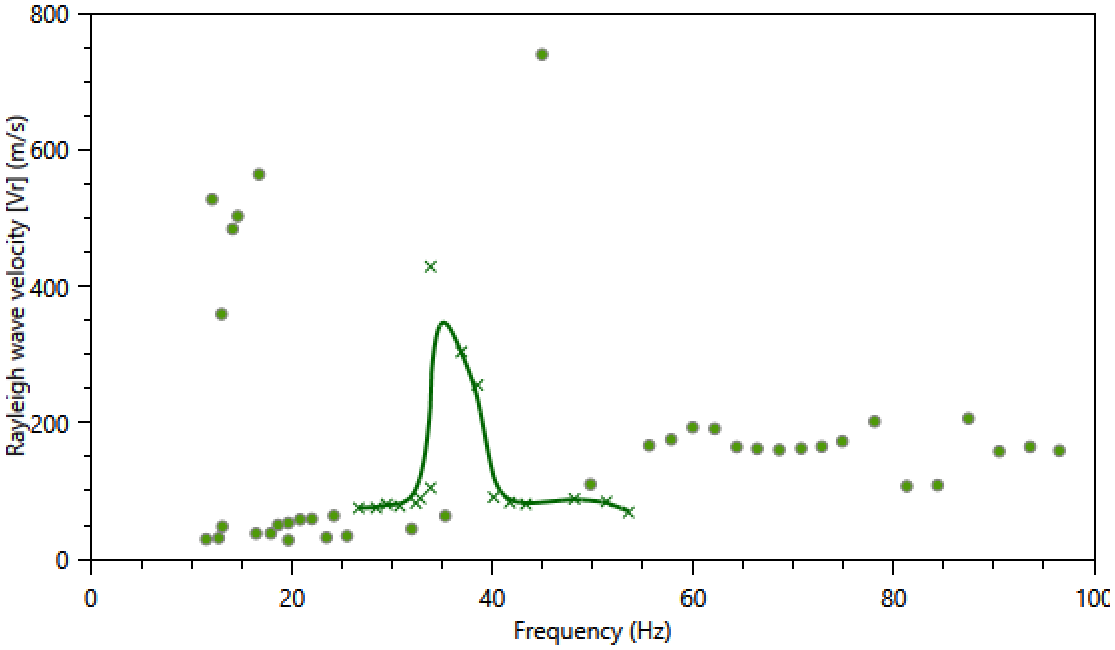
CSW02A Field dispersion curve



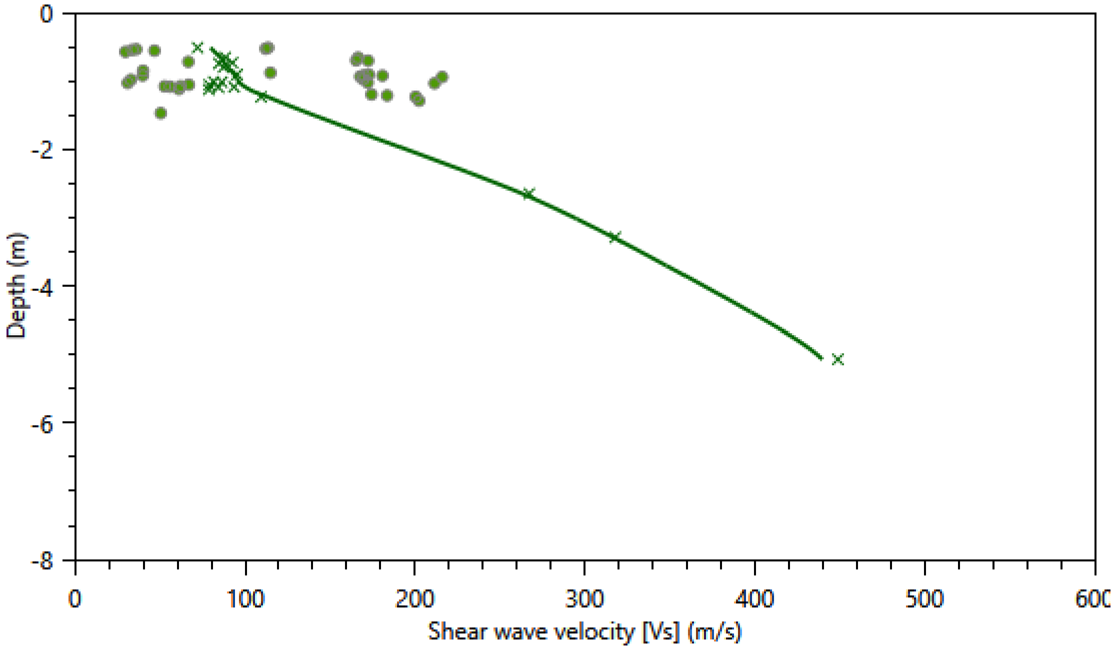
CSW02A Simple & advanced inversion



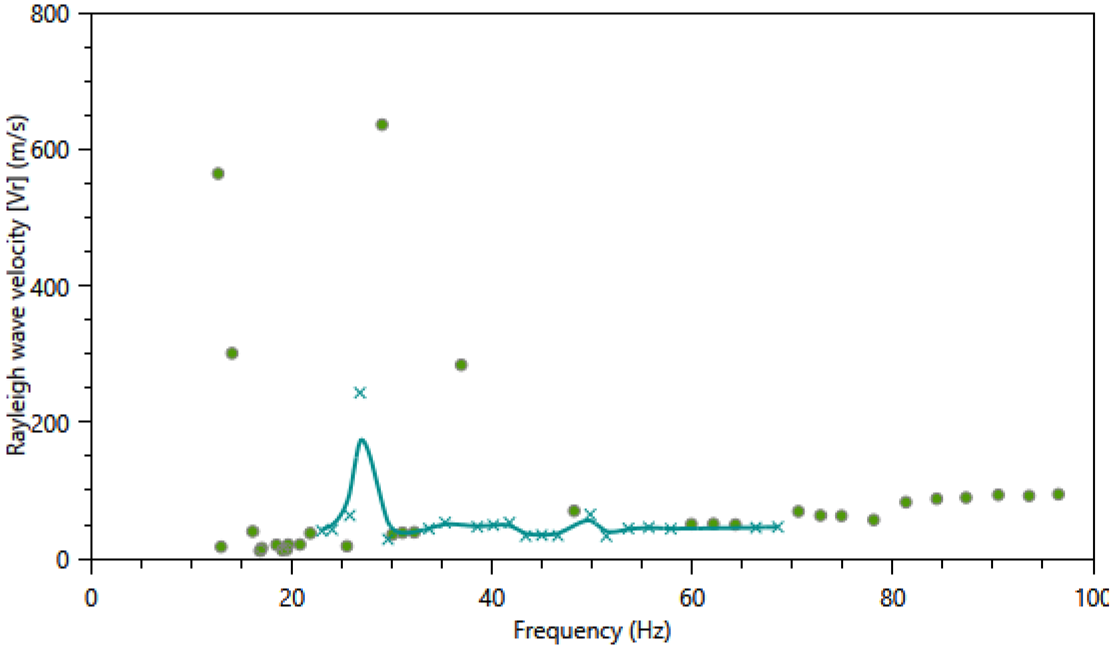
CSW02B Field dispersion curve



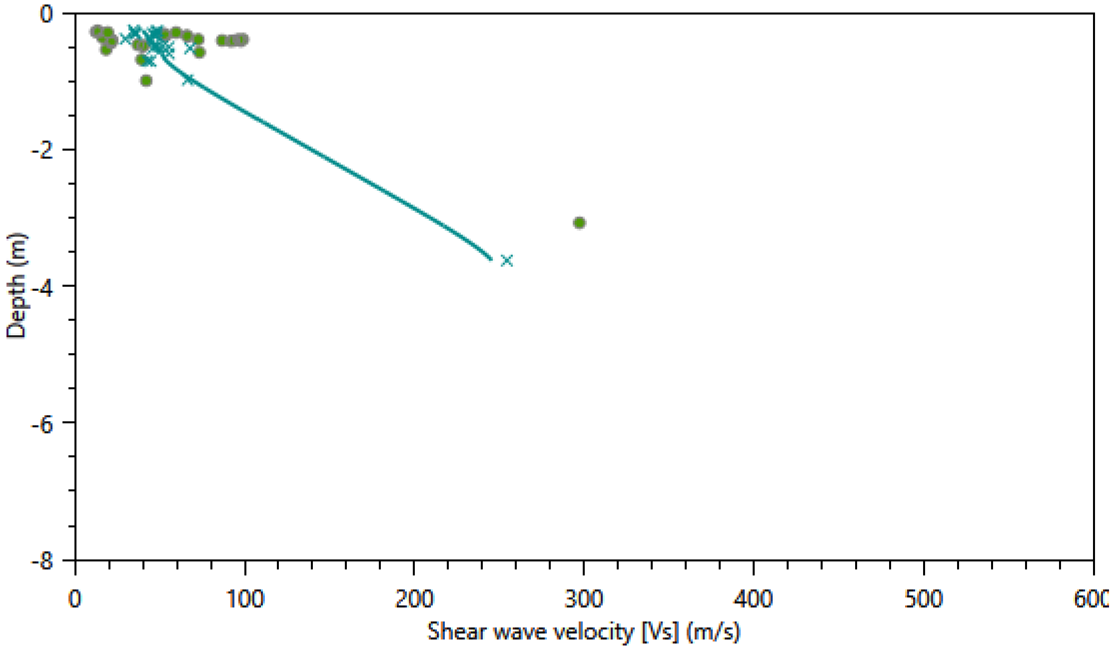
CSW02B Simple & advanced inversion



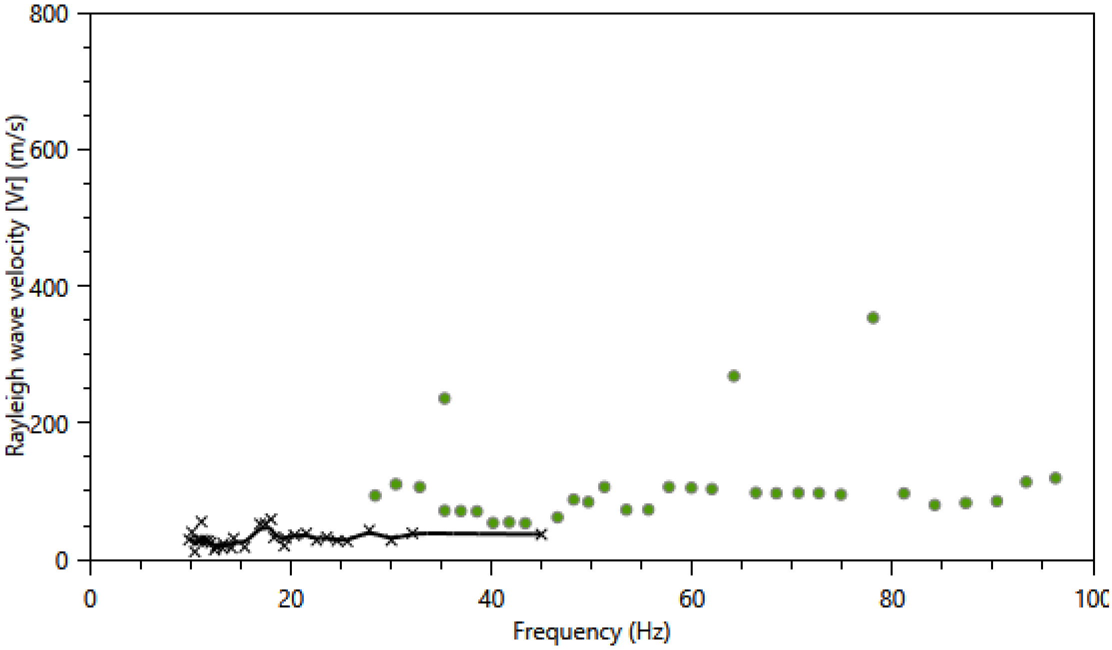
CSW02C Field dispersion curve



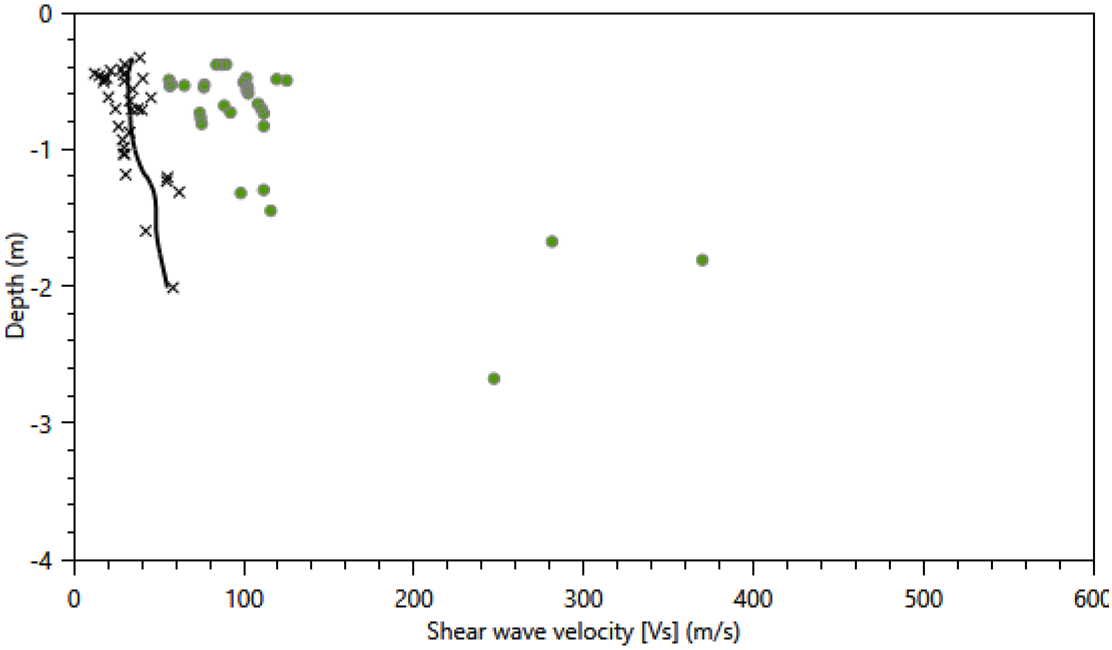
CSW02C Simple & advanced inversion



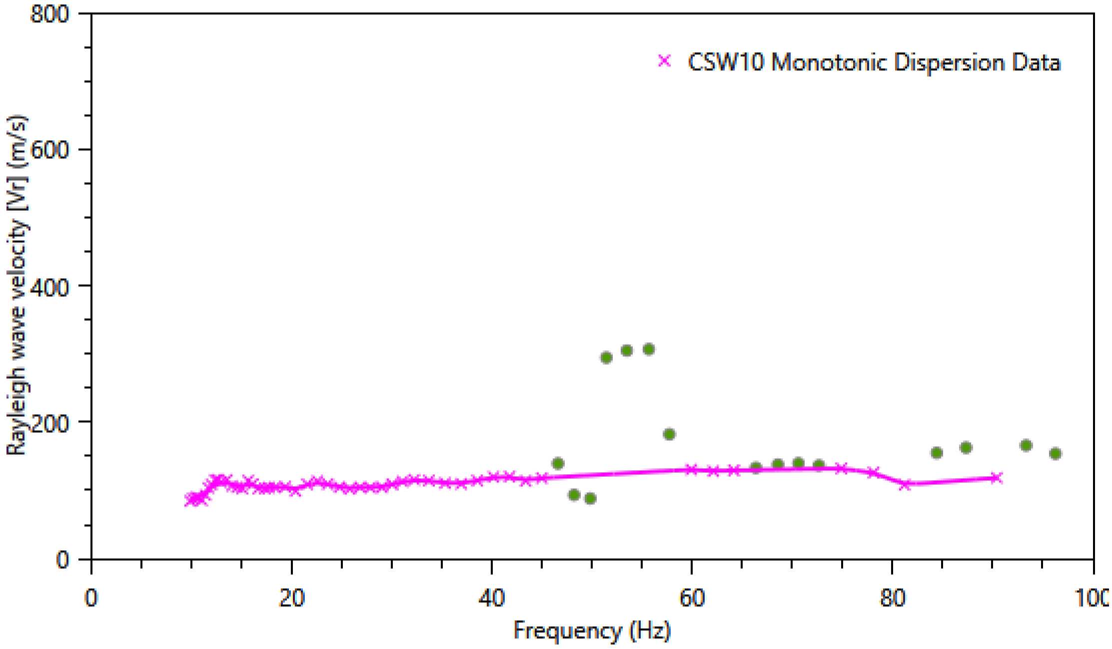
CSW04 Field dispersion curve



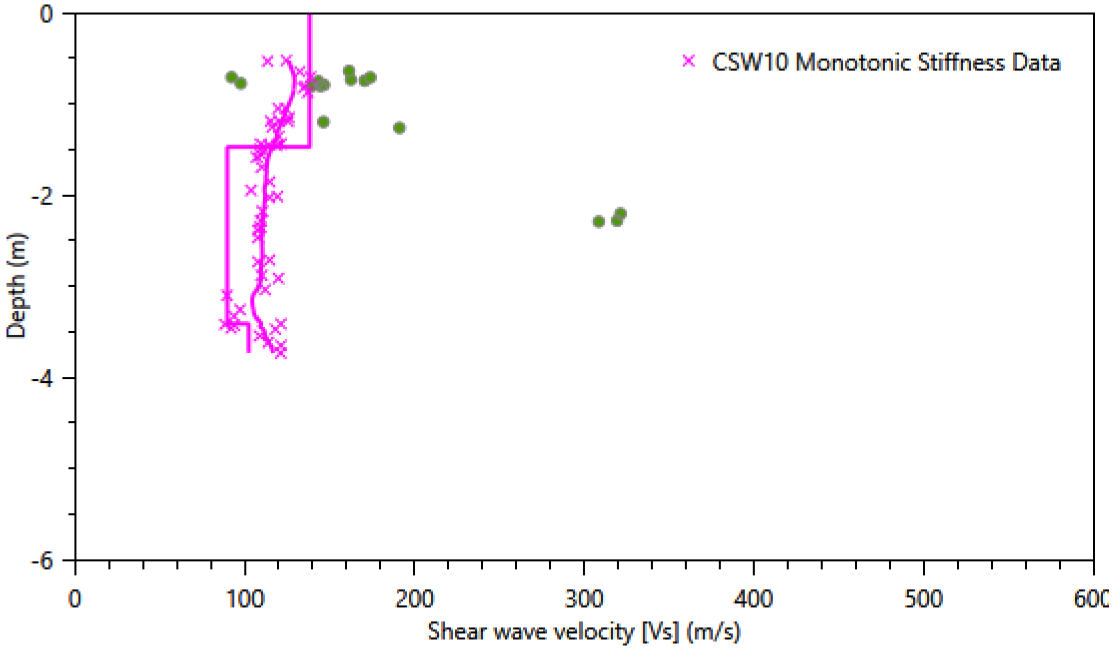
CSW04 Simple & advanced inversion



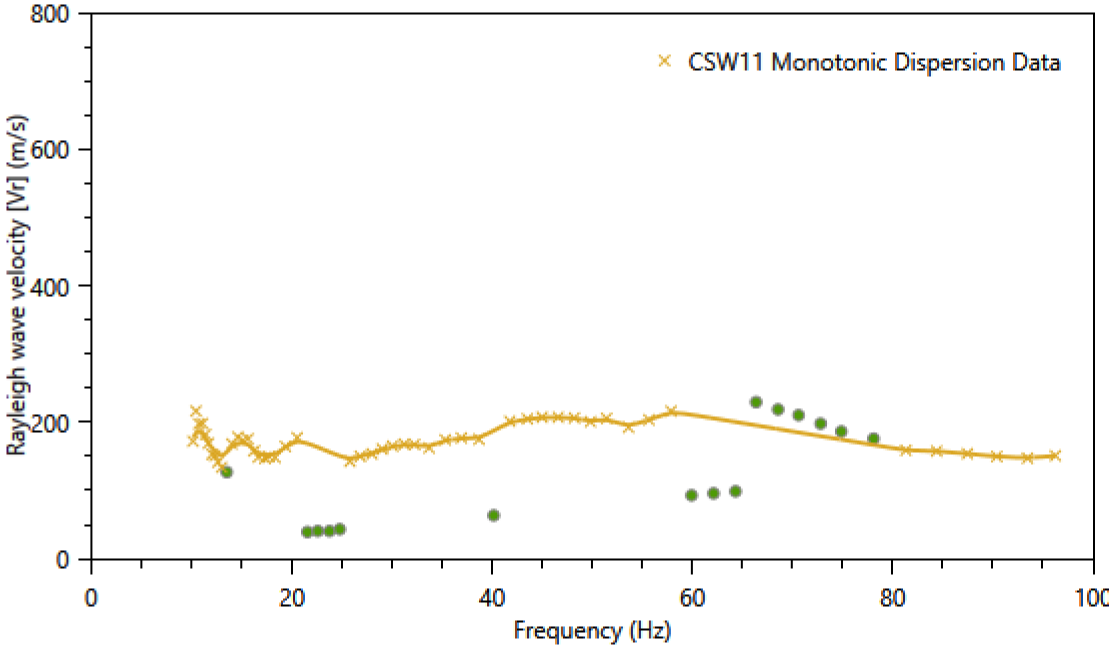
CSW10 Field dispersion curve



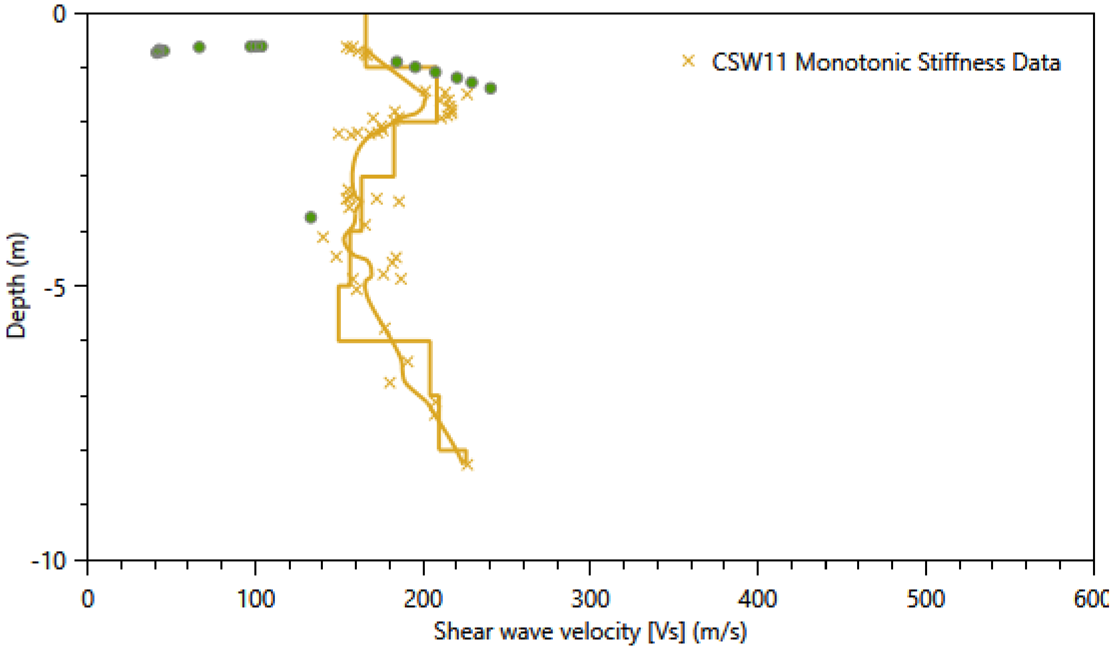
CSW10 Simple & advanced inversion



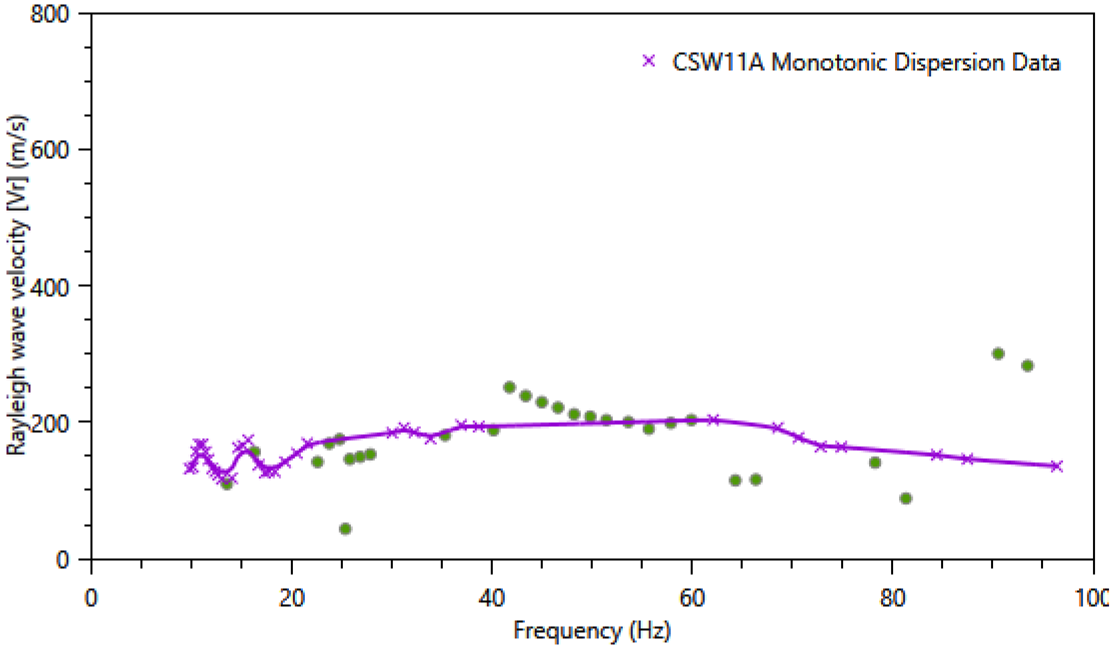
CSW11 Field dispersion curve



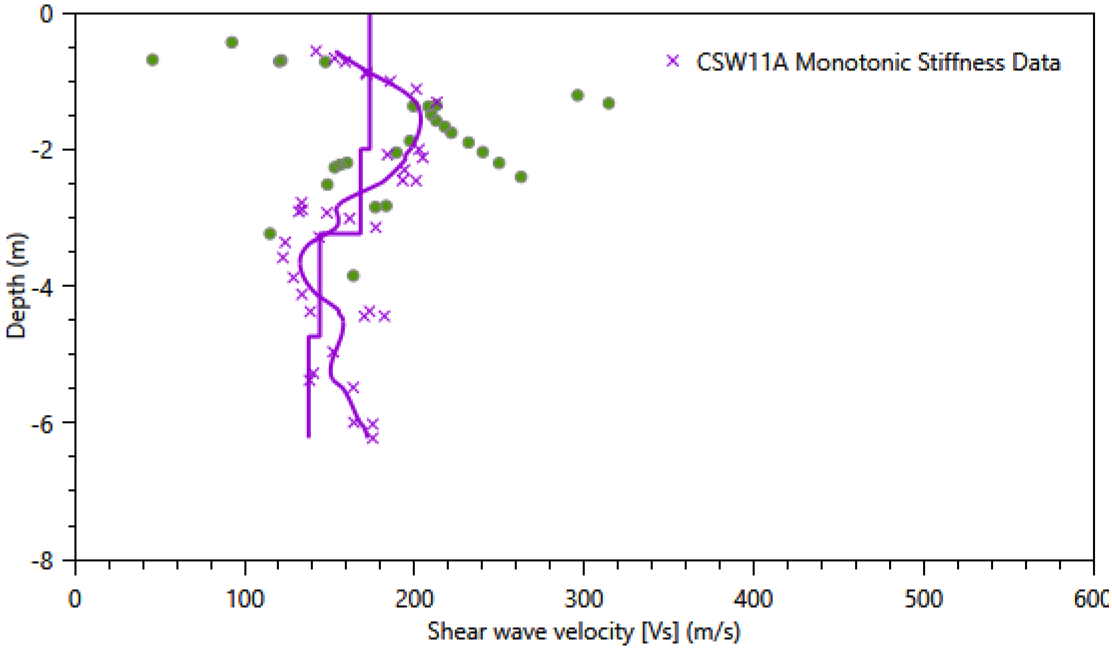
CSW11 Simple & advanced inversion



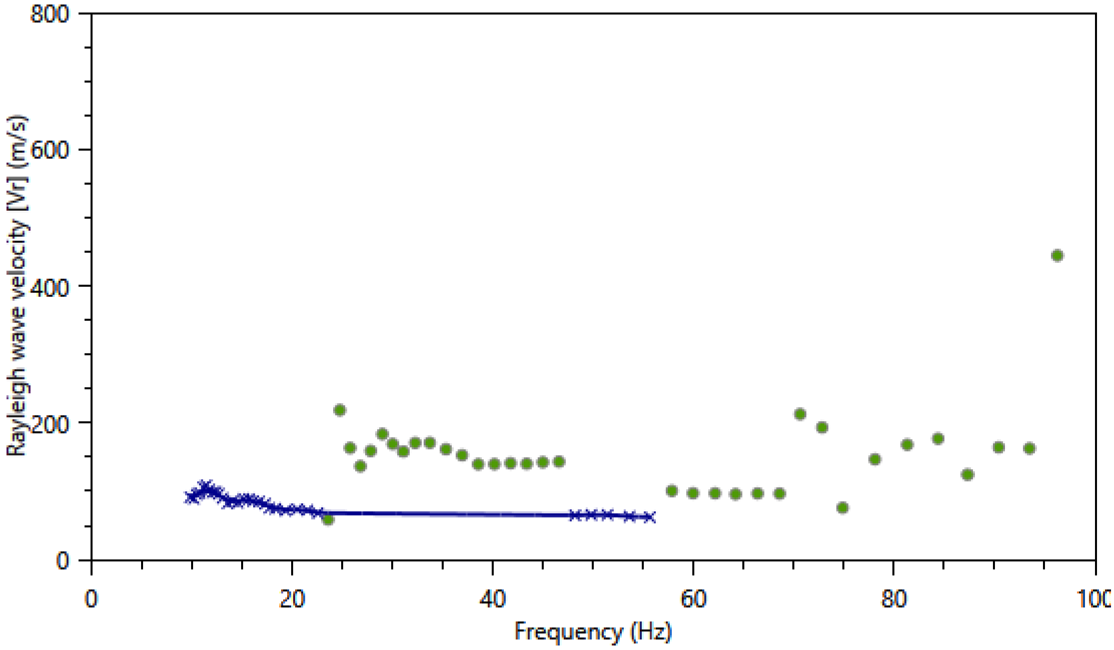
CSW11A Field dispersion curve



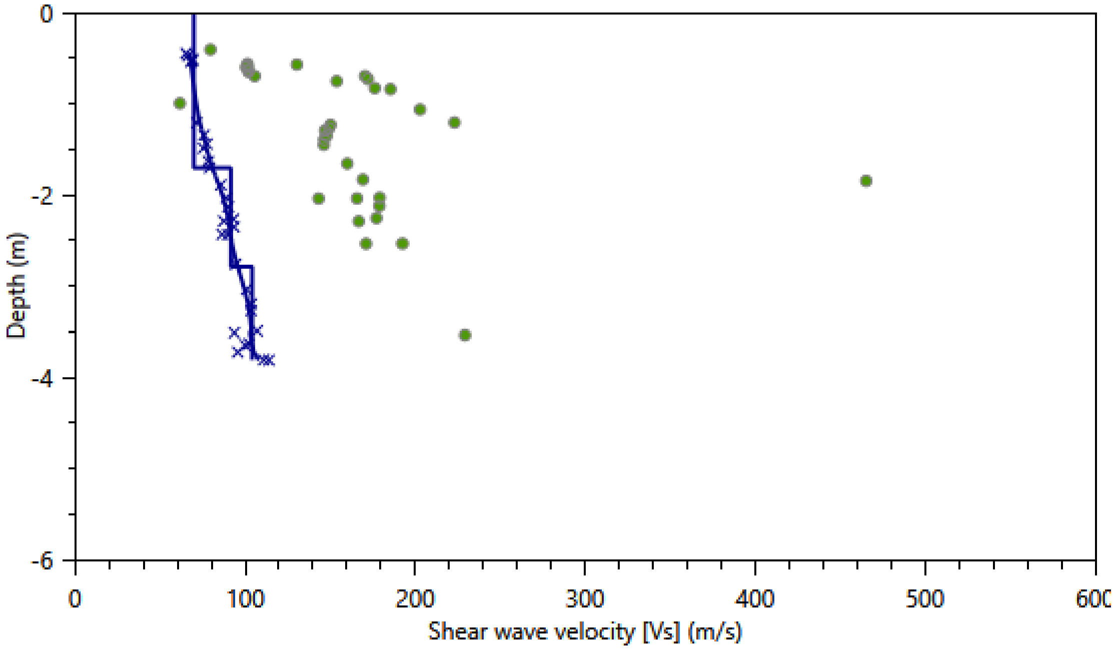
CSW11A Simple & advanced inversion



CSW12 Field dispersion curve



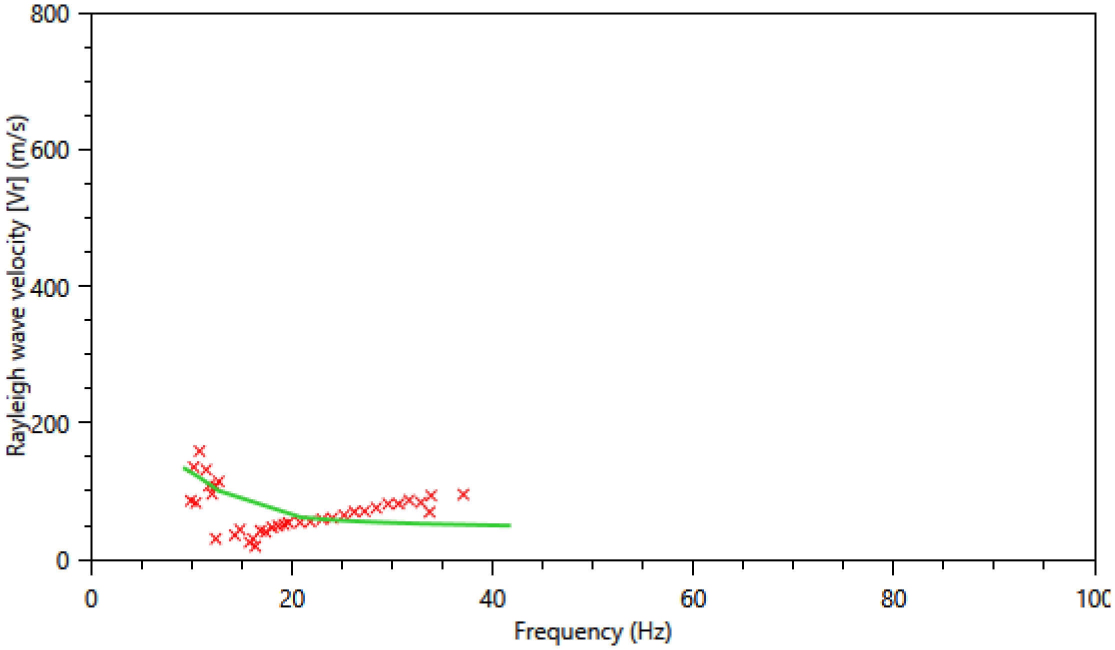
CSW12 Simple & advanced inversion



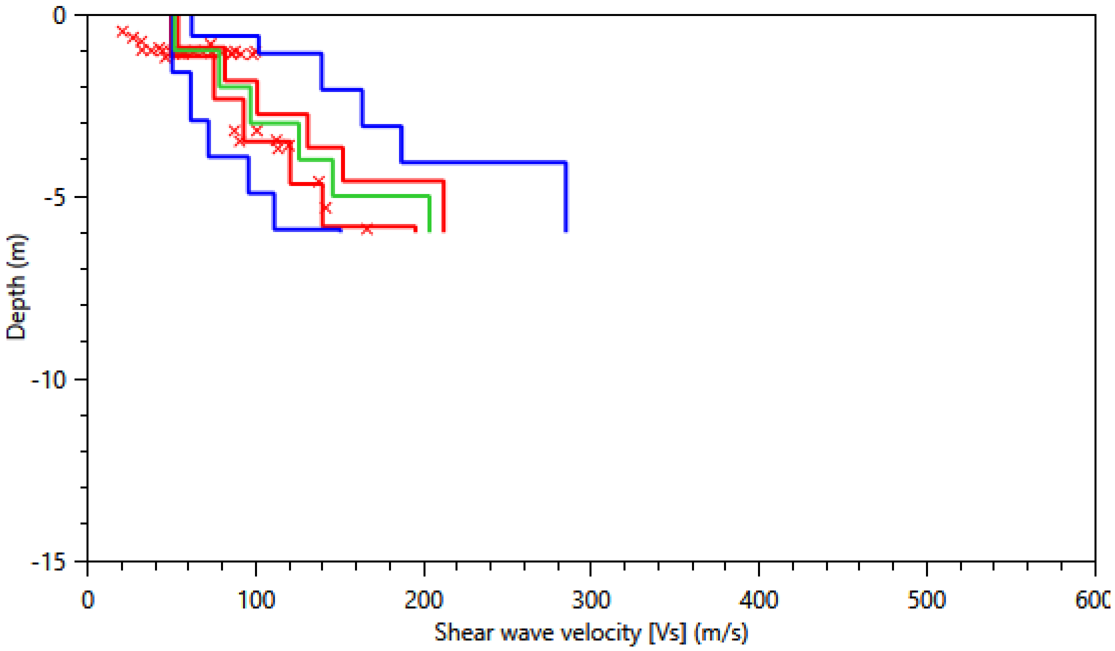
Appendix B: Synthetic dispersion curves & advanced inversion profiles

See Appendix D for key

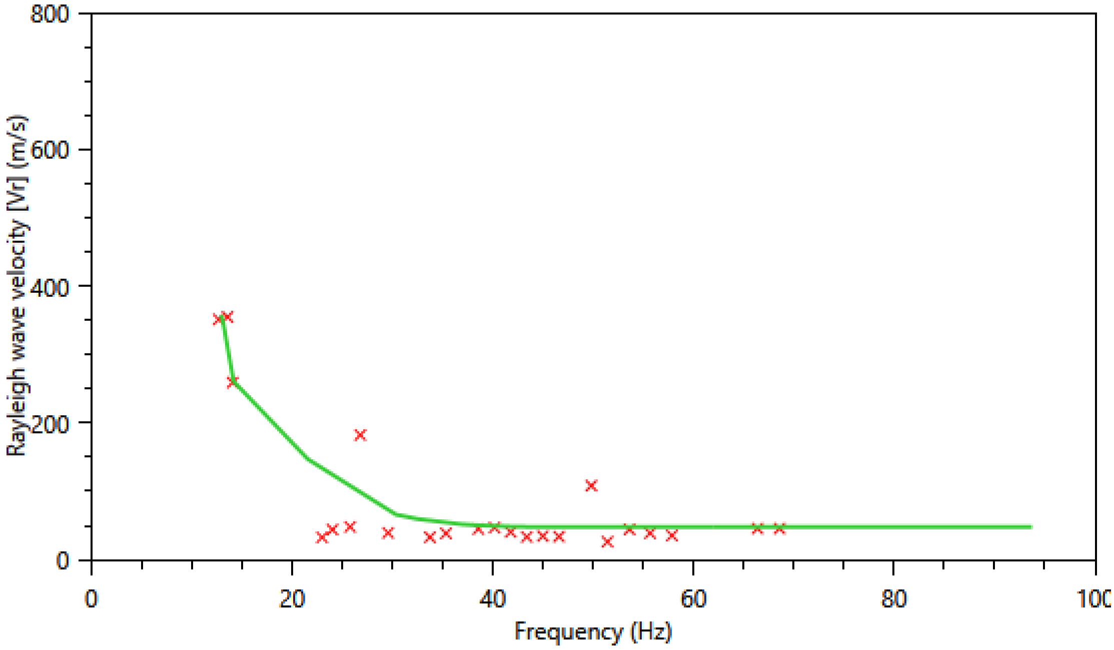
CSW01B Advanced inversion synthetic dispersion curve



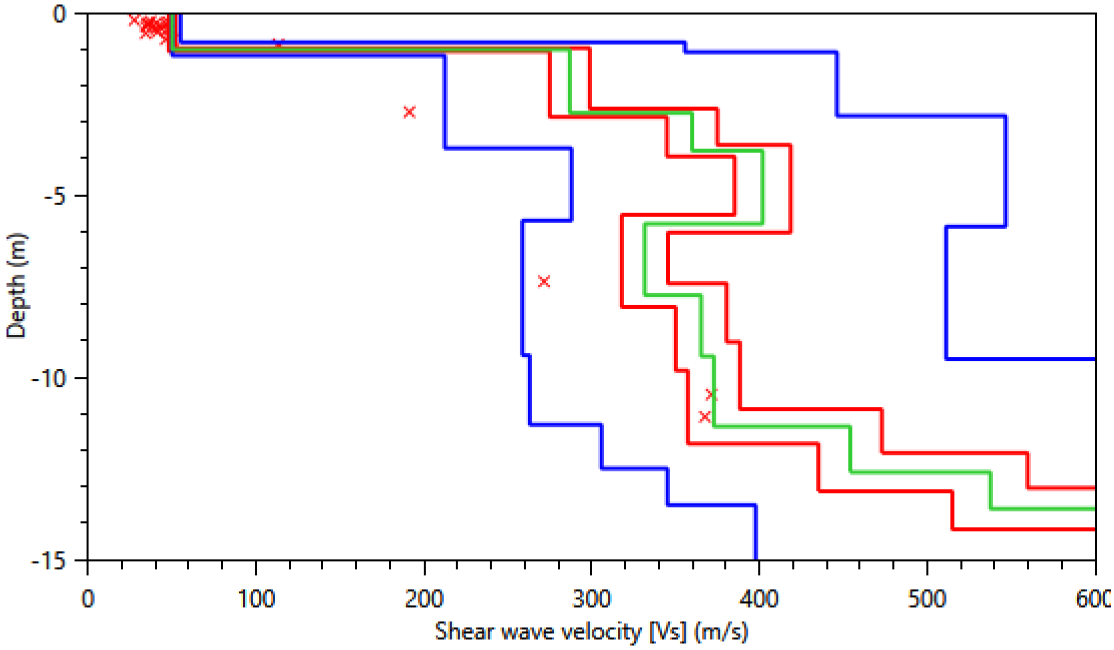
CSW01B Advanced inversion



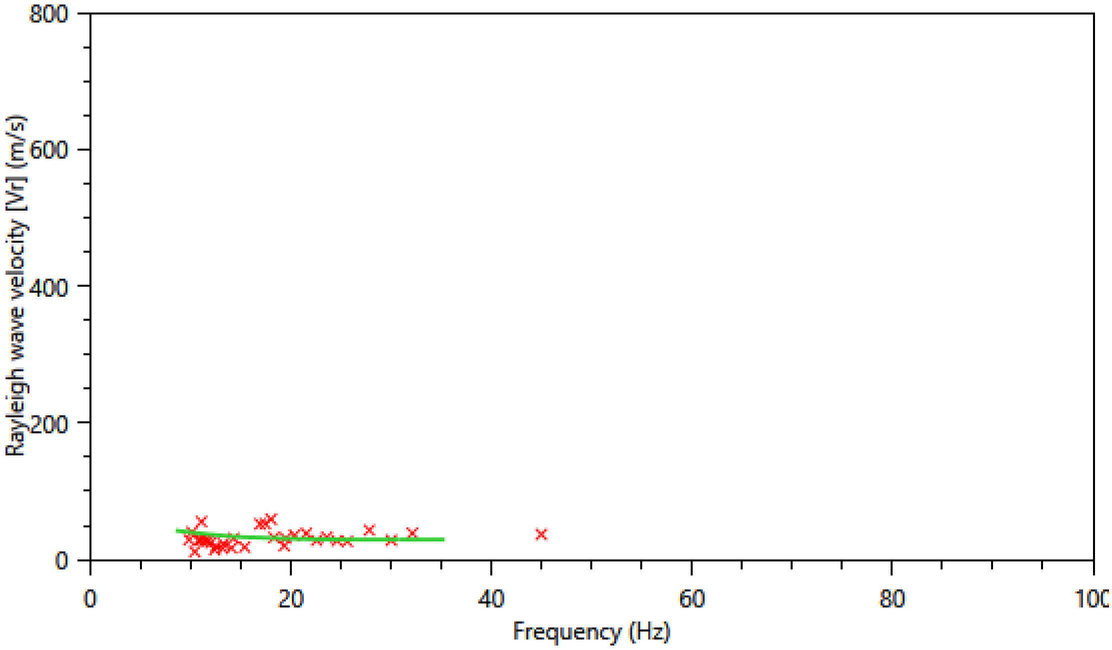
CSW02C Advanced inversion synthetic dispersion curve



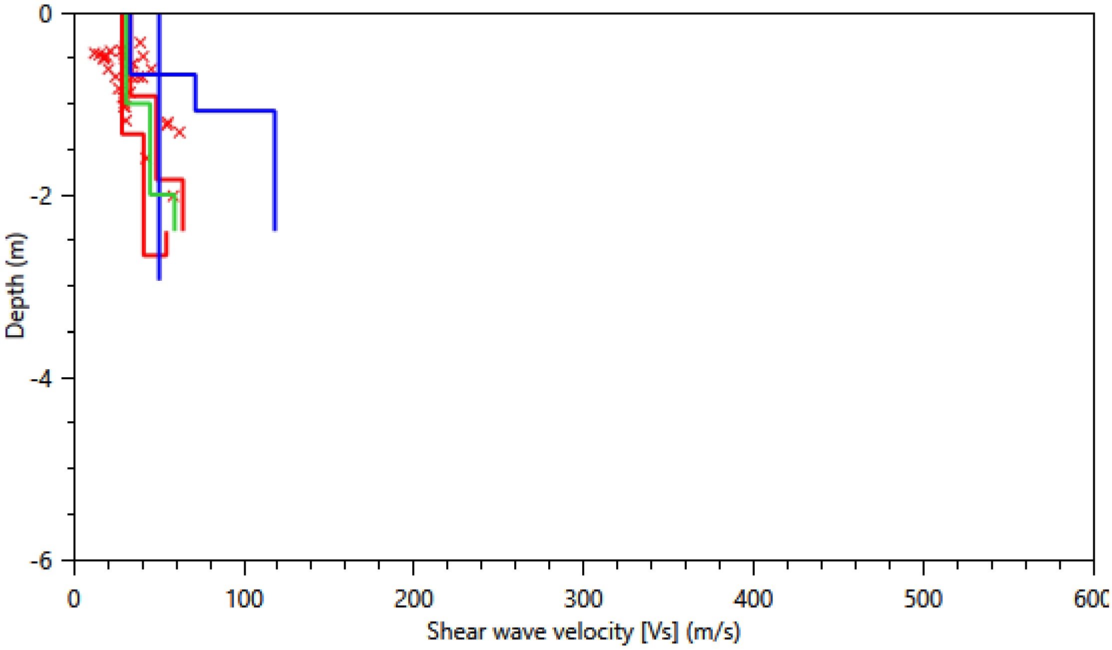
CSW02C Advanced inversion



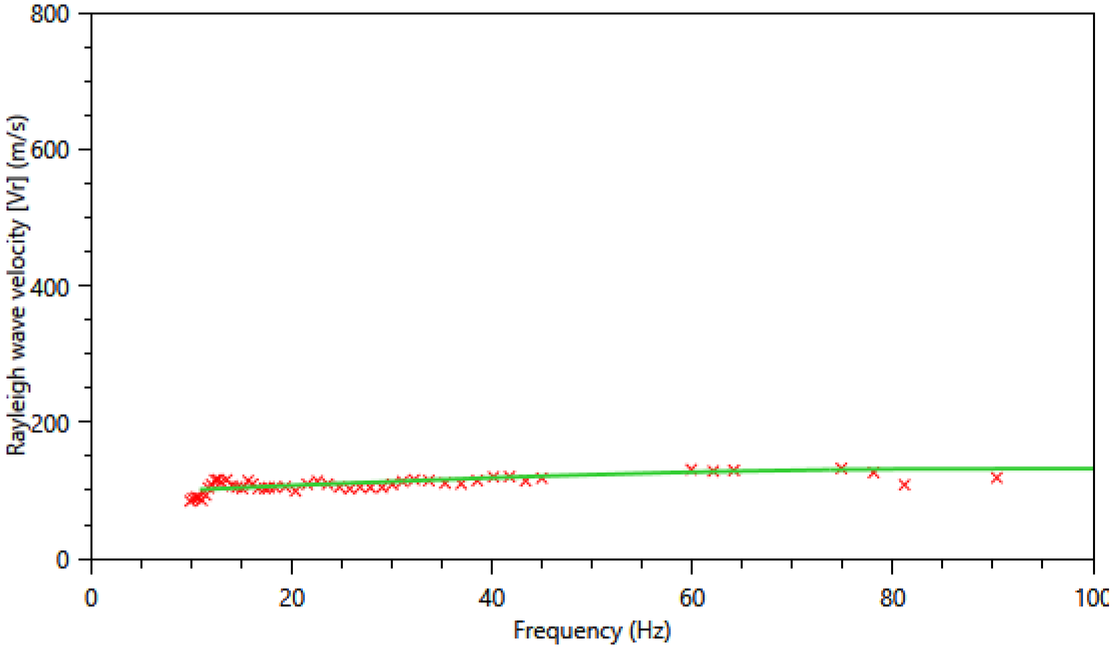
CSW04 Advanced inversion synthetic dispersion curve



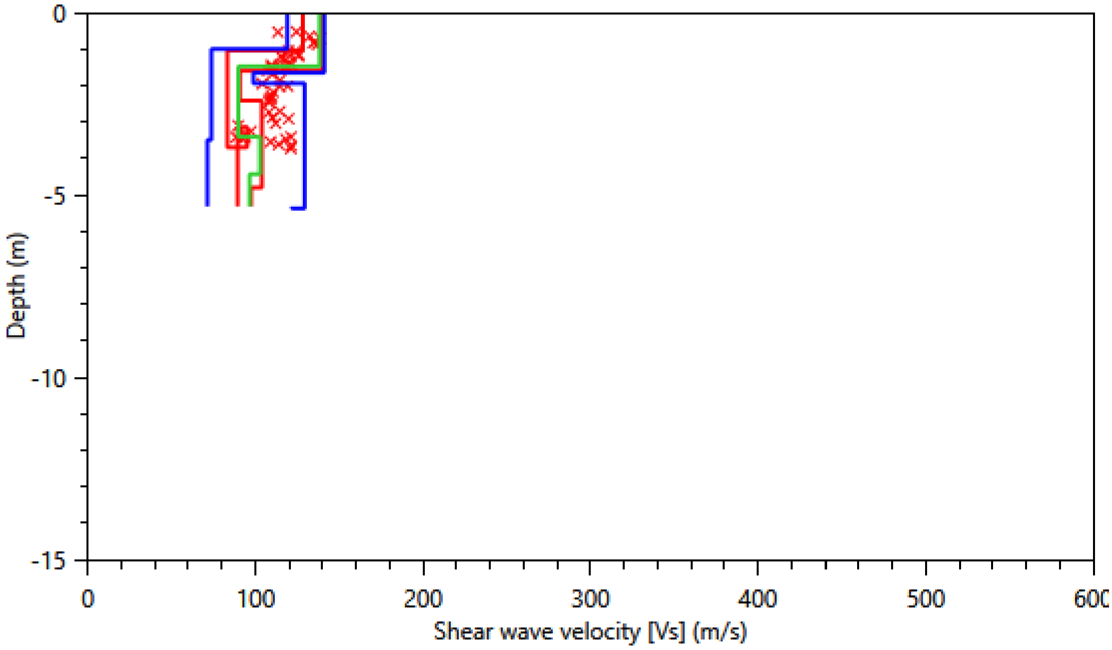
CSW04 Advanced inversion



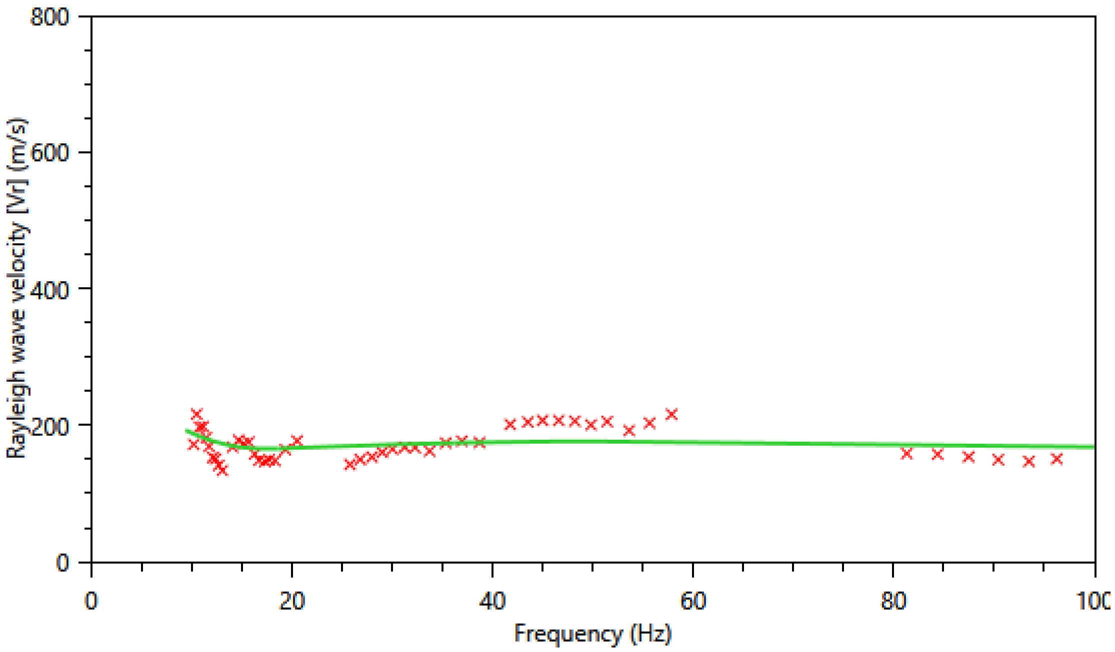
CSW10 Advanced inversion synthetic dispersion curve



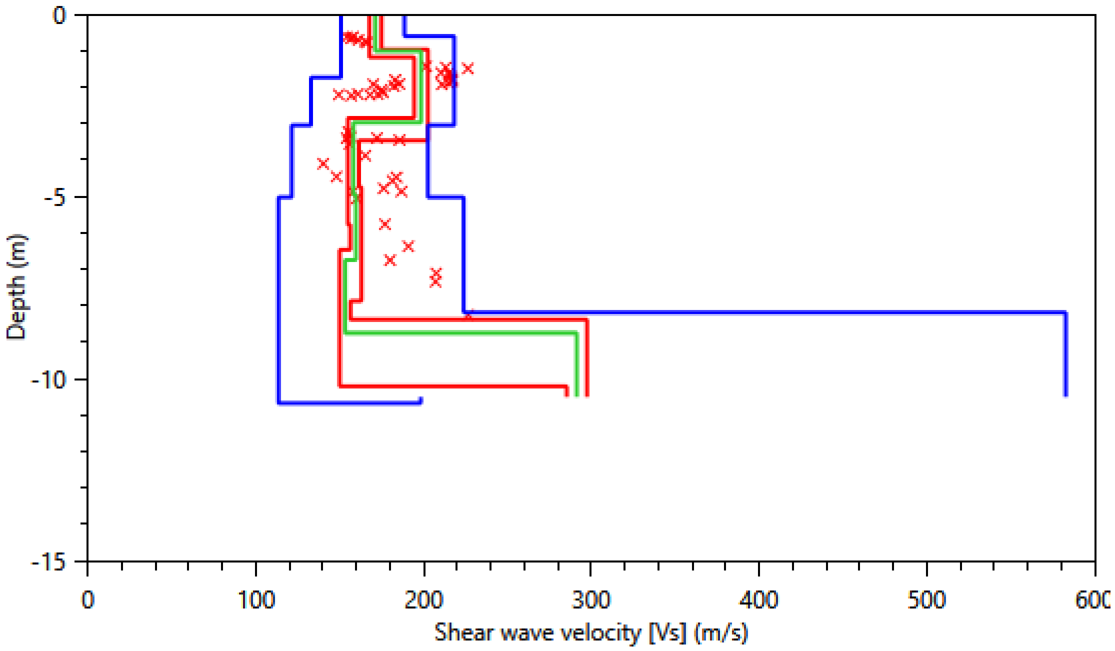
CSW10 Advanced inversion



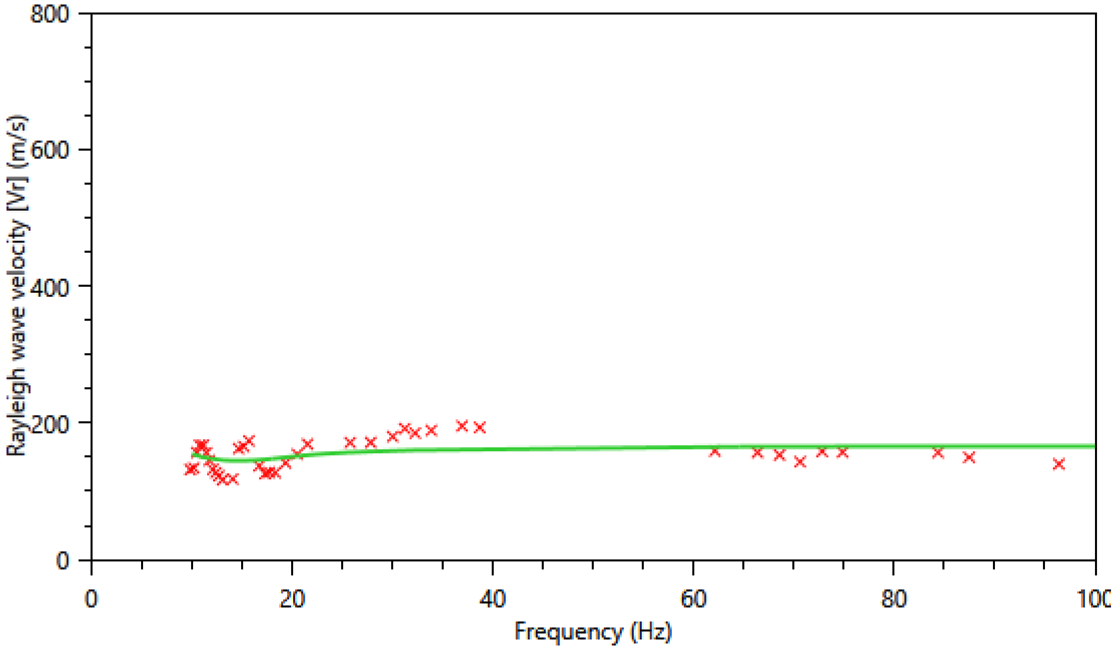
CSW11 Advanced inversion synthetic dispersion curve



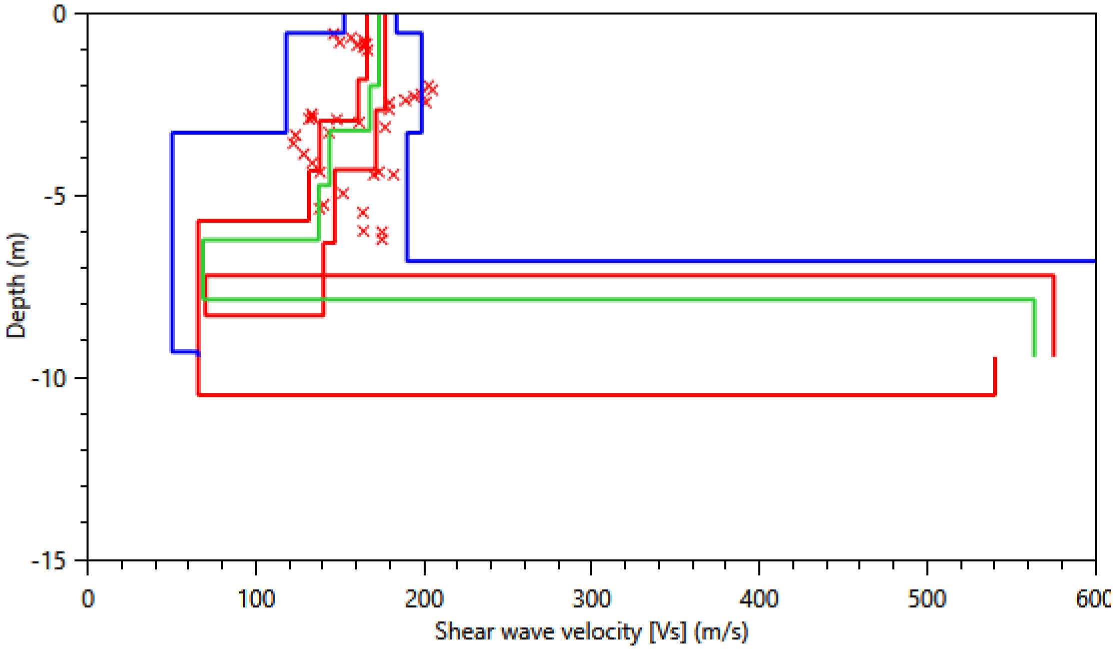
CSW11 Advanced inversion



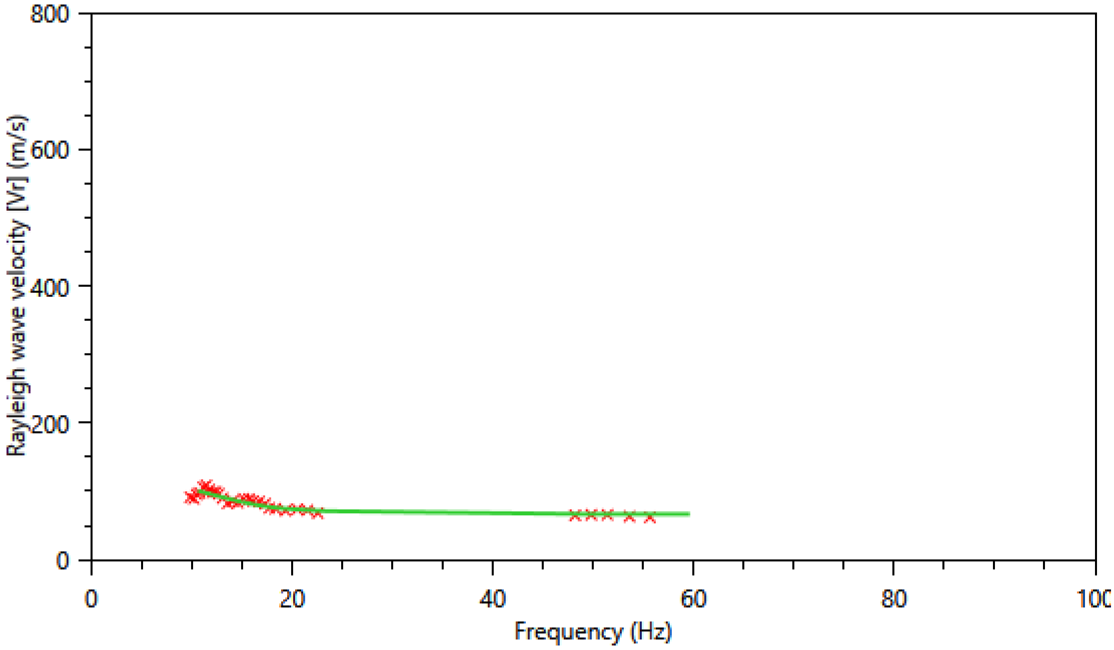
CSW11A Advanced inversion synthetic dispersion curve



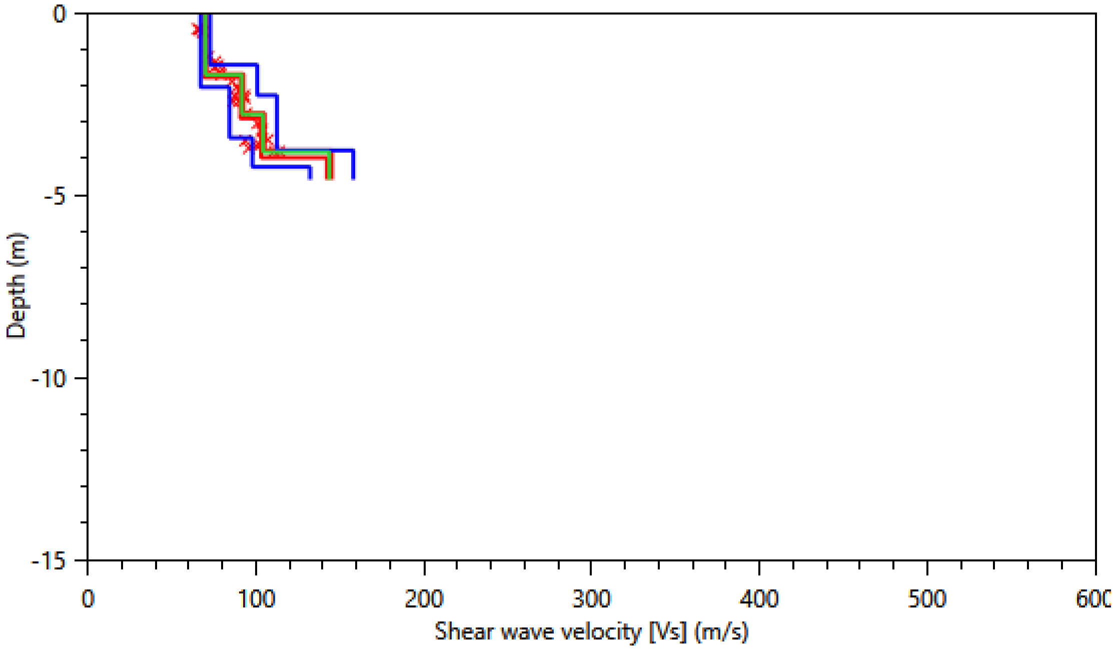
CSW11A Advanced inversion



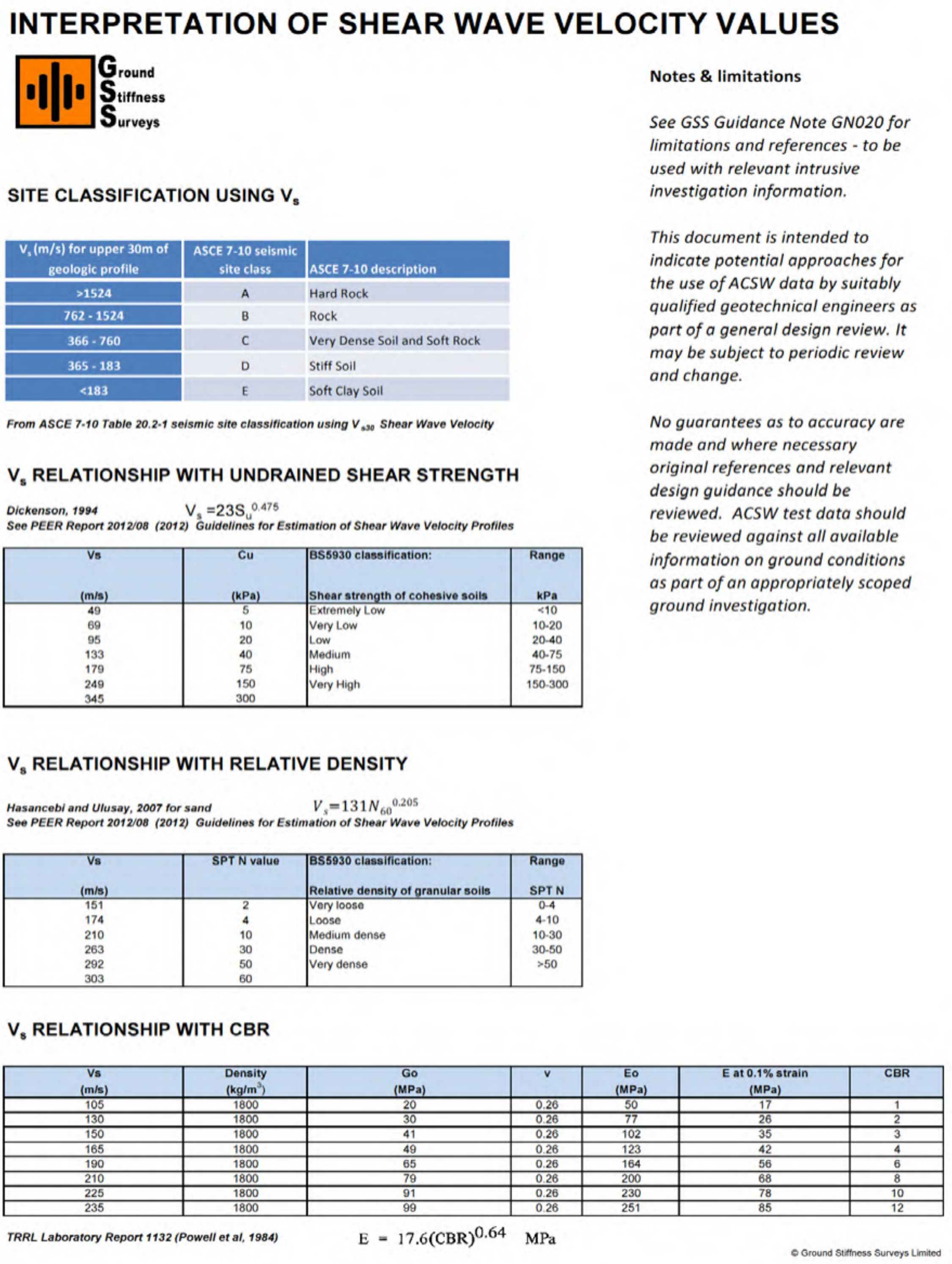
CSW12 Advanced inversion synthetic dispersion curve



CSW12 Advanced inversion



Appendix C: Advanced inversion data



INTERPRETATION OF SHEAR WAVE VELOCITY VALUES

Ground Stiffness Surveys

SITE CLASSIFICATION USING V_s

V_s (m/s) for upper 30m of geologic profile	ASCE 7-10 seismic site class	ASCE 7-10 description
>1524	A	Hard Rock
762 - 1524	B	Rock
366 - 760	C	Very Dense Soil and Soft Rock
365 - 183	D	Stiff Soil
<183	E	Soft Clay Soil

From ASCE 7-10 Table 20.2-1 seismic site classification using V_{s30} Shear Wave Velocity

V_s RELATIONSHIP WITH UNDRAINED SHEAR STRENGTH

Dickenson, 1994 $V_s = 23S_u^{0.475}$

See PEER Report 2012/08 (2012) Guidelines for Estimation of Shear Wave Velocity Profiles

Vs (m/s)	Cu (kPa)	BS5930 classification: Shear strength of cohesive soils	Range kPa
49	5	Extremely Low	<10
69	10	Very Low	10-20
95	20	Low	20-40
133	40	Medium	40-75
179	75	High	75-150
249	150	Very High	150-300
345	300		

V_s RELATIONSHIP WITH RELATIVE DENSITY

Hasancebi and Ulusay, 2007 for sand $V_s = 131N_{60}^{0.205}$

See PEER Report 2012/08 (2012) Guidelines for Estimation of Shear Wave Velocity Profiles

Vs (m/s)	SPT N value	BS5930 classification: Relative density of granular soils	Range SPT N
151	2	Very loose	0-4
174	4	Loose	4-10
210	10	Medium dense	10-30
263	30	Dense	30-50
292	50	Very dense	>50
303	60		

Notes & limitations

See GSS Guidance Note GN020 for limitations and references - to be used with relevant intrusive investigation information.

This document is intended to indicate potential approaches for the use of ACSW data by suitably qualified geotechnical engineers as part of a general design review. It may be subject to periodic review and change.

No guarantees as to accuracy are made and where necessary original references and relevant design guidance should be reviewed. ACSW test data should be reviewed against all available information on ground conditions as part of an appropriately scoped ground investigation.

V_s RELATIONSHIP WITH CBR

Vs (m/s)	Density (kg/m^3)	Go (MPa)	v	Eo (MPa)	E at 0.1% strain (MPa)	CBR
105	1800	20	0.26	50	17	1
130	1800	30	0.26	77	26	2
150	1800	41	0.26	102	35	3
165	1800	49	0.26	123	42	4
190	1800	65	0.26	164	56	6
210	1800	79	0.26	200	68	8
225	1800	91	0.26	230	78	10
235	1800	99	0.26	251	85	12

TRRL Laboratory Report 1132 (Powell et al, 1984) $E = 17.6(CBR)^{0.64}$ MPa

Project:	RSPB Conwy	**Report:**	P-1084
Shift:		**Client:**	GroundSolve Ltd
Test:	CSW10	**Date:**	26/01/2024

Test notes: Sandbag under shaker.
Geophone with ceramic bases used.
Test runs N-S.
W3W: concerts.amplified.until

Default values of density and Poisson's Ratio in the highlighted columns may be adjusted to known values
Strain level of softened value of Young's Modulus using the Rollins equation can be adjusted in the cell below.
See the SoilSafe report ref P-1084 for conditions of use of data

Strain level to softened to: 0.1 %

Vs (m/s)	Thickness (m)	Depth (m)	Density (kg/m^3)	Go (MPa)	v	Eo (MPa)	E at x% strain (MPa)
138	1.5	0.0	1800	34	0.26	86.6	29.5
90	1.9	1.5	1800	15	0.26	36.6	12.5
103	1.0	3.4	1800	19	0.26	47.7	16.3
97	0.9	4.4	1800	17	0.26	42.3	14.4

Notes:

1 Vs values have been determined from advanced inversion of field dispersion data.
2 $G = \rho . v_s^2$
3 $E=G.(2.(1+\nu))$
4 Softened values of stiffness are calculated using Rollins equation:

$$\frac{G}{G_o} = \frac{1}{\left[1+16\gamma\left(1.2+10^{-20\gamma}\right)\right]}$$

Rollins et al. (1998)

where Υ is shear strain.

Project:	RSPB Conwy	**Report:**	P-1084
Shift:		**Client:**	GroundSolve Ltd
Test:	CSW11	**Date:**	26/01/2024

Test notes: Sandbag under shaker.
Geophone with ceramic bases used.
Test runs W-E.
W3W: snowstorm.halt.remaining

Default values of density and Poisson's Ratio in the highlighted columns may be adjusted to known values
Strain level of softened value of Young's Modulus using the Rollins equation can be adjusted in the cell below.
See the SoilSafe report ref P-1084 for conditions of use of data

Strain level to softened to: 0.1 %

Vs (m/s)	Thickness (m)	Depth (m)	Density (kg/m^3)	Go (MPa)	ν	Eo (MPa)	E at x% strain (MPa)
171	1.0	0.0	1800	53	0.26	133.2	45.4
198	2.0	1.0	1800	71	0.26	178.5	60.8
158	2.0	3.0	1800	45	0.26	113.6	38.7
160	1.8	5.0	1800	46	0.26	115.7	39.4
153	2.0	6.8	1800	42	0.26	106.6	36.3
291	1.8	8.8	1800	153	0.26	385.1	131.2

Notes:

1 Vs values have been determined from advanced inversion of field dispersion data.

2 $G = \rho . v_s^2$

3 $E=G.(2.(1+\nu))$

4 Softened values of stiffness are calculated using Rollins equation:

$$\frac{G}{G_o} = \frac{1}{\left[1+16\gamma\left(1.2+10^{-20\gamma}\right)\right]}$$

Rollins et al. (1998)

where ϒ is shear strain.

Project:	RSPB Conwy	**Report:**	P-1084
Shift:		**Client:**	GroundSolve Ltd
Test:	CSW11A	**Date:**	26/01/2024

Test notes:
Sandbag under shaker.
Geophone with ceramic bases used.
Test runs S-N.
W3W: snowstorm.halt.remaining

Default values of density and Poisson's Ratio in the highlighted columns may be adjusted to known values
Strain level of softened value of Young's Modulus using the Rollins equation can be adjusted in the cell below.
See the SoilSafe report ref P-1084 for conditions of use of data

Strain level to softened to: 0.1 %

Vs (m/s)	Thickness (m)	Depth (m)	Density (kg/m^3)	Go (MPa)	ν	Eo (MPa)	E at x% strain (MPa)
174	2.0	0.0	1800	54	0.26	136.7	46.5
168	1.2	2.0	1800	51	0.26	128.3	43.7
144	1.5	3.2	1800	37	0.26	94.2	32.1
138	1.5	4.7	1800	34	0.26	85.8	29.2
68	1.6	6.2	1800	8	0.26	21.3	7.2
564	1.6	7.9	1800	572	0.26	1441.0	490.8

Notes:

1 Vs values have been determined from advanced inversion of field dispersion data.

2 $G = \rho . v_s^2$

3 $E = G.(2.(1+\nu))$

4 Softened values of stiffness are calculated using Rollins equation:

$$\frac{G}{G_o} = \frac{1}{\left[1+16\gamma\left(1.2+10^{-20\gamma}\right)\right]}$$

Rollins et al. (1998)

where ϒ is shear strain.

Project: RSPB Conwy
Shift:
Test: CSW12
Report: P-1084
Client: GroundSolve Ltd
Date: 26/01/2024

Test notes: Sandbag under shaker
Geophone with metal spikes used.
Test runs N-S.
W3W: library.sting.finer

Default values of density and Poisson's Ratio in the highlighted columns may be adjusted to known values
Strain level of softened value of Young's Modulus using the Rollins equation can be adjusted in the cell below.
See the SoilSafe report ref P-1084 for conditions of use of data

Strain level to softened to: 0.1 %

Vs (m/s)	Thickness (m)	Depth (m)	Density (kg/m^3)	Go (MPa)	ν	Eo (MPa)	E at x% strain (MPa)
70	1.7	0.0	1800	9	0.26	22.1	7.5
92	1.1	1.7	1800	15	0.26	38.0	13.0
104	1.0	2.8	1800	20	0.26	49.2	16.7
144	0.8	3.8	1800	37	0.26	93.8	32.0

Notes:

1 Vs values have been determined from advanced inversion of field dispersion data.

2 $G = \rho . v_s^2$

3 $E = G.(2.(1+\nu))$

4 Softened values of stiffness are calculated using Rollins equation:

$$\frac{G}{G_o} = \frac{1}{\left[1+16\gamma\left(1.2+10^{-20\gamma}\right)\right]}$$

Rollins et al. (1998)

where ϒ is shear strain.

Appendix D: Basis and interpretation of ACSW data

Basis and interpretation of ACSW data

Introduction

Advanced Continuous Surface Wave (ACSW) testing is a proprietary engineering testing system developed by ground Stiffness Surveys Limited (GSS) based on the general methodology for Continuous Surface Wave testing set out in Heymann, 2007. This system is being used under exclusive licence by SoilSafe Ltd. Surface Rayleigh wave velocities over a range of frequencies are accurately measured using a short array of geophones to produce a *dispersion curve* plot of Rayleigh wave velocity (V_r) against frequency. This data can then be used to generate a reliable shear wave velocity (V_s) with depth profile, which in turn can be converted to a stiffness profile using standard relationships. Typical ACSW profile depths are 10m to 15m using the GSS Standard Shaker but are dependent on the stiffness of the ground (deeper profile depths are obtained in stiffer ground for the same test frequency).

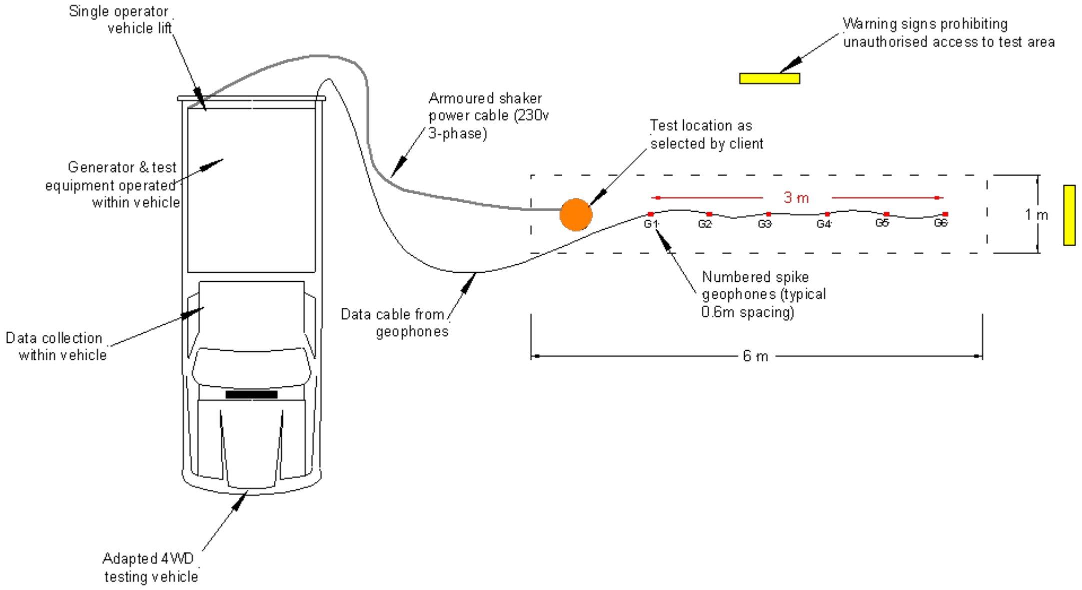


Figure 1 – Standard ACSW test layout

There is a wealth of publications available on the application of surface wave testing for shear wave velocity and stiffness profiling. The reliability of CSW data is such that it is the recommended means of assessing the stiffness of some kinds of geomaterials; for example chalk (*CIRIA C574 Engineering in Chalk, 2002*).

The ACSW testing is controlled, reviewed and the results analysed using GSS's proprietary integrated bespoke testing software, C-DAS. The software allows easy comparison between tests in the field and during processing, by which data quality and consistency can be assessed. Test reports are automatically generated by software, removing the risk of any transcribing errors.

ACSW measurement over 100 cycles at known frequencies allows effective exclusion of noise during data processing by C-DAS. C-DAS automatically compares phase angle consistency between geophones and measured against generated frequency, providing continuous calibration checks. Data out of tolerance is automatically removed. Outlying or highly scattered data can be graphically reviewed using C-DAS and removed from subsequent analysis.

C-DAS generates the following test plots, each of which provides valuable information on the ground profile:

- A *dispersion curve* of Rayleigh wave velocity against frequency
- A *simple inversion* average shear wave velocity (or stiffness) with approximate depth profile
- An *advanced inversion* shear wave velocity (or stiffness) with depth profile

Dispersion curve

The form of the *dispersion curve* defines the shear wave velocity (and stiffness profile). Test frequency data which is not consistent over the geophone array is removed automatically by C-DAS. Review and comparison of test profiles in C-DAS then allows any outlying data or parts of the *dispersion curve* which are unacceptably scattered to be removed.

For a layered deposit with increasing stiffness with depth (a '*normally dispersive'* profile), the form of the *dispersion curve* should be an even polynomial curve with a single inflection point within the lower frequencies. Changes from this form can indicate, for example, where significantly stiffer or softer layers are present (an '*inversely dispersive*' profile). Very rapid oscillations or breaks in the profile can indicate the presence of sharp stiffness contrast boundaries, which cannot be addressed by the available advanced inversion analysis methods but are reported on in assessing the quality of data.

In some data a '*multimodal*' response occurs where the ground is excited to behave in a different manner to the normal '*fundamental mode',* particularly at higher frequencies (shallower depths). This *multimodal* response can be apparent as:

- Very high Rayleigh wave velocities at low frequencies
- A rising dispersion curve at high frequencies
- Gaps or jumps in the dispersion curve

Multimodal data within the dispersion curve will affect the advanced inversion analysis process and expert user assessment of these effects is required. The presence of *multimodal* effects and any concerns over the resultant quality of analyses is commented on in the report.

Simple inversion

The *simple inversion* profile is an average shear wave velocity (or stiffness) profile against approximate depth generated from the *dispersion curve* using a set of standard assumptions included in the report. Shear wave velocity (and stiffness) is generated from the measured Rayleigh wave velocity at each frequency using conservative assumptions on Poisson's ratio and unit weight using standard relationships which are relatively insensitive to the assumptions made.

Equation 1 (Heymann, 2007) - relationship between V_s, V_r and Poisson's Ratio (ν)

$$\frac{V_r}{V_s} \cong \frac{0.874 + 1.117\mathrm{v}}{1 + \nu}$$

Equation 2 - relationship between Vs, small-strain Shear Modulus (G_o) & soil density (ρ)

$$G_0 = \rho.V_s^2$$

The approximate depth of each data point in the *dispersion curve* is determined as a proportion of the measured wavelength. Common practice is that this is normally wavelength divided by 2.5 (Foti *et al*, 2017), but it can be locally calibrated to range between 2 and 4.

The *simple inversion* profile is a good indication of small scale local variation in stiffness which cannot be resolved by the *advanced inversion* process. The *simple inversion* allows qualitative comparison between tests and an independent check on the *advanced inversion* results. For *normally dispersive* conditions, the averaging effect of the profile will mean that the *simple inversion* will be conservative at any depth.

The *simple inversion* has been traditionally and successfully used for design purposes and construction control, however care must be taken in using this data in that:

- Depths are approximate only; more accurate boundaries may be generated by the *advanced inversion*
- In some circumstance the averaging effect may mean that stiffnesses indicated may not be conservative (for example where the ground is *inversely dispersive*)
- Where *multimodal* data is present this may provide an overestimate of stiffness (particularly at shallow depth)

In some circumstances (e.g. very complex or poor data) it may be possible only to present the *simple inversion*. Comments on the *simple inversion* data for assessment of the *advanced inversion* results are included in the report.

Advanced inversion

Advanced inversion involves the generation of a layered stiffness profile from the *dispersion curve* data. Published algorithms, selected depending on the extent of *multimodal* data, are used to generate a *synthetic dispersion curve* from an assumed ground profile which is then compared with the *field dispersion curve* using standard model constraints in line with guidance given in Foti *et al* 2017. An appropriate automatic iterative search methodology is then selected which refines the model until the minimum statistical misfit between the field and synthetic *dispersion curve* is achieved. Checks are made in the modelling process against the *simple inversion* profile, adjacent test locations and, where available, any information on known ground profile.

In using the *advanced inversion* profile it should be noted that:

- The level of resolution of layer thicknesses and accuracy of layer boundary depth possible is around 0.5m at shallow depth, increasing to 1 to 2m at the typical maximum depth of the profile
- Within each modelled layer the stiffnesses of any thinner layers will be averaged
- Transitional boundaries will be represented as a stepped boundary and allowance for this simplification will be required in subsequent analysis
- Strongly *multimodal* data is more difficult to model and the fit of any model generated and therefore the accuracy of any results will tend to be poorer
- Model profiles extending significantly beyond the depth of the *simple inversion* profile will not generally be reliable and hence will normally not be reported in the absence of other information
- It is theoretically possible in some cases for more than one solution to the advanced inversion. Whilst the modelling undertaken follows appropriate guidance and uses the *simple inversion* to limit this possibility, comparison with other tests and against available information on ground conditions is required
- In some cases it may not be considered possible to present a reliable *advanced inversion* profile.

The fit of the *synthetic dispersion curve* to the field data is assessed statistically by C-DAS as a misfit value; the lower the misfit value the greater confidence in the model. The misfit of the final inversion model is reported qualitatively using the following ranges:

- >30m/s Very Poor
- ≤30m/s Poor
- ≤20m/s Fair
- ≤10m/s Good
- ≤5m/s Excellent

Having calculated the most likely layered profile, C-DAS provides a graphical indication of the uncertainty with the model in two formats using threshold of a change in the statistical fit of 5% or less. The first calculation is made by adjusting all layers in the model at once, for both stiffness and depth which represents the most likely 5% error range in the inversion process. The second calculation shows maximum extent of adjusting each layer individually to achieve a 5% change in the model fit and provides the maximum extent of the search area in which the model could reasonably lie. Larger error extent areas indicate greater uncertainty in the model. The modelling approach used and any site-specific cautions regarding the use or validity of data are included in the report (including the quality of fit).

Advanced inversion data is output as a shear wave velocity profile. The profile is provided in editable spreadsheet format which provides conversions to small-strain shear stiffness (G_0), small strain Young's modulus (E_0) and a strained softened value of E based on published functions. Default values of Poisson's ratio, unit weight and percentage strain in the spreadsheet can be adjusted based on site specific user knowledge and requirements.

Use of data

The ACSW report is intended for use by an experienced geotechnical engineer taking into account the general and site-specific qualifications for the ACSW data set out above and in the test report, including the overall model fit and the extent of layer misfit bars presented. Suitable intrusive investigation data will be required to determine the nature of the materials included within the profiles for design purposes. As with all geotechnical test data, the user should:

- Review the assumptions used based on available information and design requirements (these can be altered in the *advanced inversion* output spreadsheet)
- For stiffness data consider the application of strain-stiffness functions, drainage conditions and the appropriate stiffness modulus to apply
- Compare tests to assess the variability of data and to select design values and profiles
- Compare test data against other information including published information, intrusive investigation and other data
- Apply appropriate conservatism based on the intended design use, design codes and any uncertainties

References & further information

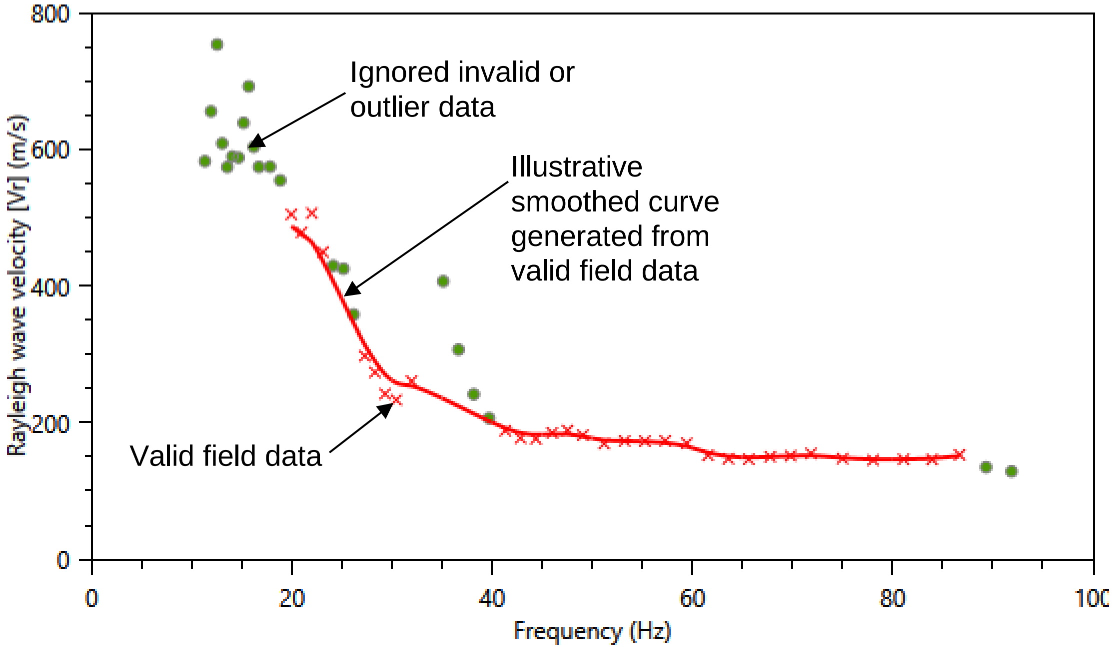
- Heymann, G. (2007) Ground stiffness measurement by the continuous surface wave test. *Journal of the South African Institution of Civil Engineering*. Vol.49, No.1, p25-31.
- Foti, S. *et al.* (2017) Guidelines for the good practice of surface wave analysis: a product of the InterPACIFIC project *Bull Earthquake Eng* DOI 10.1007/s10518-017-0206-7
- Leong, E. and Aung, A. (2013) Global Inversion of Surface Waves Dispersion Curves Based on Improved Weighted Average Velocity (WAVe) Method.

Journal of Geotechnical and Geoenvironmental Engineering, 10.1061/(ASCE)GT.1943-5606.0000939 (Apr. 8, 2013).

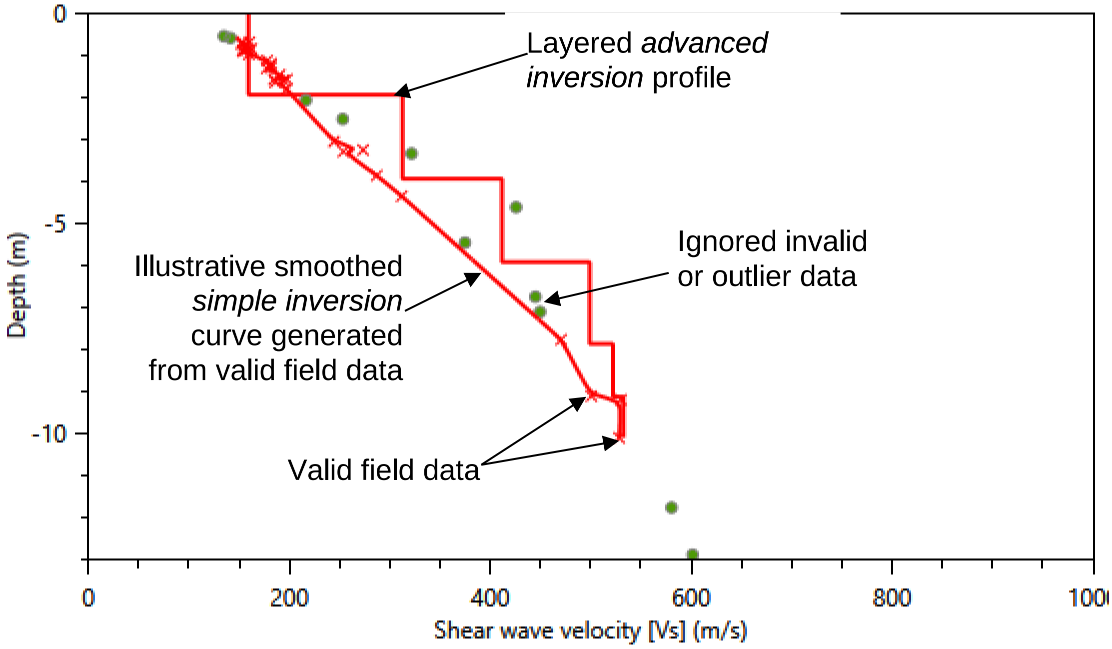
- Wathelet, M (2008) An improved neighbourhood algorithm: Parameter conditions and dynamic scaling. *Geophysical Research Letters*, 35(9), DOI:10.1029/2008GL033256, 2008.

The above is intended as a brief introduction to ACSW testing for assessment by an experienced geotechnical engineer user. Additional information on the ACSW technique including specification, limitations and application is available on the GSS website. A full range of references is also available. Further advice should be sought where there are concerns as to the use of ACSW test data reported.

Key to C-DAS output graphs: *Appendix A*

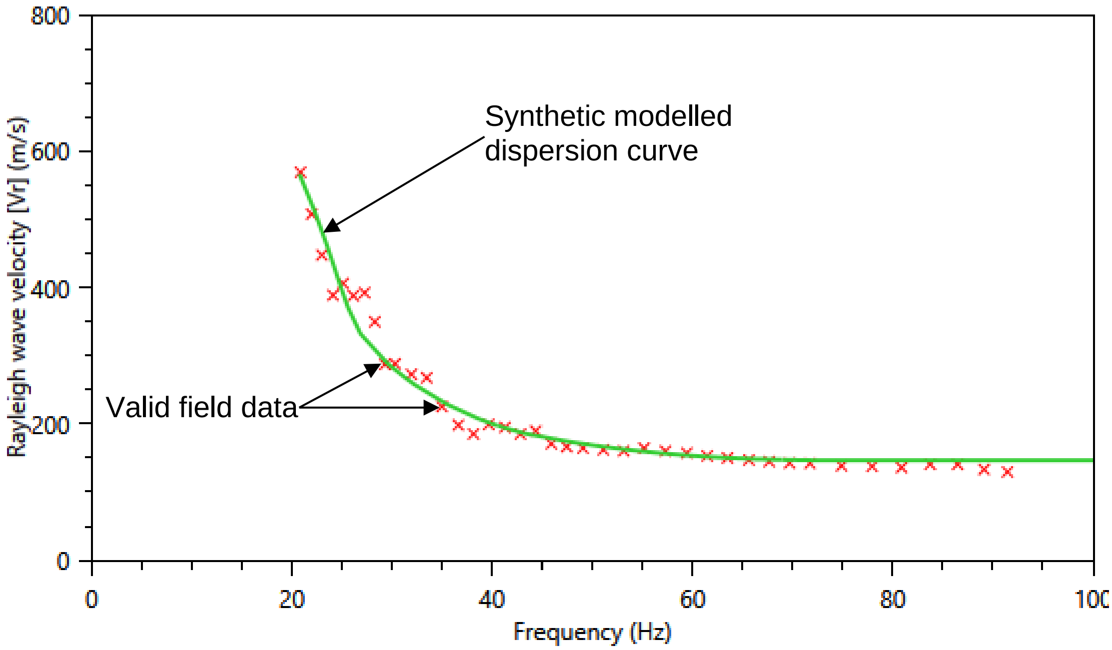


Example dispersion curve (Rayleigh wave velocity against frequency)

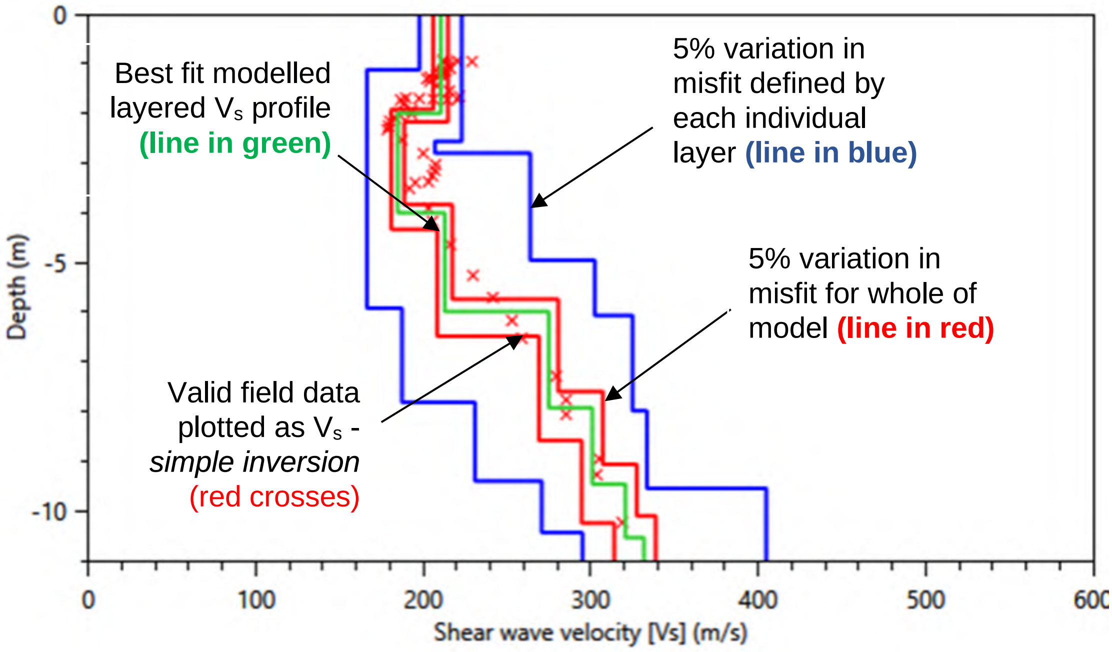


Example simple & advanced inversion plots (shear wave velocity against depth)

Key to C-DAS output graphs: *Appendix B*



Example field & synthetic dispersion curves (Rayleigh wave velocity against frequency)



Example modelled shear wave velocity profile

Appendix E: 3rd Party Information

KEY

□ Site Location

● WS Location

● DCP Location

● ACSW Location

Sampling locations and features annotated are approximate and are based upon observed measurements unless otherwise stated. Do not scale from this drawing and work from marked dimensions only. All dimensions and features should be confirmed on site by the Contractor.

GroundSolve Ltd
Consulting Geotechnical Engineers

Client: Conwy County Borough Council

Site: RSPB Conwy

Title: Proposed Sampling Location Plan

Job No.: GSL 2996
Scale (see scale bar): 1:5,000 @ A4
Figure: 0
Rev: 1
Drawn By: PW
Checked By: SF
Drawn: Jan 2024

APPENDIX D – DYNAMIC CONE PENETROMETER RESULTS

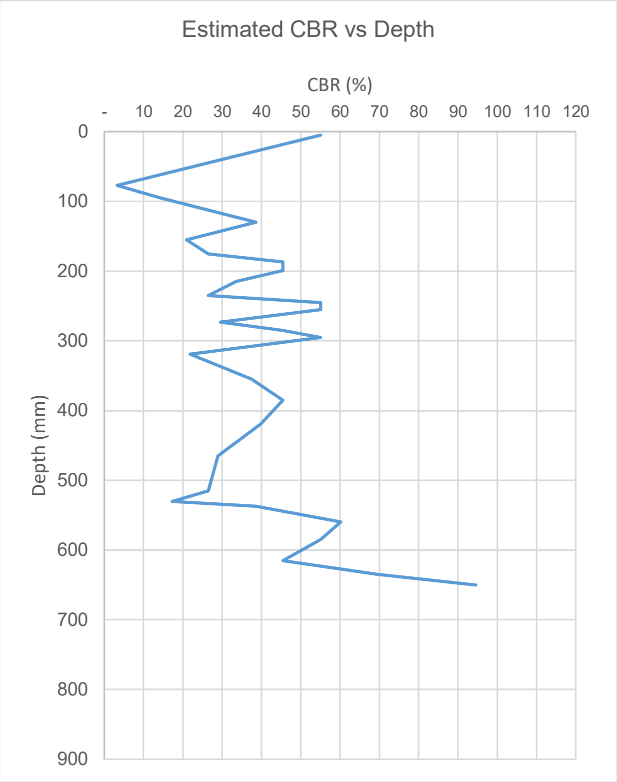
IN SITU CBR (TRRL DCP)

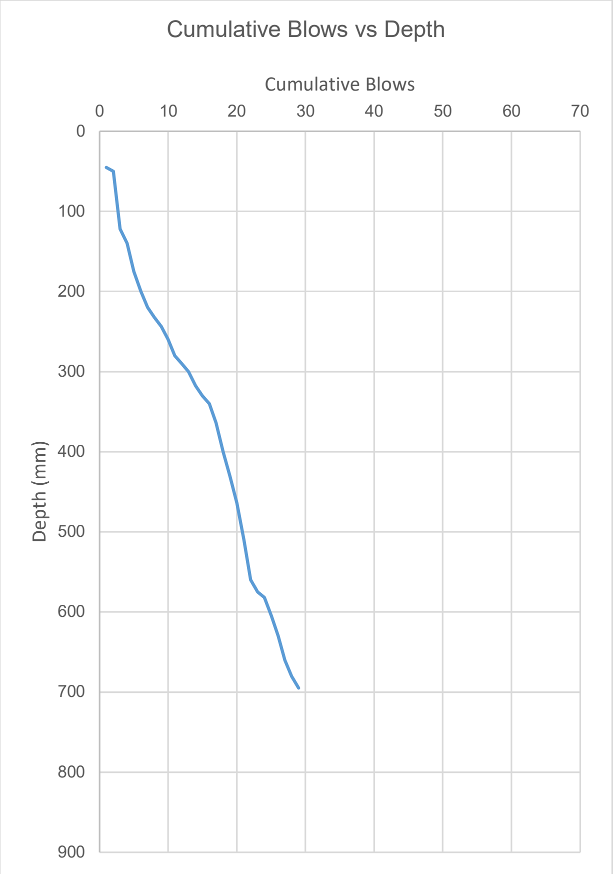
GroundSolve Ltd
Consulting Geotechnical Engineers

Operator:	Date:	Weather:		Remarks:
AB	26/01/2022	Dry		
Chkd by:	Start depth:	Surface layer:	Zero reading (mm):	Termination reason:
PW	0	TS	45	Target Depth Reached

Location:	
mE:	280306
mN:	376904
mAOD:	-
Grid:	OSGB

Depth to top of increment:	Cumulative blows:	Cumulative pen (mm):	Increment blows:	Increment pen (mm):	mm per blow:	Layer CBR (%)
45	0	0	0	0		
50	1	5	1	5	5.0	55
122	2	77	1	72	72.0	3
140	3	95	1	18	18.0	14
175	8	130	5	35	7.0	39
200	10	155	2	25	12.5	21
220	12	175	2	20	10.0	26
232	14	187	2	12	6.0	45
244	16	199	2	12	6.0	45
260	18	215	2	16	8.0	34
280	20	235	2	20	10.0	26
290	22	245	2	10	5.0	55
300	24	255	2	10	5.0	55
318	26	273	2	18	9.0	30
330	28	285	2	12	6.0	45
340	30	295	2	10	5.0	55
364	32	319	2	24	12.0	22
400	37	355	5	36	7.2	37
430	42	385	5	30	6.0	45
464	47	419	5	34	6.8	40
510	52	465	5	46	9.2	29
560	57	515	5	50	10.0	26
575	58	530	1	15	15.0	17
582	59	537	1	7	7.0	39
605	64	560	5	23	4.6	60
630	69	585	5	25	5.0	55
660	74	615	5	30	6.0	45
680	79	635	5	20	4.0	70
695	84	650	5	15	3.0	95





Layer	**Estimated CBR %**	**Layer Depth (mm)**		
1	37	0	364	
2	31	364	582	
3	61	582	695	

AGS

Notes: For explanation of symbols and abbreviations see Key Sheet.
All depths in meters.

Issue: FINAL

Project: RSPB Conwy
Project No: 2996
Client: Conwy CC

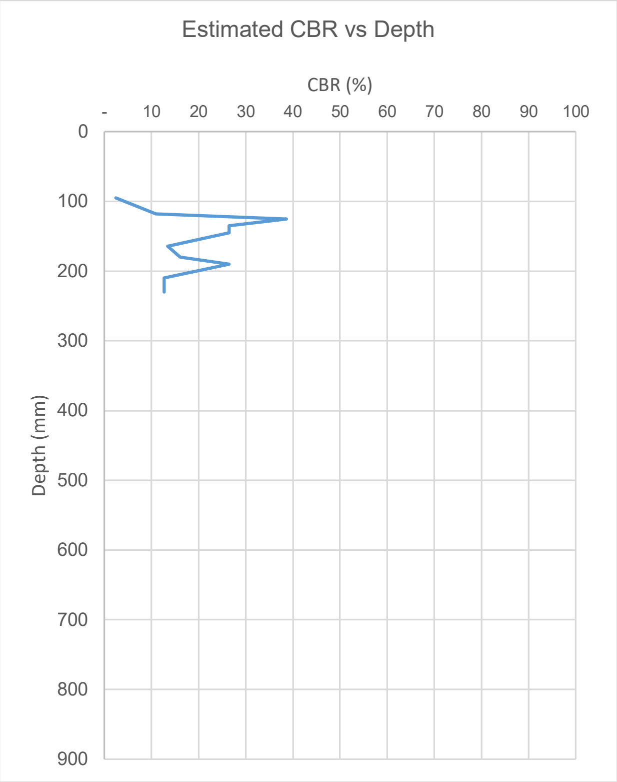
Test reference:
DCP101

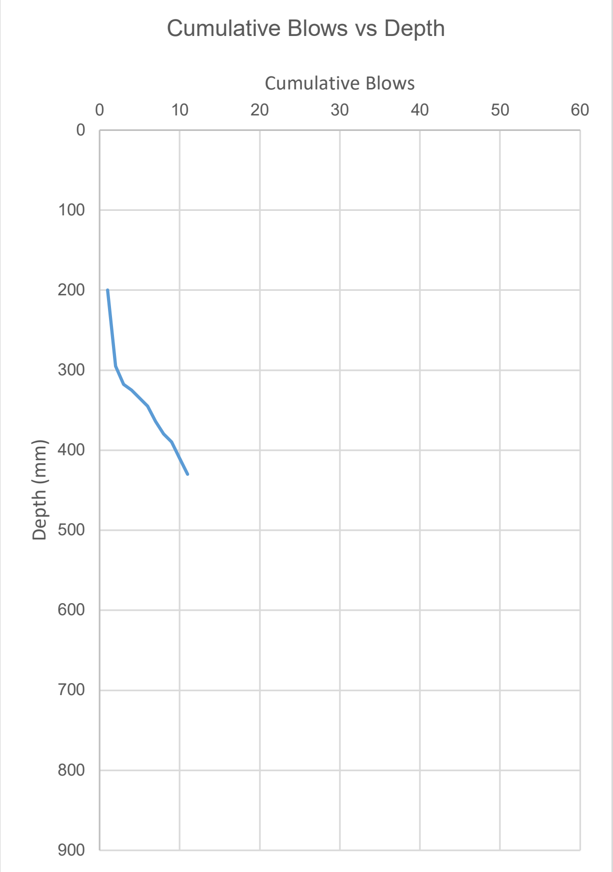
IN SITU CBR (TRRL DCP)

Operator:	Date:	Weather:	Remarks:	Location:	
AB	26/01/2022	Dry		mE:	280314
				mN:	376992
Chkd by:	Start depth:	Surface layer:	Zero reading (mm):	Termination reason:	mAOD:	-
PW	0	TS	200	Target Depth Reached	Grid:	OSGB

Depth to top of increment:	Cumulative blows:	Cumulative pen (mm):	Increment blows:	Increment pen (mm):	mm per blow:	Layer CBR (%)
200	0	0	0	0		
295	1	95	1	95	95.0	2
318	2	118	1	23	23.0	11
325	3	125	1	7	7.0	39
335	4	135	1	10	10.0	26
345	5	145	1	10	10.0	26
364	6	164	1	19	19.0	13
380	7	180	1	16	16.0	16
390	8	190	1	10	10.0	26
410	9	210	1	20	20.0	13
430	10	230	1	20	20.0	13

Layer	Estimated CBR %	Layer Depth (mm)	
1	19	0	430
2			
3			





Notes: For explanation of symbols and abbreviations see Key Sheet.
All depths in meters.

Issue: FINAL

Project: RSPB Conwy
Project No: 2996
Client: Conwy CC

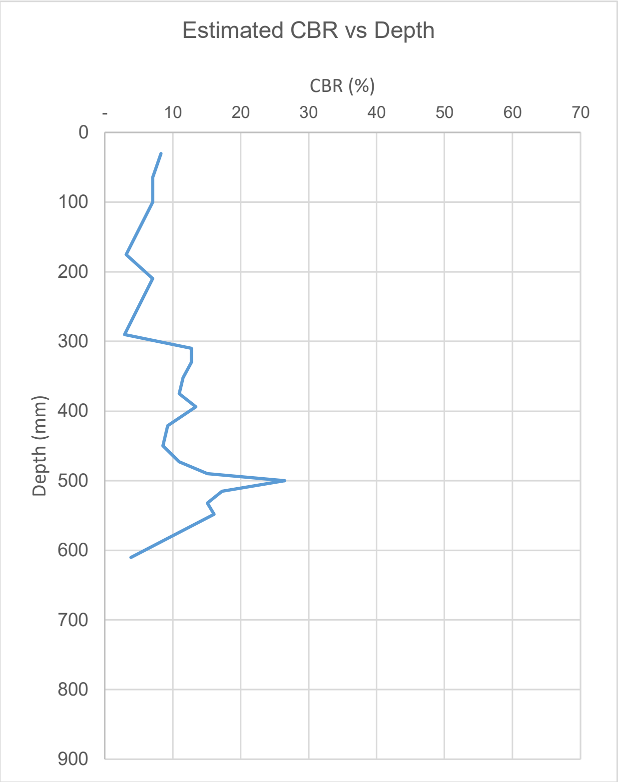
Test reference:
DCP102

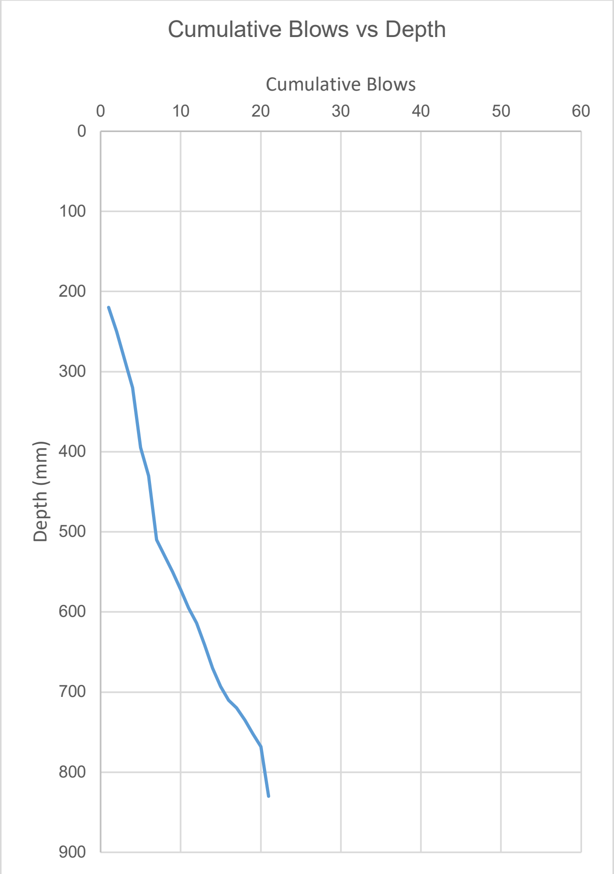
IN SITU CBR (TRRL DCP)

GroundSolve Ltd
Consulting Geotechnical Engineers

Operator:	Date:	Weather:		Remarks:	Location:	
AB	26/01/2022	Dry			mE:	280306
					mN:	377027
Chkd by:	Start depth:	Surface layer:	Zero reading (mm):	Termination reason:	mAOD:	-
PW	0	TS	220	Target Depth Reached	Grid:	OSGB

Depth to top of increment:	Cumulative blows:	Cumulative pen (mm):	Increment blows:	Increment pen (mm):	mm per blow:	Layer CBR (%)
220	0	0	0	0		
250	1	30	1	30	30.0	8
285	2	65	1	35	35.0	7
320	3	100	1	35	35.0	7
395	4	175	1	75	75.0	3
430	5	210	1	35	35.0	7
510	6	290	1	80	80.0	3
530	7	310	1	20	20.0	13
550	8	330	1	20	20.0	13
572	9	352	1	22	22.0	12
595	10	375	1	23	23.0	11
614	11	394	1	19	19.0	13
641	12	421	1	27	27.0	9
670	13	450	1	29	29.0	9
693	14	473	1	23	23.0	9
710	15	490	1	17	17.0	11
720	16	500	1	10	10.0	15
735	17	515	1	15	15.0	26
752	18	532	1	17	17.0	17
768	19	548	1	16	16.0	15
830	20	610	1	62	62.0	16





Layer	**Estimated CBR %**	**Layer Depth (mm)**		
1	6	0	530	
2	13	530	830	
3				

AGS

Notes: For explanation of symbols and abbreviations see Key Sheet.
All depths in meters.

Issue: FINAL

Project: RSPB Conwy
Project No: 2996
Client: Conwy CC

Test reference:

DCP103

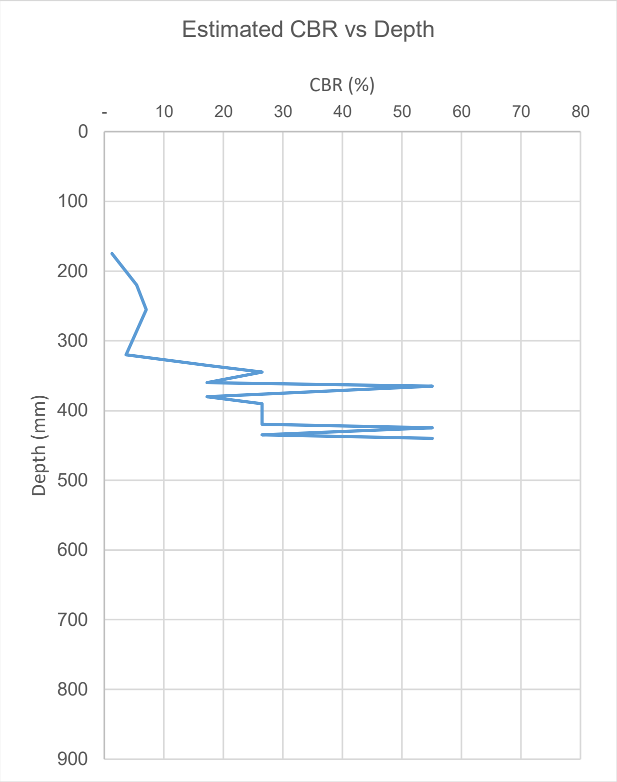
IN SITU CBR (TRRL DCP)

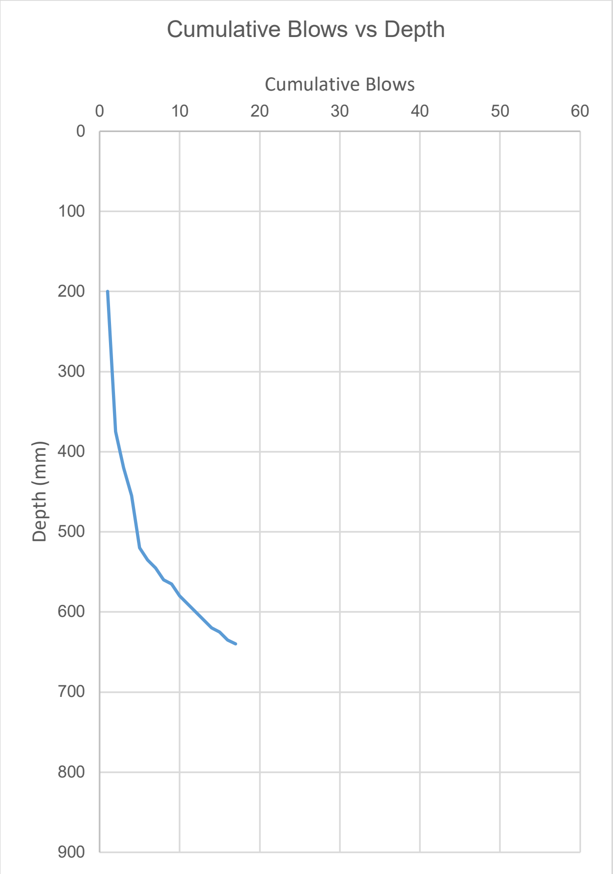
GroundSolve Ltd
Consulting Geotechnical Engineers

Operator:	Date:	Weather:	Remarks:	Location:
AB	26/01/2022	Dry		mE: 280268 mN: 377150
Chkd by:	**Start depth:**	**Surface layer:**	**Zero reading (mm):**	**Termination reason:**
PW	0	TS	200	Target Depth Reached

mAOD: -
Grid: OSGB

Depth to top of increment:	Cumulative blows:	Cumulative pen (mm):	Increment blows:	Increment pen (mm):	mm per blow:	Layer CBR (%)
200	0	0	0	0		
375	1	175	1	175	175.0	1
420	2	220	1	45	45.0	5
455	3	255	1	35	35.0	7
520	4	320	1	65	65.0	4
535	5	335	1	15	15.0	17
545	6	345	1	10	10.0	26
560	7	360	1	15	15.0	17
565	8	365	1	5	5.0	55
580	9	380	1	15	15.0	17
590	10	390	1	10	10.0	26
600	11	400	1	10	10.0	26
610	12	410	1	10	10.0	26
620	13	420	1	10	10.0	26
625	14	425	1	5	5.0	26
635	15	435	1	10	10.0	55
640	16	440	1	5	5.0	26





Layer	Estimated CBR %	Layer Depth (mm)		
1	4	0	535	
2	31	535	640	
3				

AGS

Notes: For explanation of symbols and abbreviations see Key Sheet.
All depths in meters.

Issue: FINAL

Project: RSPB Conwy
Project No: 2996
Client: Conwy CC

Test reference:
DCP104

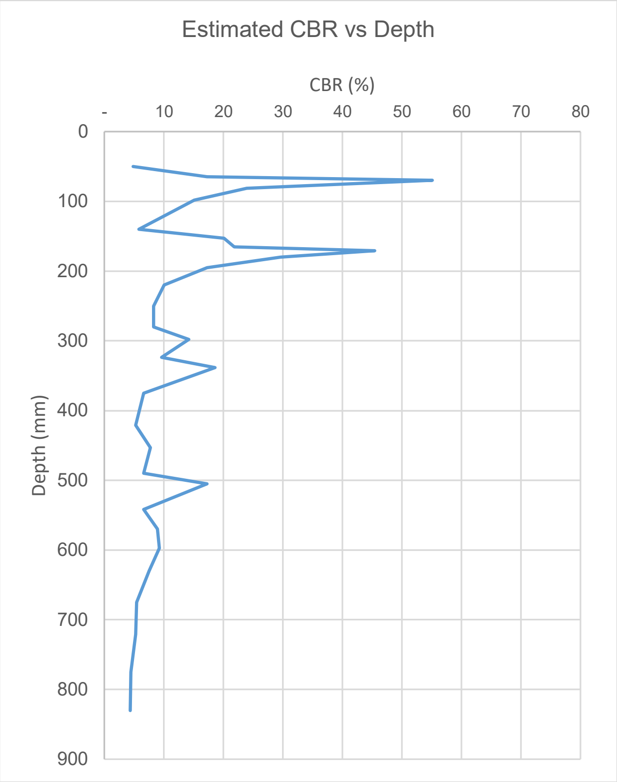
IN SITU CBR (TRRL DCP)

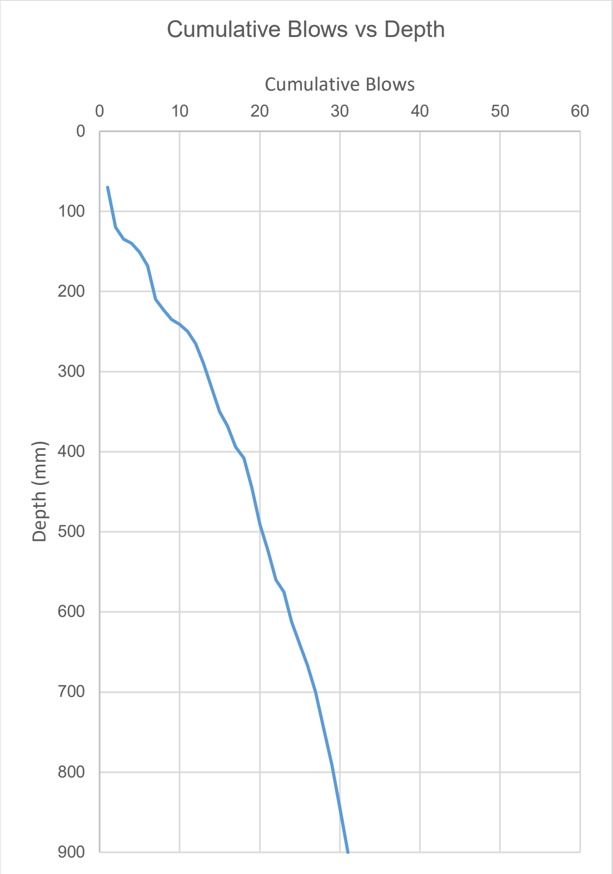
GroundSolve Ltd
Consulting Geotechnical Engineers

Operator:	Date:	Weather:	Remarks:	Location:	
AB	26/01/2022	Dry		mE:	280166
				mN:	377301
Chkd by:	Start depth:	Surface layer:	Zero reading (mm):	Termination reason:	mAOD:	-
PW	0	TS	70	Target Depth Reached	Grid:	OSGB

Depth to top of increment:	Cumulative blows:	Cumulative pen (mm):	Increment blows:	Increment pen (mm):	mm per blow:	Layer CBR (%)
70	0	0	0	0		
120	1	50	1	50	50.0	5
135	2	65	1	15	15.0	17
140	3	70	1	5	5.0	55
151	4	81	1	11	11.0	24
168	5	98	1	17	17.0	15
210	6	140	1	42	42.0	6
223	7	153	1	13	13.0	20
235	8	165	1	12	12.0	22
241	9	171	1	6	6.0	45
250	10	180	1	9	9.0	30
265	11	195	1	15	15.0	17
290	12	220	1	25	25.0	10
320	13	250	1	30	30.0	8
350	14	280	1	30	30.0	8
368	15	298	1	18	18.0	8
394	16	324	1	26	26.0	14
408	17	338	1	14	14.0	10
445	18	375	1	37	37.0	19
491	19	421	1	46	46.0	7
523	20	453	1	32	32.0	5
560	21	490	1	37	37.0	8
575	22	505	1	15	15.0	7
612	23	542	1	37	37.0	17
640	24	570	1	28	28.0	7
667	25	597	1	27	27.0	9
700	26	630	1	33	33.0	9
745	27	675	1	45	45.0	7
791	28	721	1	46	46.0	5
845	29	775	1	54	54.0	5
900	30	830	1	55	55.0	4

Layer	Estimated CBR %	Layer Depth (mm)		
1	19	0	445	
2	7	445	900	
3				





AGS

Notes: For explanation of symbols and abbreviations see Key Sheet.
All depths in meters.

Issue: FINAL

Project: RSPB Conwy
Project No: 2996
Client: Conwy CC

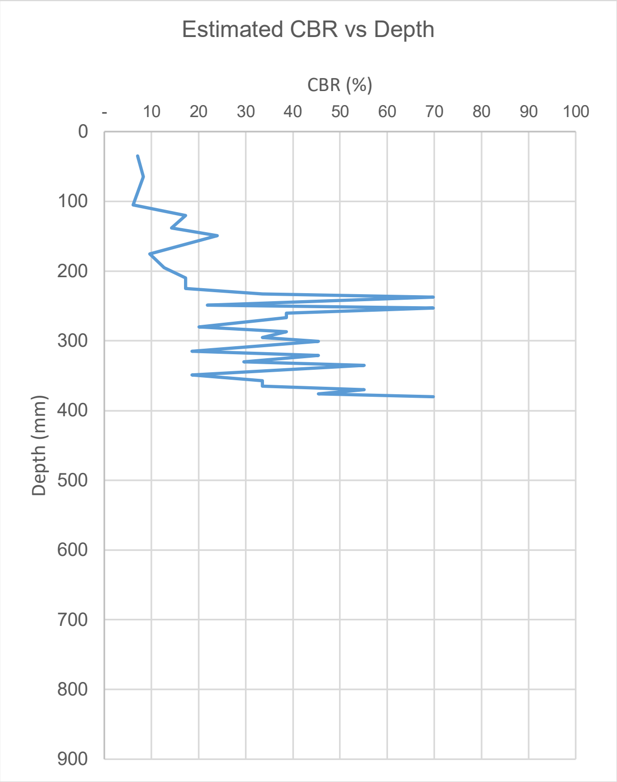
Test reference:
DCP106

IN SITU CBR (TRRL DCP)

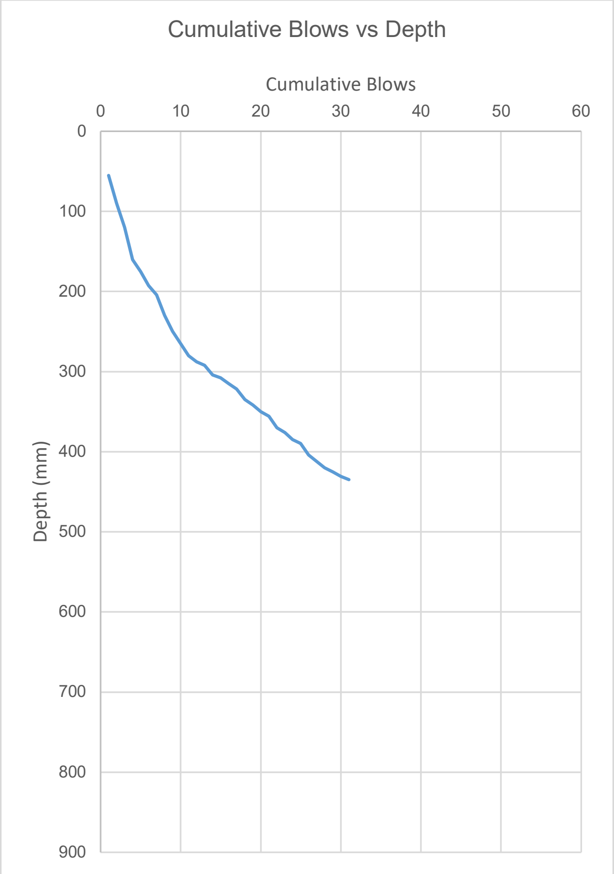
GroundSolve Ltd
Consulting Geotechnical Engineers

Operator:	Date:	Weather:		Remarks:	Location:
AB	26/01/2022	Dry			mE: 280080 mN: 377334
Chkd by:	Start depth:	Surface layer:	Zero reading (mm):	Termination reason:	mAOD: -
PW	0	TS	55	Target Depth Reached	Grid: OSGB

Depth to top of increment:	Cumulative blows:	Cumulative pen (mm):	Increment blows:	Increment pen (mm):	mm per blow:	Layer CBR (%)
55	0	0	0	0		
90	1	35	1	35	35.0	7
120	2	65	1	30	30.0	8
160	3	105	1	40	40.0	6
175	4	120	1	15	15.0	17
193	5	138	1	18	18.0	14
204	6	149	1	11	11.0	24
230	7	175	1	26	26.0	10
250	8	195	1	20	20.0	13
265	9	210	1	15	15.0	17
280	10	225	1	15	15.0	17
288	11	233	1	8	8.0	34
292	12	237	1	4	4.0	70
304	13	249	1	12	12.0	22
308	14	253	1	4	4.0	22
315	15	260	1	7	7.0	70
322	16	267	1	7	7.0	39
335	17	280	1	13	13.0	39
342	18	287	1	7	7.0	20
350	19	295	1	8	8.0	39
356	20	301	1	6	6.0	34
370	21	315	1	14	14.0	45
376	22	321	1	6	6.0	19
385	23	330	1	9	9.0	45
390	24	335	1	5	5.0	30
404	25	349	1	14	14.0	55
412	26	357	1	8	8.0	19
420	27	365	1	8	8.0	34
425	28	370	1	5	5.0	34
431	29	376	1	6	6.0	55
435	30	380	1	4	4.0	45



Layer	Estimated CBR %	Layer Depth (mm)	
1	13	0	288
2	41	288	435
3			



AGS

Notes: For explanation of symbols and abbreviations see Key Sheet.
All depths in meters.

Issue: FINAL

Project: RSPB Conwy
Project No: 2996
Client: Conwy CC

Test reference:

DCP107

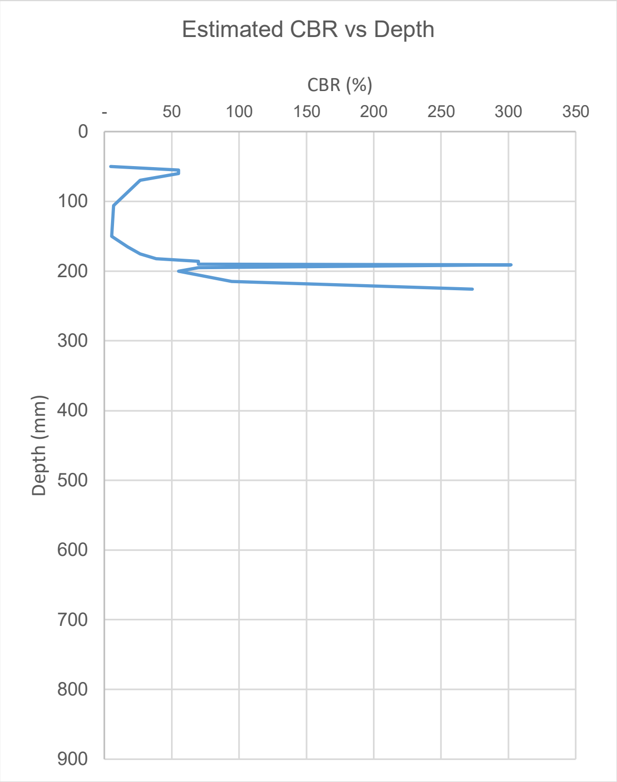
IN SITU CBR (TRRL DCP)

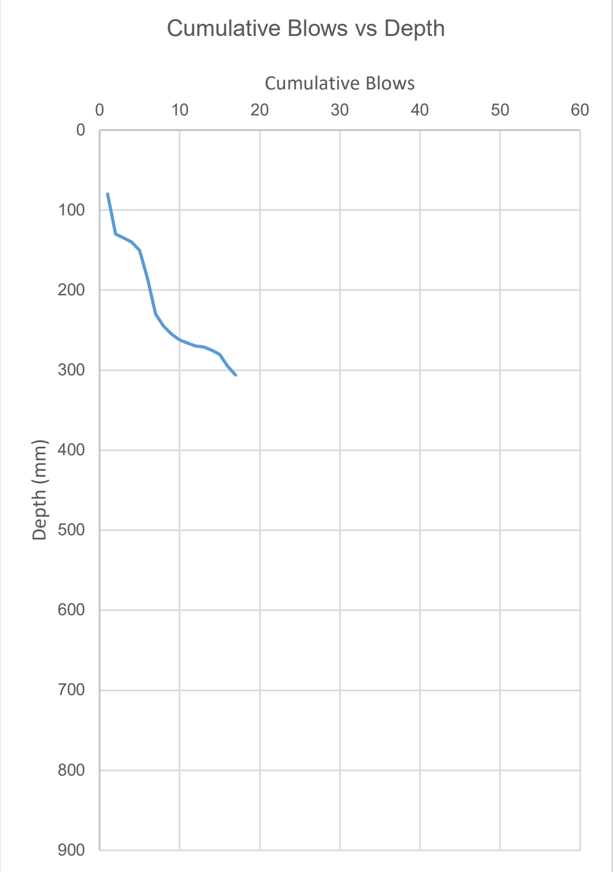
GroundSolve Ltd
Consulting Geotechnical Engineers

Operator:	Date:	Weather:		Remarks:	Location:	
AB	26/01/2022	Dry			mE:	279930
					mN:	377359
Chkd by:	Start depth:	Surface layer:	Zero reading (mm):	Termination reason:	mAOD:	-
PW	0	TS	80	Target Depth Reached	Grid:	OSGB

Depth to top of increment:	Cumulative blows:	Cumulative pen (mm):	Increment blows:	Increment pen (mm):	mm per blow:	Layer CBR (%)
80	0	0	0	0		
130	1	50	1	50	50.0	5
135	2	55	1	5	5.0	55
140	3	60	1	5	5.0	55
150	4	70	1	10	10.0	26
186	5	106	1	36	36.0	7
230	6	150	1	44	44.0	6
245	7	165	1	15	15.0	17
255	8	175	1	10	10.0	26
262	9	182	1	7	7.0	39
266	10	186	1	4	4.0	70
270	11	190	1	4	4.0	70
271	12	191	1	1	1.0	>100
275	13	195	1	4	4.0	70
280	14	200	1	5	5.0	70
295	19	215	5	15	3.0	55
306	29	226	10	11	1.1	95

Layer	Estimated CBR %	Layer Depth (mm)	
1	26	0	266
2	133	266	306
3			





AGS

Notes: For explanation of symbols and abbreviations see Key Sheet.
All depths in meters.

Issue: FINAL

Project: RSPB Conwy
Project No: 2996
Client: Conwy CC

Test reference:
DCP108

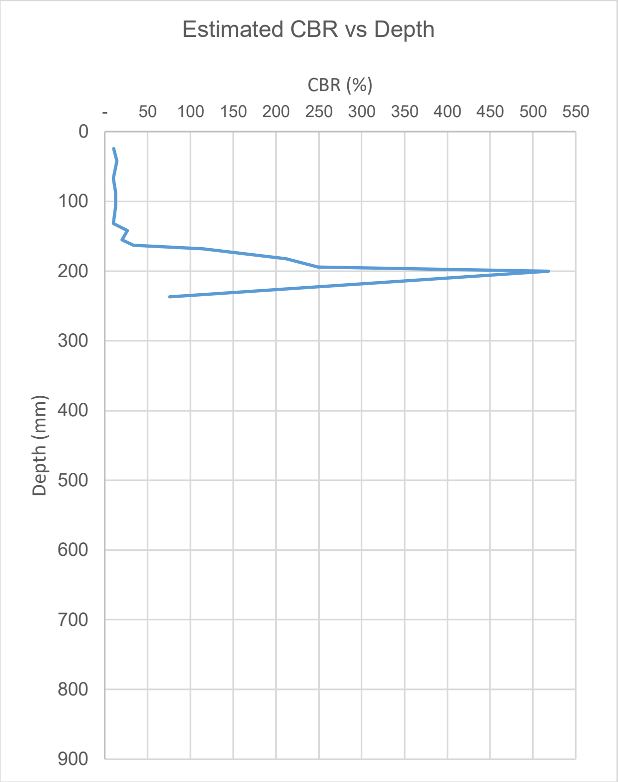
IN SITU CBR (TRRL DCP)

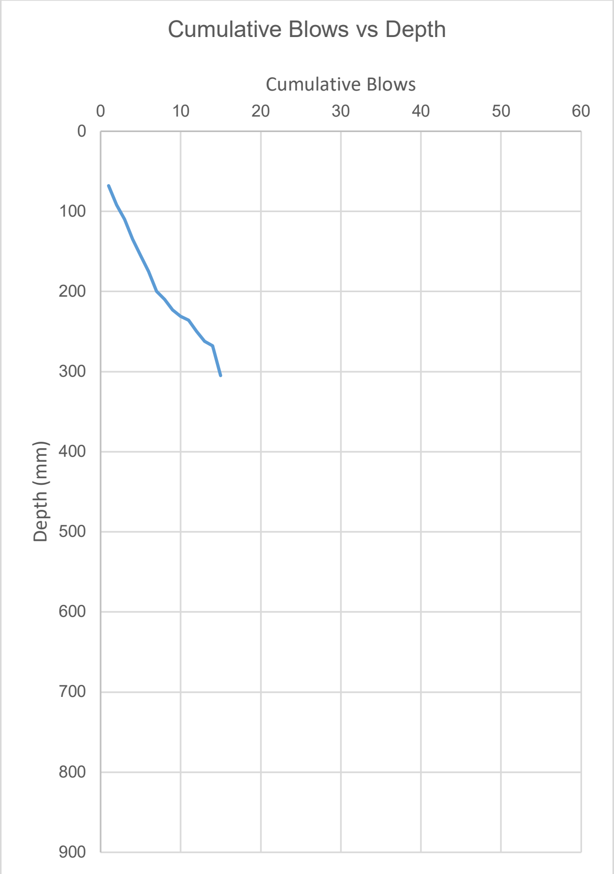
GroundSolve Ltd
Consulting Geotechnical Engineers

Operator:	Date:	Weather:		Remarks:	Location:	
AB	26/01/2022	Dry			mE:	279791
					mN:	377394
Chkd by:	Start depth:	Surface layer:	Zero reading (mm):	Termination reason:	mAOD:	-
PW	0	TS	68	Target Depth Reached	Grid:	OSGB

Depth to top of increment:	Cumulative blows:	Cumulative pen (mm):	Increment blows:	Increment pen (mm):	mm per blow:	Layer CBR (%)
68	0	0	0	0		
92	1	24	1	24	24.0	10
110	2	42	1	18	18.0	14
135	3	67	1	25	25.0	10
155	4	87	1	20	20.0	13
175	5	107	1	20	20.0	13
200	6	132	1	25	25.0	10
210	7	142	1	10	10.0	26
223	8	155	1	13	13.0	20
231	9	163	1	8	8.0	34
236	11	168	2	5	2.5	>100
250	21	182	10	14	1.4	>100
262	31	194	10	12	1.2	>100
268	41	200	10	6	0.6	>100
305	51	237	10	37	3.7	>100

Layer	Estimated CBR %	Layer Depth (mm)	
1	17	0	236
2	234	236	305
3			





AGS

Notes: For explanation of symbols and abbreviations see Key Sheet.
All depths in meters.

Issue: FINAL

Project: RSPB Conwy
Project No: 2996
Client: Conwy CC

Test reference:
DCP109

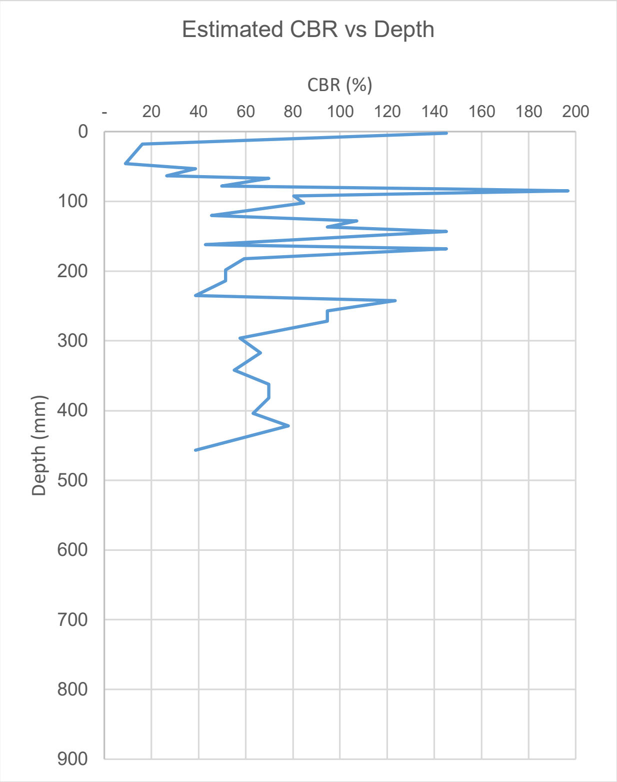
IN SITU CBR (TRRL DCP)

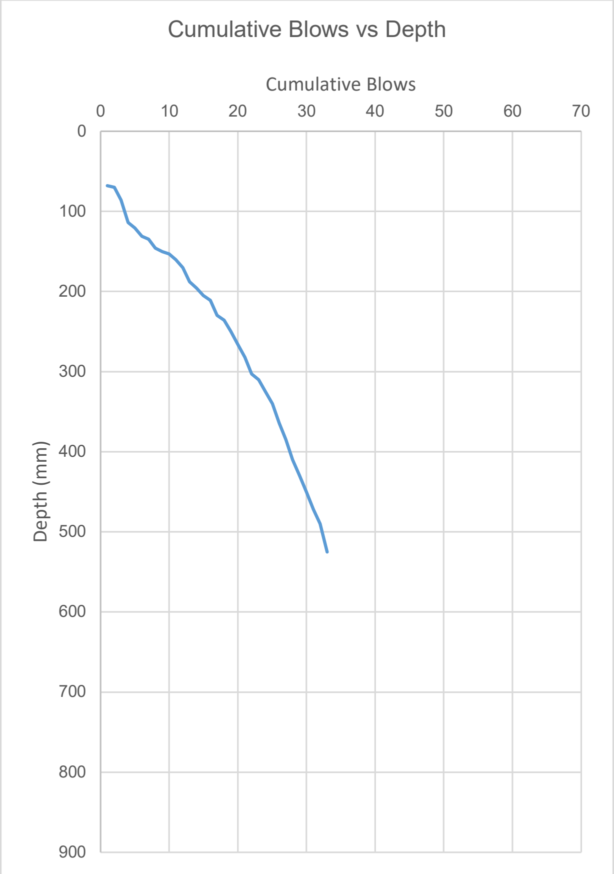
GroundSolve Ltd
Consulting Geotechnical Engineers

Operator:	Date:	Weather:		Remarks:	Location:	
AB	26/01/2022	Dry			mE:	279682
					mN:	377407
Chkd by:	Start depth:	Surface layer:	Zero reading (mm):	Termination reason:	mAOD:	-
PW	0	MG	68	Target Depth Reached	Grid:	OSGB

Depth to top of increment:	Cumulative blows:	Cumulative pen (mm):	Increment blows:	Increment pen (mm):	mm per blow:	Layer CBR (%)
68	0	0	0	0		
70	1	2	1	2	2.0	>100
86	2	18	1	16	16.0	16
114	3	46	1	28	28.0	9
121	4	53	1	7	7.0	39
131	5	63	1	10	10.0	26
135	6	67	1	4	4.0	70
146	8	78	2	11	5.5	50
150	10	82	2	4	2.0	>100
153	12	85	2	3	1.5	>100
160	14	92	2	7	3.5	80
170	17	102	3	10	3.3	85
188	20	120	3	18	6.0	45
196	23	128	3	8	2.7	>100
205	26	137	3	9	3.0	>100
211	29	143	3	6	2.0	95
230	32	162	3	19	6.3	>100
236	35	168	3	6	2.0	43
250	38	182	3	14	4.7	>100
266	41	198	3	16	5.3	59
282	44	214	3	16	5.3	51
303	47	235	3	21	7.0	51
310	50	242	3	7	2.3	39
325	55	257	5	15	3.0	>100
340	60	272	5	15	3.0	95
364	65	296	5	24	4.8	95
385	70	317	5	21	4.2	58
410	75	342	5	25	5.0	66
430	80	362	5	20	4.0	55
450	85	382	5	20	4.0	70
472	90	404	5	22	4.4	70
490	95	422	5	18	3.6	63
525	100	457	5	35	7.0	78

Layer	**Estimated CBR %**	**Layer Depth (mm)**	
1	51	0	150
2	109	150	250
3	67	250	525





AGS

Notes: For explanation of symbols and abbreviations see Key Sheet. All depths in meters.

Issue: FINAL

Project: RSPB Conwy
Project No: 2996
Client: Conwy CC

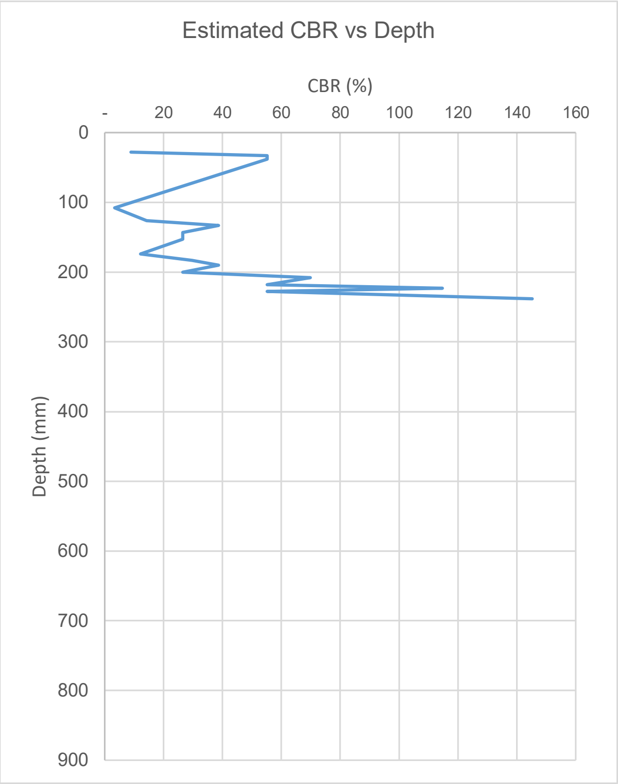
Test reference:
DCP110

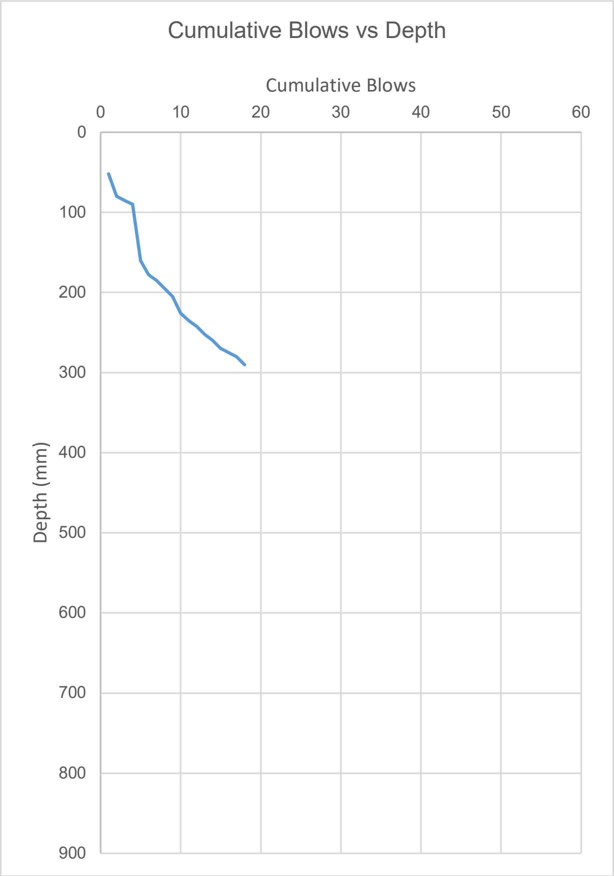
IN SITU CBR (TRRL DCP)

GroundSolve Ltd
Consulting Geotechnical Engineers

Operator:	Date:	Weather:		Remarks:	Location:	
AB	26/01/2022	Dry			mE:	279574
					mN:	377437
Chkd by:	Start depth:	Surface layer:	Zero reading (mm):	Termination reason:	mAOD:	-
PW	0	TS	52	Target Depth Reached	Grid:	OSGB

Depth to top of increment:	Cumulative blows:	Cumulative pen (mm):	Increment blows:	Increment pen (mm):	mm per blow:	Layer CBR (%)
52	0	0	0	0		
80	1	28	1	28	28.0	9
85	2	33	1	5	5.0	55
90	3	38	1	5	5.0	55
160	4	108	1	70	70.0	3
178	5	126	1	18	18.0	14
185	6	133	1	7	7.0	39
195	7	143	1	10	10.0	26
205	8	153	1	10	10.0	26
226	9	174	1	21	21.0	12
235	10	183	1	9	9.0	30
242	11	190	1	7	7.0	39
252	12	200	1	10	10.0	26
260	14	208	2	8	4.0	70
270	16	218	2	10	5.0	70
275	18	223	2	5	2.5	55
280	19	228	1	5	5.0	>100
290	24	238	5	10	2.0	55





Layer	Estimated CBR %	Layer Depth (mm)	
1	28	0	260
2	88	260	290
3			

AGS

Notes: For explanation of symbols and abbreviations see Key Sheet.
All depths in meters.

Issue: FINAL

Project: RSPB Conwy
Project No: 2996
Client: Conwy CC

Test reference:
DCP111

IN SITU CBR (TRRL DCP)

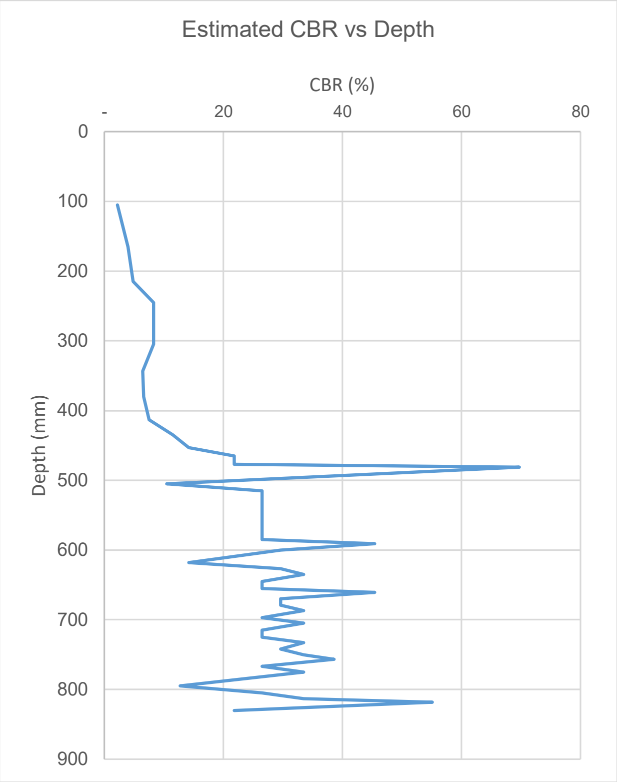
GroundSolve Ltd
Consulting Geotechnical Engineers

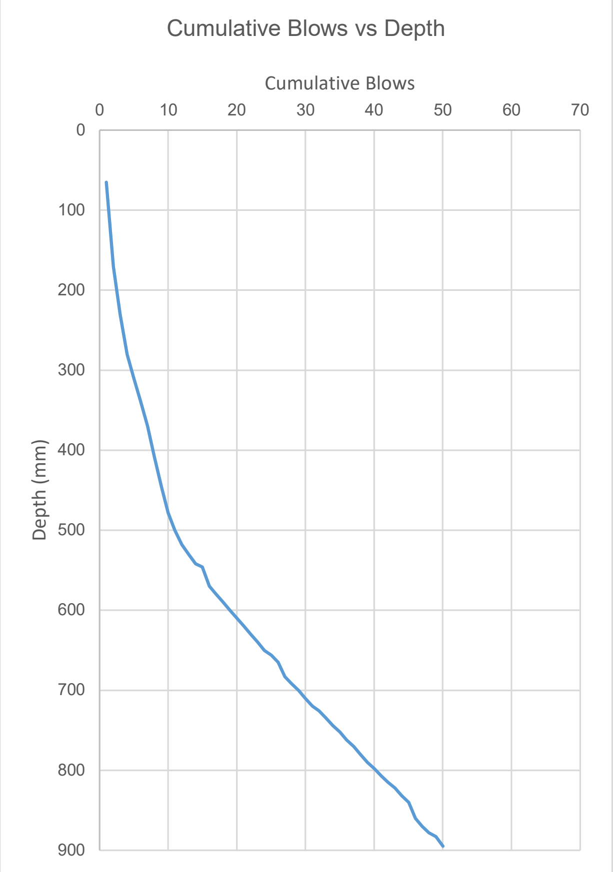
Operator:	Date:	Weather:		Remarks:
AB	26/01/2022	Dry		
Chkd by:	Start depth:	Surface layer:	Zero reading (mm):	Termination reason:
PW	0	TS	65	Target Depth Reached

Location:	
mE:	279479
mN:	377405
mAOD:	-
Grid:	OSGB

Depth to top of increment:	Cumulative blows:	Cumulative pen (mm):	Increment blows:	Increment pen (mm):	mm per blow:	Layer CBR (%)
65	0	0	0	0		
170	1	105	1	105	105.0	2
230	2	165	1	60	60.0	4
280	3	215	1	50	50.0	5
310	4	245	1	30	30.0	8
340	5	275	1	30	30.0	8
370	6	305	1	30	30.0	8
408	7	343	1	38	38.0	6
445	8	380	1	37	37.0	7
478	9	413	1	33	33.0	7
500	10	435	1	22	22.0	12
518	11	453	1	18	18.0	14
530	12	465	1	12	12.0	22
542	13	477	1	12	12.0	22
546	14	481	1	4	4.0	22
570	15	505	1	24	24.0	70
580	16	515	1	10	10.0	10
590	17	525	1	10	10.0	26
600	18	535	1	10	10.0	26
610	19	545	1	10	10.0	26
620	20	555	1	10	10.0	26
630	21	565	1	10	10.0	26
640	22	575	1	10	10.0	26
650	23	585	1	10	10.0	26
656	24	591	1	6	6.0	26
665	25	600	1	9	9.0	45
683	26	618	1	18	18.0	30
692	27	627	1	9	9.0	14
700	28	635	1	8	8.0	30
710	29	645	1	10	10.0	34
720	30	655	1	10	10.0	26
726	31	661	1	6	6.0	26
735	32	670	1	9	9.0	45
744	33	679	1	9	9.0	30
752	34	687	1	8	8.0	30
762	35	697	1	10	10.0	34
770	36	705	1	8	8.0	26
780	37	715	1	10	10.0	34
790	38	725	1	10	10.0	26
798	39	733	1	8	8.0	26
807	40	742	1	9	9.0	34
815	41	750	1	8	8.0	30
822	42	757	1	7	7.0	34
832	43	767	1	10	10.0	39
840	44	775	1	8	8.0	26
860	45	795	1	20	20.0	34
870	46	805	1	10	10.0	13
878	47	813	1	8	8.0	26
883	48	818	1	5	5.0	34
895	49	830	1	12	12.0	55

Layer	Estimated CBR %	Layer Depth (mm)	
1	7	0	530
2	28	530	700
3	31	700	895





AGS

Notes: For explanation of symbols and abbreviations see Key Sheet.
All depths in meters.

Issue: FINAL

Project: RSPB Conwy
Project No: 2996
Client: Conwy CC

Test reference:
DCP112

APPENDIX E – CHEMICAL TEST RESULTS

UKAS TESTING
2683

Unit A2
Windmill Road
Ponswood Industrial Estate
St Leonards on Sea
East Sussex
TN38 9BY
Telephone: (01424) 718618

cs@elab-uk.co.uk
info@elab-uk.co.uk

Certificate of Analysis

THE ENVIRONMENTAL LABORATORY LTD

Analytical Report Number:	24-52137
Issue:	1
Date of Issue:	07/02/2024
Contact:	Phillip Windslow
Customer Details:	GroundSolve Ltd Unit 1 Well House Barns Chester Road Bretton FlintshireCH4 0DH
Quotation No:	Q24-04319
Order No:	Not Supplied
Customer Reference:	996
Date Received:	31/01/2024
Date Approved:	07/02/2024
Details:	RSPB Conwy
Approved by:	

Ben Rees, Customer Services Assistant

Sample Summary

Report No.: 24-52137, issue number 1

Elab No.	Client's Ref.	Date Sampled	Date Scheduled	Description	Deviations
351660	DCP08 0.20	26/01/2024	31/01/2024	Stones	
351661	DCP10 0.10	26/01/2024	31/01/2024	Loamy sand	
351662	DCP10 0.50	26/01/2024	31/01/2024	Sandy loam	
351663	DCP11 0.30	26/01/2024	31/01/2024		
351664	DCP12 0.10	26/01/2024	31/01/2024	Silty loam	
351665	DCP12 0.60	26/01/2024	31/01/2024	Sand	
351666	WS101 0.20	26/01/2024	31/01/2024	Silty loam	
351667	WS101 0.40	26/01/2024	31/01/2024	Sandy silty loam	
351668	WS102 0.00 - 0.30	26/01/2024	31/01/2024	Silty loam	
351669	WS103 0.00 - 0.30	26/01/2024	31/01/2024		
351670	WS104 0.00 - 0.30	26/01/2024	31/01/2024	Sandy silty loam	
351671	WS105 0.00 - 0.30	26/01/2024	31/01/2024	Silty loam	
351672	WS105 1.00 - 2.00	26/01/2024	31/01/2024	Silty clayey loam	
351673	WS105 4.0 - 5.00	26/01/2024	31/01/2024	Sandy loam	
351674	WS106 0.00 - 1.00	26/01/2024	31/01/2024		
351675	WS106 3.40 - 4.00	26/01/2024	31/01/2024		
351676	WS108 0.30	26/01/2024	31/01/2024	Loamy sand	
351677	WS101 0.70	26/01/2024	31/01/2024		
351678	WS105 2.00 - 3.00	26/01/2024	31/01/2024		
351679	WS108 1.00	26/01/2024	31/01/2024		

2683

Results Summary

Report No.: 24-52137, issue number 1

ELAB Reference				351660	351661	351662	351664	351665	351666	351667	351668	351670	351671
Customer Reference													
Sample ID													
Sample Type				SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
Sample Location				DCP08	DCP10	DCP10	DCP12	DCP12	WS101	WS101	WS102	WS104	WS105
Sample Depth (m)				0.20	0.10	0.50	0.10	0.60	0.20	0.40	0.00 - 0.30	0.00 - 0.30	0.00 - 0.30
Sampling Date				26/01/2024	26/01/2024	26/01/2024	26/01/2024	26/01/2024	26/01/2024	26/01/2024	26/01/2024	26/01/2024	26/01/2024
Determinand	**Codes**	**Units**	**LOD**										
Soil sample preparation parameters													
Moisture Content	N	%	0.1	3.0	7.1	8.7	15.6	9.8	20.6	9.2	17.5	7.2	24.4
Stones Content	N	%	0.1	38.0	42.6	16.0	< 0.1	< 0.1	< 0.1	45.2	< 0.1	< 0.1	< 0.1
Material removed	N	%	0.1	38.0	42.6	16.0	< 0.1	< 0.1	< 0.1	45.2	< 0.1	< 0.1	< 0.1
Description of Inert material removed	N		0	Stones	Stones	Stones	None	None	None	Stones	None	None	None
Metals													
Arsenic	M	mg/kg	1	^ 3.3	3.5	7.2	15.8	6.4	21.3	13.7	6.6	4.7	26.3
Cadmium	M	mg/kg	0.5	^ < 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.6
Chromium	M	mg/kg	5	^ 10.0	39.3	21.4	27.6	10.2	21.8	32.7	21.4	20.5	38.4
Copper	M	mg/kg	5	^ 11.5	41.9	20.2	68.0	9.0	34.2	41.9	15.2	16.8	26.8
Lead	M	mg/kg	5	^ 24.0	22.5	15.4	86.7	12.4	159	78.0	25.8	20.7	58.3
Mercury	M	mg/kg	0.5	^ < 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.6	< 0.5	< 0.5	< 0.5	< 0.5
Nickel	M	mg/kg	5	^ 6.0	25.0	21.9	26.2	9.4	24.5	47.8	12.8	16.6	30.2
Selenium	M	mg/kg	1	^ < 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Zinc	M	mg/kg	5	^ 27.6	85.2	65.4	184	55.2	142	126	64.9	89.9	200
Anions													
Water Soluble Sulphate	M	g/l	0.02	^ < 0.02	< 0.02	0.03	< 0.02	< 0.02	< 0.02	0.03	< 0.02	< 0.02	< 0.02
Inorganics													
Total Cyanide	M	mg/kg	1	^ < 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0

Results Summary

Report No.: 24-52137, issue number 1

ELAB Reference				351660	351661	351662	351664	351665	351666	351667	351668	351670	351671
Customer Reference													
Sample ID													
Sample Type				SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
Sample Location				DCP08	DCP10	DCP10	DCP12	DCP12	WS101	WS101	WS102	WS104	WS105
Sample Depth (m)				0.20	0.10	0.50	0.10	0.60	0.20	0.40	0.00 - 0.30	0.00 - 0.30	0.00 - 0.30
Sampling Date				26/01/2024	26/01/2024	26/01/2024	26/01/2024	26/01/2024	26/01/2024	26/01/2024	26/01/2024	26/01/2024	26/01/2024
Determinand	**Codes**	**Units**	**LOD**										
Miscellaneous													
pH	M	pH units	0.1	^ 8.5	8.8	9.3	8.3	8.8	7.6	8.3	8.1	8.6	8.0
Soil Organic Matter	U	%	0.1	0.3	1.0	0.3	2.6	0.1	6.8	2.7	4.4	1.0	2.3
Total Organic Carbon	N	%	0.01	2.3	0.56	0.26	2.8	0.16	4.0	1.2	2.3	0.91	1.7
Phenols													
Total Monohydric Phenols	N	mg/kg	5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Polyaromatic hydrocarbons													
Naphthalene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Acenaphthylene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Acenaphthene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1	0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Fluorene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Phenanthrene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1	0.2	< 0.1	0.2	0.2	< 0.1	< 0.1	< 0.1
Anthracene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Fluoranthene	N	mg/kg	0.1	0.1	< 0.1	< 0.1	0.5	< 0.1	1.2	0.5	< 0.1	< 0.1	< 0.1
Pyrene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1	0.4	< 0.1	1.1	0.4	< 0.1	< 0.1	< 0.1
Benzo(a)anthracene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	0.6	0.2	< 0.1	< 0.1	< 0.1
Chrysene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1	0.2	< 0.1	0.8	0.3	< 0.1	< 0.1	< 0.1
Benzo(b)fluoranthene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1	0.5	< 0.1	1.3	0.6	< 0.1	< 0.1	< 0.1
Benzo(k)fluoranthene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1	0.5	< 0.1	1.0	0.4	< 0.1	< 0.1	< 0.1
Benzo(a)pyrene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1	0.3	< 0.1	1.2	0.3	< 0.1	< 0.1	< 0.1
Indeno(1,2,3-cd)pyrene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1	0.2	< 0.1	1.1	0.2	< 0.1	< 0.1	< 0.1
Dibenzo(a,h)anthracene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	< 0.1	< 0.1	< 0.1	< 0.1
Benzo[g,h,i]perylene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	1.0	0.2	< 0.1	< 0.1	< 0.1
Coronene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	< 0.1	< 0.1	< 0.1	< 0.1
Total PAH(16)	N	mg/kg	0.4	< 0.4	< 0.4	< 0.4	3.3	< 0.4	9.8	3.4	< 0.4	< 0.4	< 0.4

Results Summary

2683

Report No.: 24-52137, issue number 1

			ELAB Reference	351672	351673	351676
			Customer Reference			
			Sample ID			
			Sample Type	SOIL	SOIL	SOIL
			Sample Location	WS105	WS105	WS108
			Sample Depth (m)	1.00 - 2.00	4.0 - 5.00	0.30
			Sampling Date	26/01/2024	26/01/2024	26/01/2024
Determinand	**Codes**	**Units**	**LOD**			
Soil sample preparation parameters						
Moisture Content	N	%	0.1	26.7	30.8	8.2
Stones Content	N	%	0.1	< 0.1	< 0.1	24.8
Material removed	N	%	0.1	< 0.1	< 0.1	24.8
Description of Inert material removed	N		0	None	None	Stones
Metals						
Arsenic	M	mg/kg	1	10.3	13.7	7.4
Cadmium	M	mg/kg	0.5	< 0.5	< 0.5	< 0.5
Chromium	M	mg/kg	5	20.9	21.5	15.5
Copper	M	mg/kg	5	8.4	8.9	15.4
Lead	M	mg/kg	5	13.8	14.4	16.4
Mercury	M	mg/kg	0.5	< 0.5	< 0.5	< 0.5
Nickel	M	mg/kg	5	20.3	21.6	12.4
Selenium	M	mg/kg	1	< 1.0	< 1.0	< 1.0
Zinc	M	mg/kg	5	58.7	60.4	62.2
Anions						
Water Soluble Sulphate	M	g/l	0.02	1.78	0.10	< 0.02
Inorganics						
Total Cyanide	M	mg/kg	1	< 1.0	< 1.0	< 1.0

UKAS TESTING 2683

mCERTS THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

Results Summary

Report No.: 24-52137, issue number 1

			ELAB Reference	351672	351673	351676
			Customer Reference			
			Sample ID			
			Sample Type	SOIL	SOIL	SOIL
			Sample Location	WS105	WS105	WS108
			Sample Depth (m)	1.00 - 2.00	4.0 - 5.00	0.30
			Sampling Date	26/01/2024	26/01/2024	26/01/2024
Determinand	**Codes**	**Units**	**LOD**			
Miscellaneous						
pH	M	pH units	0.1	7.9	9.1	8.7
Soil Organic Matter	U	%	0.1	1.9	2.2	0.7
Total Organic Carbon	N	%	0.01	0.94	0.75	0.32
Phenols						
Total Monohydric Phenols	N	mg/kg	5	< 5	< 5	< 5
Polyaromatic hydrocarbons						
Naphthalene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Acenaphthylene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Acenaphthene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Fluorene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Phenanthrene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Anthracene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Fluoranthene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Pyrene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Benzo(a)anthracene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Chrysene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Benzo(b)fluoranthene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Benzo(k)fluoranthene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Benzo(a)pyrene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Indeno(1,2,3-cd)pyrene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Dibenzo(a,h)anthracene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Benzo[g,h,i]perylene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Coronene	N	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Total PAH(16)	N	mg/kg	0.4	< 0.4	< 0.4	< 0.4

Tests marked N are not UKAS accredited.

Results Summary

Report No.: 24-52137, issue number 1

Asbestos Results

Analytical result only applies to the sample as submitted by the client. Any comments, opinions or interpretations (marked #) in this report are outside UKAS accreditation (Accreditation No2683). They are subjective comments only which must be verified by the client.

In accordance with procedures, a 1kg soil sample should be analysed. For amounts less than this caution should be used when analysing the data as sample size is smaller than the recommended amount, therefore samples could be deemed as not being representative of the materials present on site.

Elab No	Depth (m)	Clients Reference	Description of Sample Matrix #	Asbestos Identification	Gravimetric Analysis Total (%)	Gravimetric Analysis by ACM Type (%)	Free Fibre Analysis (%)	Total Asbestos (%)	F/mm2 (I)
351660	0.20	DCP08	Red Soil, Stones, Clinker, Brick, Concrete	No asbestos detected	n/t	n/t	n/t	n/t	n/t
351661	0.10	DCP10	Grey Soil, Stones, Clinker, Shale, Organics	No asbestos detected	n/t	n/t	n/t	n/t	n/t
351662	0.50	DCP10	Brown Soil, Stones, Clinker	No asbestos detected	n/t	n/t	n/t	n/t	n/t
351664	0.10	DCP12	Brown Soil, Stones, Clinker, Organics	No asbestos detected	n/t	n/t	n/t	n/t	n/t
351665	0.60	DCP12	Brown Sandy Soil	No asbestos detected	n/t	n/t	n/t	n/t	n/t
351666	0.20	WS101	Brown Soil, Stones, Clinker, Organics	No asbestos detected	n/t	n/t	n/t	n/t	n/t
351667	0.40	WS101	Brown Soil, Stones, Clinker, Shale	No asbestos detected	n/t	n/t	n/t	n/t	n/t
351668	0.00 - 0.30	WS102	Brown Soil, Stones, Clinker, Organics	No asbestos detected	n/t	n/t	n/t	n/t	n/t
351670	0.00 - 0.30	WS104	Brown Soil, Stones, Organics	No asbestos detected	n/t	n/t	n/t	n/t	n/t
351671	0.00 - 0.30	WS105	Brown Soil, Stones, Organics	No asbestos detected	n/t	n/t	n/t	n/t	n/t
351672	1.00 - 2.00	WS105	Brown Soil, Stones, Organics	No asbestos detected	n/t	n/t	n/t	n/t	n/t
351673	4.0 - 5.00	WS105	Grey Soil	No asbestos detected	n/t	n/t	n/t	n/t	n/t
351676	0.30	WS108	Brown Soil, Stones, Clinker	No asbestos detected	n/t	n/t	n/t	n/t	n/t

Method Summary

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Parameter	**Codes**	**Analysis Undertaken On**	**Date Tested**	**Method Number**	**Technique**
Soil					
pH	M	Air dried sample	01/02/2024	113	Electromeric
Aqua regia extractable metals	M	Air dried sample	01/02/2024	300	ICPMS
Phenols in solids	N	As submitted sample	01/02/2024	121	HPLC
PAH (GC-FID)	N	As submitted sample	01/02/2024	133	GC-FID
Water soluble anions	M	Air dried sample	01/02/2024	172	Ion Chromatography
Total cyanide	M	As submitted sample	01/02/2024	204	Colorimetry
Total organic carbon/Total sulphur	N	Air dried sample	02/02/2024	210	IR
Asbestos identification	U	Air dried sample	06/02/2024	281	Microscopy
Soil organic matter	U	Air dried sample	01/02/2024	BS1377:P3	Titrimetry

Tests marked N are not UKAS accredited

Report Information

Report No.: 24-52137, issue number 1

Key

U	hold UKAS accreditation
M	hold MCERTS and UKAS accreditation
N	do not currently hold UKAS accreditation
^	MCERTS accreditation not applicable for sample matrix
*	UKAS accreditation not applicable for sample matrix
S	Subcontracted to approved laboratory UKAS Accredited for the test
SM	Subcontracted to approved laboratory MCERTS/UKAS Accredited for the test
NS	Subcontracted to approved laboratory. UKAS accreditation is not applicable.
I/S	Insufficient Sample
U/S	Unsuitable sample
n/t	Not tested
<	means "less than"
>	means "greater than"
LOD	LOD refers to limit of detection, except in the case of pH soils and pH waters where it means limit of discrimination.
	Soil sample results are expressed on an air dried basis (dried at < 30°C), and are uncorrected for inert material removed.
	ELAB are unable to provide an interpretation or opinion on the content of this report.
	The results relate only to the sample received.
	PCB congener results may include any coeluting PCBs
	Uncertainty of measurement for the determinands tested are available upon request
	Unless otherwise stated, sample information has been provided by the client. This may affect the validity of the results.

Deviation Codes

a	No date of sampling supplied
b	No time of sampling supplied (Waters Only)
c	Sample not received in appropriate containers
d	Sample not received in cooled condition
e	The container has been incorrectly filled
f	Sample age exceeds stability time (sampling to receipt)
g	Sample age exceeds stability time (sampling to analysis)

Where a sample has a deviation code, the applicable test result may be invalid.

Sample Retention and Disposal

All soil samples will be retained for a period of one month
All water samples will be retained for 7 days following the date of the test report
Charges may apply to extended sample storage

TPH Classification - HWOL Acronym System

HS	Headspace analysis
EH	Extractable Hydrocarbons - i.e. everything extracted by the solvent
CU	Clean-up - e.g. by florisil, silica gel
1D	GC - Single coil gas chromatography
Total	Aliphatics & Aromatics
AL	Aliphatics only
AR	Aromatics only
2D	GC-GC - Double coil gas chromatography
#1	EH_Total but with humics mathematically subtracted
#2	EH_Total but with fatty acids mathematically subtracted
_	Operator - underscore to separate acronyms (exception for +)
+	Operator to indicate cumulative e.g. EH+HS_Total or EH_CU+HS_Total
MS	Mass Spectrometry

End of Report

Job No. 2996

Job Name. Conwy Active Travel RSBC

POS(park) (1% SOM)

GroundSolve Ltd
Consulting Geotechnical Engineers

Metals & Non-Metals	DCP08	DCP10	DCP10	DCP12	DCP12	WS101	WS101	WS102	WS104	WS105	WS105	WS105	WS108	Min (mg/kg)	Max (mg/kg)	Average (Unrounded)	Average (mg/kg)	Count	Adopted Guideline (mg/kg)	Source	Exceedances
	0.2	0.1	0.5	0.1	0.6	0.2	0.4	0.00 - 0.30	0.00 - 0.30	0.00 - 0.30	1.00 - 2.00	4.0 - 5.00	0.3								
Arsenic	3.3	3.5	7.2	5.8	6.4	21.3	13.7	6.6	4.7	26.3	10.3	13.7	7.4	3.3	26.3	10.02	10.02	13	170	C4SL	0
Cadmium	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.6	< 0.5	< 0.5	< 0.5	< 0.5	0.6	0.51	0.51	13	880	C4SL	0
Chromium	10	39.3	21.4	27.6	10.2	21.8	32.7	21.4	20.5	38.4	20.9	21.5	15.5	10	39.3	23.17	23.17	13	33000	S4UL	0
Copper	11.5	41.9	20.2	68	9	34.2	41.9	15.2	16.8	26.8	8.4	8.9	15.4	8.4	68	24.48	24.48	13	44000	S4UL	0
Lead	24	22.5	15.4	86.7	12.4	159	78	25.8	20.7	58.3	13.8	14.4	16.4	12.4	159	42.11	42.11	13	1300	C4SL	0
Mercury	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.6	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.6	0.64	0.64	13	30	S4UL	0
Nickel	6	25	21.9	26.2	9.4	24.5	47.8	12.8	16.6	30.2	20.3	21.6	12.4	6	47.8	21.13	21.13	13	800	S4UL	0
Total Monohydric Phenols	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	<5	5.00	5	13	440	S4UL	0
Selenium	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	<1.0	1.00	1	13	1800	S4UL	0
Zinc	27.6	85.2	65.4	184	55.2	142	126	64.9	89.9	200	58.7	60.4	62.2	27.6	200	93.96	93.96	13	170000	S4UL	0

Polyaromatic Hydrocarbons (PAH)	DCP08	DCP10	DCP10	DCP12	DCP12	WS101	WS101	WS102	WS104	WS105	WS105	WS105	WS108	Min (mg/kg)	Max (mg/kg)	Average (Unrounded)	Average (mg/kg)	Count	Adopted Guideline (mg/kg)	Source	Exceedances
	0.2	0.1	0.5	0.1	0.6	0.2	0.4	0.00 - 0.30	0.00 - 0.30	0.00 - 0.30	1.00 - 2.00	4.0 - 5.00	0.3								
Acenaphthene	< 0.1	< 0.1	< 0.1	0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.20	0.2	13	29000	S4UL	0
Acenaphthylene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	<0.1	0.10	0.1	13	29000	S4UL	0
Anthracene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	<0.1	0.10	0.1	13	150000	S4UL	0
Benzo(a)anthracene	< 0.1	< 0.1	< 0.1	0.1	< 0.1	0.6	0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.6	0.30	0.3	13	49	S4UL	0
Benzo(a)pyrene	< 0.1	< 0.1	< 0.1	0.3	< 0.1	1.2	0.3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1.2	0.27	0.27	13	21	C4SL	0
Benzo(b)fluoranthene	< 0.1	< 0.1	< 0.1	0.5	< 0.1	1.3	0.6	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1.3	0.33	0.33	13	13	S4UL	0
Benzo[g,h,i]perylene	< 0.1	< 0.1	< 0.1	0.1	< 0.1	1	0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1.0	0.43	0.43	13	1400	S4UL	0
Benzo(k)fluoranthene	< 0.1	< 0.1	< 0.1	0.5	< 0.1	1	0.4	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1.0	0.28	0.28	13	370	S4UL	0
Chrysene	< 0.1	< 0.1	< 0.1	0.2	< 0.1	0.8	0.3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.8	0.43	0.43	13	93	S4UL	0
Dibenzo(a,h)anthracene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.15	0.15	13	1.1	S4UL	0
Fluoranthene	0.1	< 0.1	< 0.1	0.5	< 0.1	1.2	0.5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1.2	0.58	0.58	13	6300	S4UL	0
Fluorene	< 0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.10	0.1	13	20000	S4UL	0
Indeno(1,2,3-cd)pyrene	< 0.1	< 0.1	< 0.1	0.2	< 0.1	1.1	0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1.1	0.23	0.23	13	150	S4UL	0
Naphthalene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	<0.1	0.10	0.1	13	1200	S4UL	0
Phenanthrene	< 0.1	< 0.1	< 0.1	0.2	< 0.1	0.2	0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.13	0.13	13	6200	S4UL	0
Pyrene	< 0.1	< 0.1	< 0.1	0.4	< 0.1	1.1	0.4	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	1.1	0.28	0.28	13	15000	S4UL	0

Other Contaminants / Testing	DCP08	DCP10	DCP10	DCP12	DCP12	WS101	WS101	WS102	WS104	WS105	WS105	WS105	WS108	Min (mg/kg)	Max (mg/kg)	Average (Unrounded)	Average (mg/kg)	Count	Adopted Guideline (mg/kg)	Source	Exceedances
	0.2	0.1	0.5	0.1	0.6	0.2	0.4	0.00 - 0.30	0.00 - 0.30	0.00 - 0.30	1.00 - 2.00	4.0 - 5.00	0.3								
Soil Organic Matter	0.3	1.0	0.3	2.6	0.1	6.8	2.7	4.4	1.0	2.3	1.9	2.2	0.7	0.1	6.8	2.02	2.02	13	-	-	-
pH	8.5	8.8	9.3	8.3	8.8	7.6	8.3	8.1	8.6	8	7.9	9.1	8.7	7.6	9.3	8.46	8.46	13	-	-	-
Total Cyanide	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	<0.1	1.00	1	13	-	-	-
Water Soluble Sulphate	< 0.02	< 0.02	0.03	< 0.02	< 0.02	< 0.02	0.03	< 0.02	< 0.02	< 0.02	1.78	0.1	< 0.02	< 0.02	1.78	0.19	0.19	13	-	-	-

APPENDIX F – GEOTECHNICAL TEST RESULTS

Guidance for Classification of Soil for Off Site Disposal at a Landfill Site

Many site developments create a portion of excess soils and Made Ground which if not re-usable, are required to be disposed off-site at a suitably licensed landfill site. The regulations and associated guidance published by the Environment Agency is relatively complex and lengthy. This guidance provides a summary of the following documents which should be referred to when assessing soil (and common constituents found within Made Ground on remediation sites) for off-site disposal:

- Guidance for Waste destined for disposal in landfills: Interpretation of the Waste Acceptance Requirements of the Landfill (England and Wales) Regulations 2002 (as amended) (EA, 2004);
- Guidance on Sampling and Testing of Wastes to Meet Landfill Waste Acceptance Procedures (EA, April 2005);
- WM3 - Hazardous Waste: Interpretation of the Definition and Classification of Hazardous Wastes (EA, May 2015);
- European Regulation No 1272/2008 on Classification, Labelling and Packaging of substances 2015 (CLP 2015);
- Guidance on Waste Destined for Disposal in Landfill (EA, June 2006);
- Treatment of Non-hazardous wastes for Landfill (EA, February 2007).

It is important to distinguish between the waste classification system and the designation of materials as “suitable for use” on site. A material may be retained on site for an appropriate end use if that end-use is clearly designated and that a site-specific risk assessment ensures that it does not pose a risk to human health or controlled waters. However, if this material is excavated and sent for disposal, the material is then subject to waste management regulations and the two systems cannot be directly correlated. It is therefore important to note that classifying a material as hazardous (should it be excavated and become a waste) does not necessarily indicate that it might not be suitable to be kept on site for re-use. Separate guidance in the form of a Code of Practice (CL:AIRE Version 2, 2011) has been developed jointly between the development industry and the Environment Agency to provide best practice when assessing whether materials are wastes or not, and for determining when waste can cease to be waste for a particular use.

In accordance with the current waste regulations (or Landfill Directive, as they are more commonly known), from 30th October 2007 all waste materials produced from construction sites have to be pre-treated prior to disposal. Pre-treatment includes waste minimisation, recovery (e.g., separation of demolition waste to be used as hardcore) and separation of materials into different waste categories (e.g., separate inert waste from hazardous waste etc). Mixing of different waste types shall be avoided and intentional mixing of inert materials with hazardous waste to ‘dilute it’ and hence change its waste classification, is illegal.

The current waste regulations (based on the EU landfill directive) introduced a two-tier classification system for waste materials, defining them as either being hazardous or non-hazardous. Landfills are licensed to take wastes based on a three-tier classification system with the non- hazardous waste divided into two sub-categories:

- Non-Hazardous - inert;
- Non-Hazardous - non-hazardous;
- Hazardous.

Waste materials are categorised with a six-figure numeric code in the European Waste Catalogue. Commonly found construction and demolition wastes including excavated soil from contaminated sites and Made Ground with their waste codes are summarised below (this is not a comprehensive list):

Waste Code	**What is it?**	**Likely Waste Category–**		
		Inert Waste	**Non-Hazardous**	**Hazardous Waste**
17 01 01 Concrete	Concrete, possibly with reinforcement (from Construction & Demolition)	✓		
17 01 02 Bricks		✓		
17 01 06* Mixtures of concrete, bricks, tiles & ceramics containing dangerous substances	These are not normally considered hazardous but if they are contaminated (e.g., by asbestos) then could be hazardous – see comment above			✓
17 01 07 Mixtures of concrete, bricks, tiles & ceramics other than those in 17 01 06	This is mixed inerts c.f. 17 09 04	✓		
17 05 03* soils and stones containing dangerous substances				✓
17 05 04 soils and stones other than those mentioned in 17 05 03	Soil and stones only (excluding top soil, peat, soil and stones from contaminated sites)	✓		
17 06 05* Construction materials containing asbestos	e.g., corrugated asbestos sheeting			✓
17 08 02 Gypsum-based construction materials other than those mentioned in 17 08 01	Plaster & plasterboard (although specific disposal requirements are required for high sulphate waste – see EA guidance 'Understanding the Landfill Directive' version 1.0 March 2010.		✓	
17 09 01* Construction & demolition wastes containing mercury				✓
17 09 02* Construction & demolition wastes containing PCBs	Waste with more than 50 mg/kg of PCB's are hazardous			✓

Waste Code	What is it?	Likely Waste Category–		
		Inert Waste	Non-Hazardous	Hazardous Waste
17 09 03* Other mixed construction & demolition wastes containing dangerous substances	Broad range of potentially (see notes below – if asterix the waste is hazardous) hazardous wastes			✓
17 09 04 Mixed construction & demolition wastes other than those mentioned in 17 09 01, 17 09 02 & 17 09 03	Mixed inerts with soil, tarmac, cables, vegetation, plaster, etc. (this waste can only be considered inert if it passes the waste acceptance criteria identified in the regulations).	✓	✓	

Note: all wastes with an asterix code are hazardous regardless of whether they are mirror or absolute entries in the EWC list the decision to with regard to composition must come before applying the code for mirror entries.

Some materials are classified as Inert Waste based in its origin (e.g., 17 01 01 Concrete, or glass) without any requirement for laboratory chemical analysis.

However, most soils will require laboratory testing to confirm whether they are classified as Hazardous Waste. The protocol for assessing these materials and the appropriate threshold values is complicated and are set out in the Environment Agency's "Technical Guidance *WM3* Hazardous Waste – Interpretation of the Definition and Classification of Hazardous Waste" (2015). If the test results for the waste indicates that it is not hazardous then further analysis of the waste is required to determine whether it is Inert Waste. If the waste does not meet the criteria for either Hazardous or Inert, then it is by default classified as Non-hazardous Waste.

As an alternative location to landfills for off-site disposal of inert and non-hazardous waste, there are a number of sites which have Waste Permit Exemptions that can accept certain categories of inert and non-hazardous wastes. Additionally, some quarries can accept certain types of wastes to be used for quarry restoration material. For both alternatives to disposal at landfill sites the material still requires chemical testing as these sites have site specific acceptance criteria for wastes. It should also be noted that these types of sites do not incur landfill tax which in the 2018/19 tax year is £2.80 for inactive waste (inert and some types of non-hazardous waste) and £88.95/Tonne for active waste (some types of non-hazardous waste and hazardous waste. Note that the Inland Revenue uses a different classification scheme for waste for tax purposes to the European Waste Classification scheme.

Waste Categorisation

The process of determining the category of wastes is a three-stage process:

- Stage 1 – is the waste either Hazardous or Inert by definition without the requirement for chemical analysis (if it is then Stages 2 and 3 are not required);
- Stage 2 - Waste characterisation;
- Stage 3 - WAC classification.

Waste characterisation determines if a waste is hazardous or not. Excavated soil is characterised using a system based on the contaminants present and their hazardous properties. The system uses total concentrations of the contaminants. Thresholds (as a percentage of the waste) have been set for the various hazardous properties.

Fourteen hazardous properties together with other scenarios where material could cause a hazard have been defined:

- Hazardous properties: explosive, oxidising, highly flammable/flammable, irritant, harmful, toxic, carcinogenic, corrosive, infectious, toxic for reproduction, mutagenic and ecotoxic;
- Substances which can release toxic/very toxic gases in contact with water, acid or air;
- Substances which, after disposal, can yield another substance, e.g., a leachate, which possesses any of the above hazardous properties.

Some of the hazardous properties are sub-divided e.g., there are three categories of carcinogenic, mutagenic and toxic for reproduction substances. The hazardous properties were originally defined in the European Hazardous Waste Directive 91/689/EC. Should a waste contain a contaminant with one or more of the listed hazardous properties at a concentration equal to or above the threshold value for the particular property, then the waste is hazardous. The hazardous properties of a wide range of chemicals are sourced from CLP 2015.

There are many reasons why waste soil is classified as being hazardous, but the majority of reasons can be divided into the following four groups:

- Hydrocarbons – this is probably the most common reason for the hazardous classification of soils. For most soils hydrocarbon analysis will be required for both Polycyclic Aromatic Hydrocarbons (PAH) and speciated Petroleum Hydrocarbons (PHCs) but depending on the site's history other groups of organic contaminants may also be is included in any analysis suite for soil samples;
- Metals – Particularly sites from former metal processing or mining sites and also some types of ash have metal concentrations that are sufficiently high to characterise materials requiring disposal as hazardous waste.
- Asbestos;
- Anions – e.g., sulphate in plasterboard (there are special disposal requirements for high sulphate waste and specific WAC requirements); it is possible that sulphate salts of metals and semi-metals could make the waste hazardous – the sulphate concentration could possibly be significant under H12, H13 and H14.

The characterisation of wastes with significant metal concentrations involves some processing of the analysis data. The chemical analysis results for inorganic substances are generally reported as total concentrations e.g., total lead, total arsenic, total sulphate etc. However, CLP 2015 deals with the hazardous properties of actual compounds e.g., lead sulphate, arsenic pentoxide, nickel carbonate. Therefore, the total metal results have to be converted into assessed chemical analysis results for the compound most likely to be present in the soil samples. For example, if the sample contains high total lead concentrations and high sulphate concentrations, then the lead is likely to be present in the soil as lead sulphate. The most likely compounds can often be determined from a desk study or previous site uses. If the site has been derelict for a number of years, consideration should be given as to whether water soluble compounds should or should not be chosen, as rainfall could have removed them from the soil (this does not apply if the soil has been taken from below under a concrete slab etc). Chemical knowledge and common sense needs to be used in choosing a suitable compound.

If no data is available, then a worst-case scenario has to be assumed and the most hazardous compound likely to be present has to be chosen. For example, metal chromates (lead chromate, nickel chromate) are often the most hazardous compounds formed by many metals, but if the chromium concentrations in the soil are low, chromates are unlikely to be present. It should also be noted that for many of the hazard categories, the cumulative hazard from different compounds is added (e.g., add the concentrations of the copper, lead and zinc compounds together to assess the Hazard Category H14 Ecotoxicity).

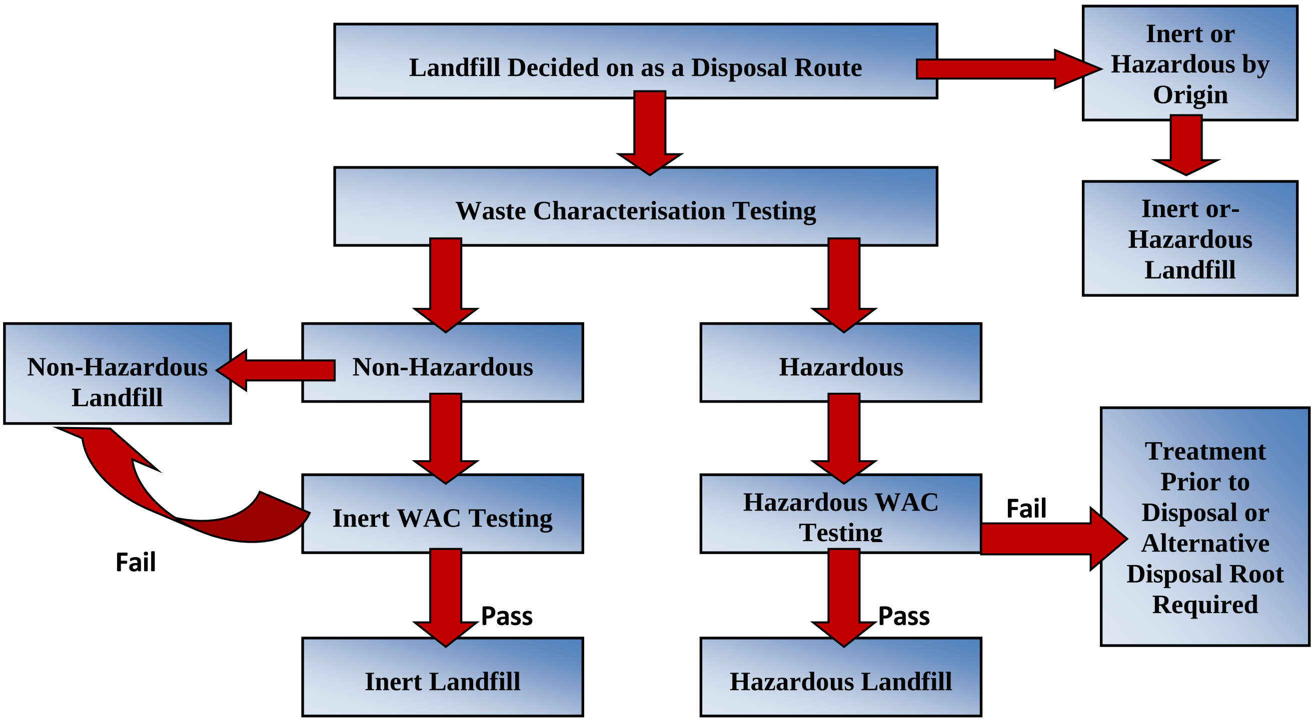
If the results of the above assessment determine that the waste is hazardous, it must then be analysed for the Waste Acceptance Criteria (WAC) analysis contained within appropriate Environmental Permitting Regulations (this comprises mainly leachate but also analysis for TOC and Loss on ignition). WAC limit values have been set for the listed determinands. If any of the determinands exceed their limit value, the waste must be pre-treated to reduce concentrations to below the limit values before the waste may be disposed of at a landfill site licensed to take hazardous waste.

For waste classified as not being hazardous, then there are two options available. Currently, waste correctly characterised as not being hazardous may be disposed of without WAC testing to a non-hazardous landfill. Alternatively, WAC testing for Inert Waste can be carried out (this is similar to the list for hazardous waste with the addition of PAH's, BTEX and Mineral Oil). If the results pass the Inert WAC criteria it can be disposed of at an Inert Waste Landfill. If any of the WAC test results exceed the Inert WAC criteria the waste has to be disposed at a non- hazardous landfill. There are WAC limits for non-hazardous waste set for pH and TOC. If these two criteria are not met then the waste must be pre-treated to so that it meets the criteria before it can be disposed.

If materials fail the WAC criteria it may be possible to pre-treat the waste on-site or be taken to a soil treatment centre for pre-treatment to reduce the soil's hazardous properties (e.g., by bioremediation of hydrocarbons).

It should be noted that in order to dispose of Hazardous Waste, the site must register as a producer of Hazardous Waste with the Environment Agency. When disposing of waste materials to landfill sites the appropriate Duty of Care Waste Transfer procedures must be followed.

Landfilled Waste Decision Tree



Landfill Tax

It should be noted that HM Revenue and Customs (HMRC) classify wastes for tax purposes using a different scheme to the threefold landfill EU Landfill Directive scheme (i.e., the hazardous, non-hazardous and inert). HMRC have a two-fold system for landfill tax. The Standard Landfill Tax is currently £88.95/T and applies to all wastes unless they qualify for the reduced rate of landfill tax of £2.80/T. The wastes that qualify for the reduced rate of Landfill Tax are set out in The Landfill Tax (Qualifying Material) Order 2011 with supplementary information on the interpretation of these regulations in HMRS “Notice LFT1 – A General Guide to Landfill Tax” (May 2012) and HMRC Briefing Notes 15/12 and 18/12.

APPENDIX G – GUIDANCE FOR CLASSIFICATION OF SOIL FOR OFF SITE DISPOSAL AT A LANDFILL SITE

Guidance for Classification of Soil for Off Site Disposal at a Landfill Site

Many site developments create a portion of excess soils and Made Ground which if not re-usable, are required to be disposed off-site at a suitably licensed landfill site. The regulations and associated guidance published by the Environment Agency is relatively complex and lengthy. This guidance provides a summary of the following documents which should be referred to when assessing soil (and common constituents found within Made Ground on remediation sites) for off-site disposal:

- Guidance for Waste destined for disposal in landfills: Interpretation of the Waste Acceptance Requirements of the Landfill (England and Wales) Regulations 2002 (as amended) (EA, 2004);
- Guidance on Sampling and Testing of Wastes to Meet Landfill Waste Acceptance Procedures (EA, April 2005);
- WM3 - Hazardous Waste: Interpretation of the Definition and Classification of Hazardous Wastes (EA, May 2015);
- European Regulation No 1272/2008 on Classification, Labelling and Packaging of substances 2015 (CLP 2015);
- Guidance on Waste Destined for Disposal in Landfill (EA, June 2006);
- Treatment of Non-hazardous wastes for Landfill (EA, February 2007).

It is important to distinguish between the waste classification system and the designation of materials as “suitable for use” on site. A material may be retained on site for an appropriate end use if that end-use is clearly designated and that a site-specific risk assessment ensures that it does not pose a risk to human health or controlled waters. However, if this material is excavated and sent for disposal, the material is then subject to waste management regulations and the two systems cannot be directly correlated. It is therefore important to note that classifying a material as hazardous (should it be excavated and become a waste) does not necessarily indicate that it might not be suitable to be kept on site for re-use. Separate guidance in the form of a Code of Practice (CL:AIRE Version 2, 2011) has been developed jointly between the development industry and the Environment Agency to provide best practice when assessing whether materials are wastes or not, and for determining when waste can cease to be waste for a particular use.

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Waste materials are categorised with a six-figure numeric code in the European Waste Catalogue. Commonly found construction and demolition wastes including excavated soil from contaminated sites and Made Ground with their waste codes are summarised below (this is not a comprehensive list):

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17 01 07 Mixtures of concrete, bricks, tiles & ceramics other than those in 17 01 06	This is mixed inerts c.f. 17 09 04	✓		
17 05 03* soils and stones containing dangerous substances				✓
17 05 04 soils and stones other than those mentioned in 17 05 03	Soil and stones only (excluding top soil, peat, soil and stones from contaminated sites)	✓		
17 06 05* Construction materials containing asbestos	e.g., corrugated asbestos sheeting			✓
17 08 02 Gypsum-based construction materials other than those mentioned in 17 08 01	Plaster & plasterboard (although specific disposal requirements are required for high sulphate waste – see EA guidance 'Understanding the Landfill Directive' version 1.0 March 2010.		✓	
17 09 01* Construction & demolition wastes containing mercury				✓
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Some of the hazardous properties are sub-divided e.g., there are three categories of carcinogenic, mutagenic and toxic for reproduction substances. The hazardous properties were originally defined in the European Hazardous Waste Directive 91/689/EC. Should a waste contain a contaminant with one or more of the listed hazardous properties at a concentration equal to or above the threshold value for the particular property, then the waste is hazardous. The hazardous properties of a wide range of chemicals are sourced from CLP 2015.

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- Metals – Particularly sites from former metal processing or mining sites and also some types of ash have metal concentrations that are sufficiently high to characterise materials requiring disposal as hazardous waste.
- Asbestos;
- Anions – e.g., sulphate in plasterboard (there are special disposal requirements for high sulphate waste and specific WAC requirements); it is possible that sulphate salts of metals and semi-metals could make the waste hazardous – the sulphate concentration could possibly be significant under H12, H13 and H14.

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If no data is available, then a worst-case scenario has to be assumed and the most hazardous compound likely to be present has to be chosen. For example, metal chromates (lead chromate, nickel chromate) are often the most hazardous compounds formed by many metals, but if the chromium concentrations in the soil are low, chromates are unlikely to be present. It should also be noted that for many of the hazard categories, the cumulative hazard from different compounds is added (e.g., add the concentrations of the copper, lead and zinc compounds together to assess the Hazard Category H14 Ecotoxicity).

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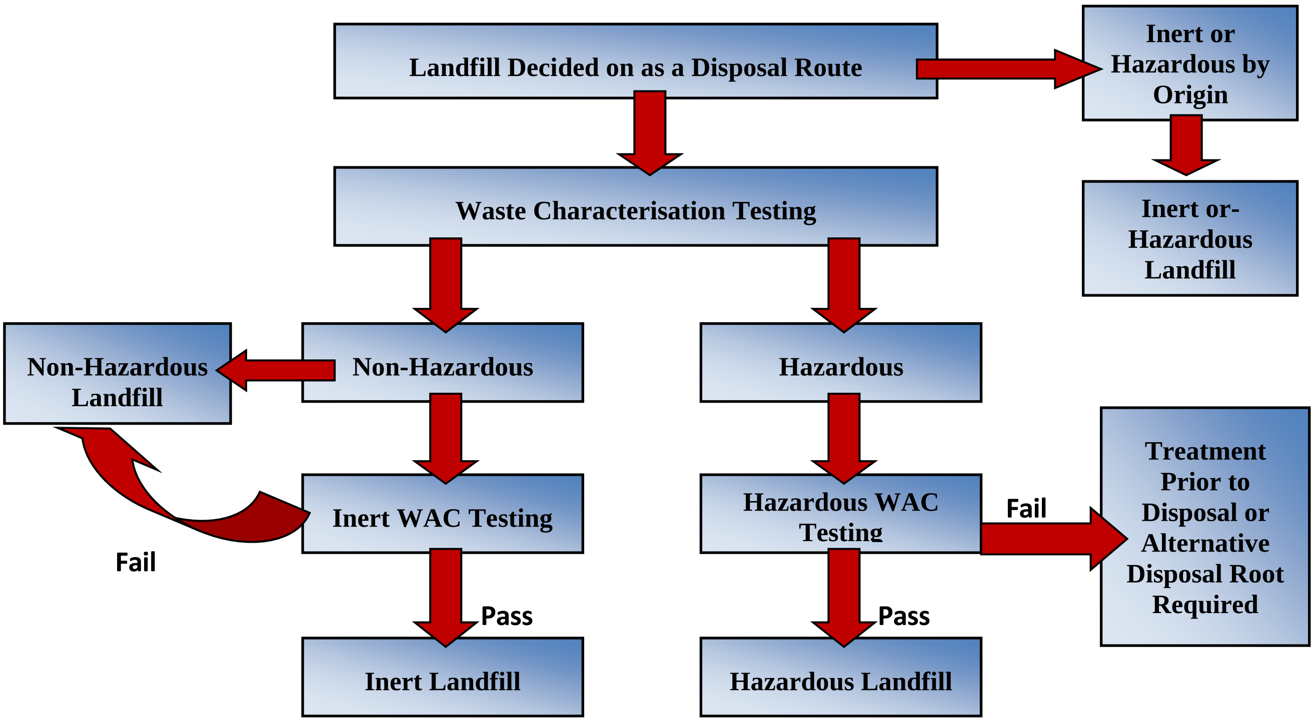
For waste classified as not being hazardous, then there are two options available. Currently, waste correctly characterised as not being hazardous may be disposed of without WAC testing to a non-hazardous landfill. Alternatively, WAC testing for Inert Waste can be carried out (this is similar to the list for hazardous waste with the addition of PAH's, BTEX and Mineral Oil). If the results pass the Inert WAC criteria it can be disposed of at an Inert Waste Landfill. If any of the WAC test results exceed the Inert WAC criteria the waste has to be disposed at a non- hazardous landfill. There are WAC limits for non-hazardous waste set for pH and TOC. If these two criteria are not met then the waste must be pre-treated to so that it meets the criteria before it can be disposed.

If materials fail the WAC criteria it may be possible to pre-treat the waste on-site or be taken to a soil treatment centre for pre-treatment to reduce the soil's hazardous properties (e.g., by bioremediation of hydrocarbons).

It should be noted that in order to dispose of Hazardous Waste, the site must register as a producer of Hazardous Waste with the Environment Agency. When disposing of waste materials to landfill sites the appropriate Duty of Care Waste Transfer procedures must be followed.

Landfilled Waste Decision Tree



Landfill Tax

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APPENDIX H – UNFORESEEN GROUND CONTAMINATION

Unforeseen Ground Contamination

There is the potential for areas of previously unexpected contamination to be present, as is the case with any “brownfield” site. Any significant quantities of asbestos, significant ashy soils, unusual, brightly coloured or significantly oily or odorous material should be considered in this category. If unexpected contamination is found the following procedures should be adhered to:

1. All site works at the position of the suspected contamination will cease.
2. A suitably trained geo-environmental specialist should assess the visual and olfactory observations of the condition of the ground and the extent of contamination, and the Client and the Local Authority should be informed of the discovery. Should the contamination be likely to affect controlled waters the Environment Agency shall also be informed.
3. The suspected contaminated material will be investigated and tested appropriately in accordance with the assessed risks. The investigation works will be carried out in the presence of a suitably qualified geo-environmental engineer. The investigation works shall commence to recover samples for testing and, using visual and olfactory observations of the condition of the ground, delineate the area over which contaminated materials are present.
4. The unexpected, contaminated material will either be left in situ or be stockpiled whilst testing is carried out and suitable assessments completed to determine whether the material can be re-used on site or requires to be disposed as appropriate.
5. Where the material is left in situ awaiting results it will be reburied or covered with plastic sheeting.
6. Where the potentially contaminated material is to be temporarily stockpiled it will either be placed either on a prepared surface of clayey Alluvium, or on 2000-gauge Visqueen sheeting (or other impermeable surface) and covered to prevent dust and odour emissions.
7. Any areas where unexpected visual or olfactory ground contamination will be surveyed, a photographic record kept, and testing results incorporated into the Verification Report.
8. A photographic recorded will be made of relevant observations.
9. The testing suite will be determined by the independent geo-environmental specialist on the basis of visual and olfactory observations.
10. Test results will be compared against current assessment criteria suitable for the future use of the area of the site affected.
11. The results of the investigation and testing of any suspect unexpected contamination will be used to determine the relevant actions. After consultation with the Local Authority and if necessary the Environment Agency, materials should either be:

- re-used in areas where test results indicate that it meets compliance targets so it can be reused without treatment; or
- treatment of material on site to meet compliance targets so it can be reused; or

- removal from site to a treatment centre or to a suitably licensed landfill or permitted treatment facility.

12. Verification Report will be produced for the work.

Asbestos

Asbestos cement products and asbestos fibres have not been encountered in the soils at the site but based on the age of the Made Ground material containing asbestos could be expected to be encountered. If non-notifiable asbestos (e.g., chrysotile asbestos cement board) is encountered in excavations then it will be dealt with in accordance with the Control of Asbestos Regulations 2012 (CAR 2012) and the HSE's ACoP for asbestos (2013). Finding non-notifiable asbestos is a very common occurrence on brownfield sites and is a relatively low risk activity and can be dealt with as a matter of routine. Therefore, it is not proposed that the Council will be notified but an appropriate record will be kept of confirmatory testing and disposal. This will be included in remediation verification reports.

If suspect notifiable asbestos is encountered then the Council and the HSE will be notified. An appropriate action plan will be agreed with the Council and the HSE in accordance with CAR 2012. The action plan will include the preparation of the Risk Assessment and Plan of Work in accordance with CAR and other statutory requirements including:

- Site mobilisation;
- Excavation methodology;
- Handling, movement and storage on-site of excavation arisings;
- Any processing of excavation arisings containing ACMs;
- Movement and placement of arisings to final destination;
- Placing of cover system over soils with and ACMs remaining on-site;
- Off-site disposal of ACMs;
- Licences;
- PPE & RPE; and,
- Dust and fibre monitoring.

Potential mitigation measures that would be required include:

- Ensuring works are carried out by suitably trained and experienced personnel with working with asbestos;
- Site investigation and risk assessment;
- Removal or treatment of asbestos hotspots;
- Use of PPE and RPE by construction workers; and,

- Compliance monitoring.

Unexpected Tanks

No buried underground fuel storage tanks have been encountered during the site investigation works; however, there remains a low risk that tanks are present on-site. Should an underground tank be encountered, operations should cease in the area. Additionally, there may be pipework associated with these tanks which could have oily residues. The following procedures are to be adhered to if tanks and pipework are identified:

1. All site works at the position of the tanks/pipework should stop.
2. A description of the tank should be made by the geo-environmental engineer including; condition and surround, along with visual and olfactory observations should any contents in the tank be apparent. A photographic recorded will also be made of relevant observations.
3. The tank's position and depth should be determined and marked on a plan of the site.
4. The independent geo-environmental engineer will inform Client and the Local Authority.
5. During the presence of the independent geo-environmental engineer, investigation works should be undertaken to obtain samples of any liquid or sludge contents and to establish dimensions of the tank.
6. Testing will be determined on the basis of visual and olfactory observations by independent geo-environmental engineer.
7. Test results will be compared against current assessment criteria and proposals for disposal of any contents determined in agreement with the appropriate Regulatory Parties.
8. Emptying the tank and disposal of contents to a suitable licenced disposal facility.
9. Degassing and removal of the tank by a suitably qualified contractor will be required, and a Naked Flame Certificate should be provided.
10. Once the tank has been emptied in accordance with the above proposals, it is to be removed for disposal to a licensed waste management facility. Copies of the relevant waste consignment notes are to be kept and included in the Verification Report.
11. Excavation and remediation of any contaminated soils around the tank will be carried out.
12. Samples of the base and sides of the resultant hole will be sampled and supervised by the independent geo-environmental engineer to confirm whether risks to human health or controlled waters.