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## ENVIRONMENT

Burbury Investments Ltd
Ellesmere Marina – 'The Nursey'
Shropshire

# Phase 2 Geo-Environmental Assessment

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# Ellesmere Marina – 'The Nursey'
# Shropshire
# Phase 2 Geo-Environmental Assessment

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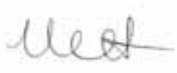
| | | |  |  |  |

## Notice

# EXECUTIVE SUMMARY

| | |
|---|---|
| Site Address | Land south of A495, Scotland Street, Ellesmere Marina. |
| Site Setting | The site comprises a roughly triangular shaped plot of land, covered by two fields, a residential garden in the north-east and a larger grassed field to the south-west. A barn is located along the southern boundary of the south-eastern field with a small stockpile in the southern corner. Potential asbestos containing materials were observed within the stockpile. |
| Published Ground Conditions | British Geological Survey (BGS) mapping indicates that superficial deposits (Secondary A Aquifers) comprising Alluvium are present along the eastern, southern and western boundaries, with Glaciofluvial Deposits (sands and gravels) present across the remainder of the site. The entire site is indicated to be underlain by the bedrock geology of the Wilmslow Sandstone Formation (Principal Aquifer). The site is not indicated to be located within an EA groundwater source protection zone. The closest mapped surface water feature to the site is Newnes Brook, which forms the southern and eastern boundaries. |
| Site Investigation | A site investigation was undertaken at the site comprising:<br>• Five dynamic sampler boreholes to a maximum depth of 3.00m below ground level (bgl), with follow-on dynamic probing to 5.50m bgl;<br>• Nine trial pits to a maximum depth of 3.50m bgl;<br>• Collection of soil samples for environmental and geotechnical testing; and<br>• Two ground gas and groundwater monitoring visits. |
| Ground Conditions Encountered | Ground conditions were generally found to comprise Topsoil over granular Glaciofluvial Deposits, with Made Ground encountered in the south of the site and cohesive Alluvium encountered overlying the Glaciofluvial Deposits in the south-west. Alluvium is likely to be present along the length of Newnes Brook, along the southern and eastern boundaries. The bedrock geology of the Wilmslow Sandstone Formation was not encountered as part of this investigation.<br>Groundwater has been encountered within the granular Glaciofluvial Deposits within most exploratory holes, with standing water levels recorded between 1.27m and 3.29m bgl, at around 87.50m AOD. In addition to shallow groundwater, excavations are noted to have displayed poor stability within granular deposits. |
| Geotechnical Appraisal | Based on the encountered ground conditions, the granular Glaciofluvial Deposits are likely to be suitable founding stratum, although localised low strength soils have been encountered where very loose sands and gravels have been recorded alongside groundwater strikes, potentially indicating blowing sands to be present.<br>It is not recommended that foundations be constructed bearing into Topsoil or Made Ground in order to avoid unpredictable and excessive total and differential settlements.<br>In accordance with the recommendations of BRE Special Digest 1, 'Concrete in Aggressive Ground' 2005, the conditions of the soils at the site would be classified as Design Sulphate Class DS-1 and ACEC Class AC-1. |
| Environmental Appraisal | Preliminary ground gas monitoring has identified low concentrations of carbon dioxide (up to 5.5% v/v), which has given the site a classification of CS2 or Amber 1. The marginally elevated concentrations above 5% v/v were recorded within one borehole in the south of the site, where peat was recorded within the Glaciofluvial Deposits. Further monitoring and risk assessment may be able to demonstrate that the site can be considered as a CS1/Green site. |

| | |
|---|---|
| | Soil chemical analysis has not reported any contaminants as exceeding their guideline screening criteria.<br>Asbestos tiles have been identified in a stockpile in the south of the site.<br>Soil leachate analysis has identified several heavy metals as exceeding their guideline screening levels. However, all concentrations are within an order of magnitude of their respective screening level and are considered to be marginal in nature. Additionally, development of the site will reduce surface water infiltration and therefore reduce leachate mobility and further reduce the risk to controlled waters. |
| Waste Assessment | The assessment indicates that the soils analysed are likely to be classified as non-hazardous. Localised surface asbestos has been found at the site. The presence of visible asbestos containing materials in waste or at concentrations exceeding 0.1% by weight will classify the waste as mixed and require disposal as hazardous waste irrespective of the chemical properties of the waste. |
| Recommendations | Due to the localised nature of the marginally elevated carbon dioxide concentrations, it is recommended that additional ground gas monitoring be undertaken prior to development to confirm the gas classification for the site.<br>Due to the localised presence of low strength soils, once a detailed masterplan is available, additional ground investigation will be required to confirm a foundation solution and/or any zoning that may be required. |
| This summary should be read in conjunction with BWB's full report (ref. EMM-BWB-ZZ-XX-RP-YE-0003-GI_P1) and reflects an assessment of the Site based on information received by BWB at the time of production. | |

# CONTENTS

EXECUTIVE SUMMARY ..... iii
1. INTRODUCTION ..... 1
Instruction ..... 1
Objectives ..... 1
Scope of Works ..... 2
2. THE SITE ..... 3
Site Location ..... 3
Site Description ..... 3
3. PUBLISHED GROUND CONDITIONS ..... 5
Published Geology ..... 5
Hydrogeology ..... 5
Hydrology ..... 5
4. PRELIMINARY ENVIRONMENTAL RISK ASSESSMENT ..... 6
Introduction ..... 6
5. GEO-ENVIRONMENTAL GROUND INVESTIGATION ..... 8
Chemical Sampling and Analytical Strategy ..... 8
6. GROUND CONDITIONS ENCOUNTERED ..... 10
Geological Summary ..... 10
Contamination Observations ..... 14
7. GEOTECHNICAL ASSESSMENT ..... 15
Floor Slabs ..... 16
Roads and Pavements ..... 16
Excavations ..... 16
Groundwater and Drainage ..... 16
Chemical Attack on Buried Concrete ..... 17
8. GROUND GAS ASSESSMENT ..... 18
Introduction ..... 18
Methodology ..... 18
Results ..... 18
9. CONTAMINANT DISTRIBUTION AND HUMAN HEALTH RISK ASSESSMENT ..... 20
Introduction ..... 20
Pathways ..... 20
10. CONTROLLED WATERS RISK ASSESSMENT ..... 22
11. ENVIRONMENTAL RISK ASSESSMENT ..... 24
12. ENVIRONMENT LIABILITY ASSESSMENT ..... 27

13. WASTE MANAGEMENT ..... 29
Waste Classification ..... 29
14. CONCLUSION AND RECOMMENDATIONS ..... 30
Recommendations ..... 31
15. REFERENCES ..... 32

## FIGURES

Figure 2:1: Site Location Plan
Figure 6:1: Corrected SPT 'N' Value ($N_{60}$) Versus Depth within Glaciofluvial Deposits
Figure 6:2: $N_{300}$ Versus Depth within Glaciofluvial Deposits

## TABLES

Table 4:1: Preliminary Conceptual Site Model
Table 6:1 : Summary of Ground Conditions
Table 6:2: Glaciofluvial Deposits Particle Size Distribution Results Summary
Table 6:3: Water Strikes
Table 8:1: Summary of Recorded Ground Gas Results
Table 9:1: Residential Exposure Pathways
Table 10:1: Controlled Water Exposure Pathways
Table 10:2: Summary of Soil Leachate Exceedances
Table 11:1: Updated Conceptual Site Model

## APPENDICES

Appendix 1: Proposed Masterplan
Appendix 2: Preliminary Risk Classification
Appendix 3: Factual Ground Investigation Report
Appendix 4: Soil Chemical Results Summary
Appendix 5: Soil Leachate Chemical Results Summary
Appendix 6: Hazwaste Assessment

# 1. INTRODUCTION

## Instruction

1.1 BWB Consulting (BWB) was instructed by Burbury Investments Ltd (the Client) to carry out a Phase 2 Geo-Environmental Assessment for the site known as 'The Nursey' at Ellesmere Marina, Shropshire. Details of the project brief are included in BWB proposal reference 210416/01/BMW2025/RTR/DZ, dated April 2021.

1.2 The development of the wider Ellesmere Marina site is understood to involve the construction of a major mixed use development comprising a new marina, residential units, hotel, leisure pa, holiday cabins and a touring caravan site. A parcel of land known as 'The Nursery' has been acquired in addition to the larger Ellesmere Marina site. The intended use of the 'The Nursery' site is currently unknown although a residential development and/or access to the wider site is most probable. A proposed masterplan for the wider Ellesmere Marina site is presented as **Appendix 1**.

## Objectives

1.3 The objectives of the report are to assess:

- The prevailing ground and groundwater conditions across the site;
- The potential presence and extent of contamination in shallow soil and groundwater beneath the site;
- The significance and magnitude of the observed contamination through comparison of analytical data to appropriate published environmental screening criteria;
- The strength properties of the soil beneath the site to enable foundation design; and
- The ground gas regime beneath the site.

1.4 The report has been completed in accordance with BS10175:2011(+A2:2017) 'Investigation of Potentially Contaminated Sites, Code of Practice' and EA Guidance on Risk Management of Land Contamination https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm.

1.5 This report presents the information obtained from a ground investigation, which together with the associated Figures and Appendices, provides a Ground Investigation Report (GIR), as defined in BS EN 1997-1:2004 and BS EN 1997-2:2007.

## Previous Reports

1.6 BWB have previously undertaken a Phase 1 Geo-Environmental Assessment for the wider Ellesmere Marina site, which has been utilised in the production of this report, with pertinent information included, as required.

- 'Phase 1 Geo-Environmental Assessment Report, Ellesmere Marina' by BWB Consulting for Formal Holdings Ltd, reference BMW2025/01/V2, dated July 2013.

1.7 It is assumed that the reader is familiar with the above report.

## Scope of Works

1.6 The ground investigation scope of works was completed on 20th May 2021 and comprised the following:

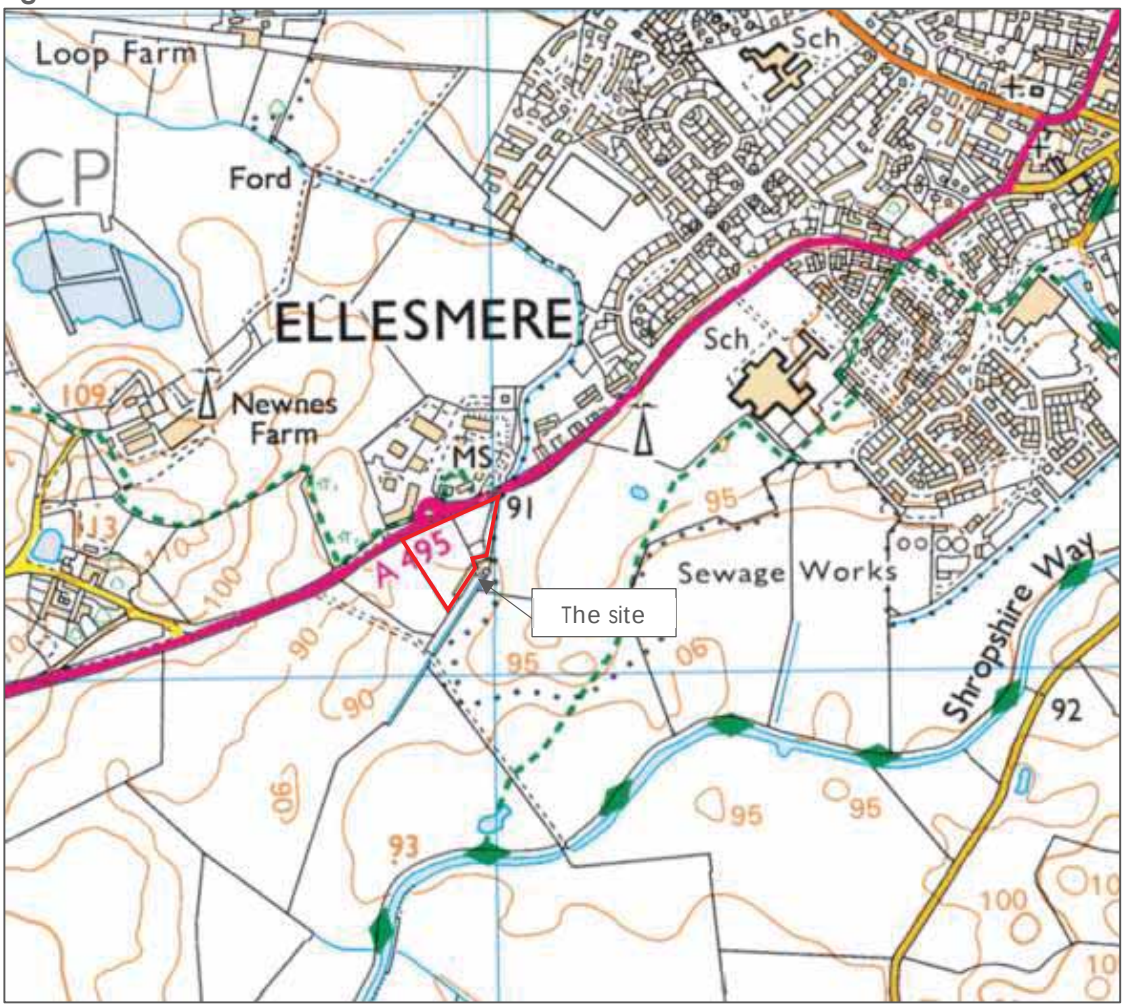
- Non-intrusive survey of excavation locations for underground utilities;
- Five dynamic sampler boreholes;
- Nine machine excavated trial pits;
- Two gas and groundwater monitoring visits;
- Chemical analysis of soils; and
- Geotechnical testing of soils.

# 2. THE SITE

## Site Location

2.1 The site is located to the south-east of the A495, to the south-west of the town of Ellesmere in Shropshire, located at approximate National Grid reference 338938, 334192. The location of the site is shown in **Figure 2:1.**

**Figure 2:1: Site Location Plan**




## Site Description

2.2 The site is roughly triangular in shape, covering an area of approximately 1 hectare to the south-east of the A495. Site topography falls from north to south.

2.3 At the time of the investigation the site comprised two fields, a residential garden in the north-east and a larger grassed field to the south-west. A barn is located along the southern boundary of the south-eastern field with a small stockpile in the southern corner. Potential asbestos containing materials were observed within the stockpile.

2.4 Site boundaries were generally formed by small wooden fences and shrubs, with scattered mature trees. The southern and eastern boundaries are formed by Newnes Brook.

# 3. PUBLISHED GROUND CONDITIONS

## Published Geology

3.1 British Geological Survey (BGS) mapping for the site indicates that superficial deposits comprising Alluvium are present along the eastern, southern and western boundaries, with Glaciofluvial Deposits (sands and gravels) present across the remainder of the site. The entire site is indicated to be underlain by the bedrock geology of the Wilmslow Sandstone Formation.

3.2 Previous investigation undertaken by BWB on the wider Ellesmere Marina site recorded ground conditions to comprise firm to stiff, locally soft sandy gravelly clay with bands of sand and gravel (Glacial Till) proven to a maximum depth of 10.45m below ground level (bgl). Localised areas of soft organic Alluvial clays and peat deposits were recorded to depths in excess of 3.80m bgl.

## Hydrogeology

3.3 The underlying ground conditions have been classified by the Environment Agency (EA) as follows:

- Alluvium and Glaciofluvial Deposits: Secondary A Aquifers; and
- Wilmslow Sandstone Formation: Principal Aquifer.

3.4 During previous investigation undertaken by BWB on the wider Ellesmere Marina site, groundwater has been recorded at depths of between 0.66m and 4.77m bgl, considered to be representative of perched water trapped within granular pockets.

3.5 The site is not indicated to be located within an EA groundwater source protection zone.

## Hydrology

3.6 The closest mapped surface water feature to the site is Newnes Brook, which forms the southern and eastern boundaries.

3.7 The eastern boundary of the site is considered by the EA to be at high risk of flooding and has been classified as a Flood Zone 2 and 3 (high vulnerability of flooding) from rivers, with no noted flood defences or flood water storage areas in the vicinity.

# 4. PRELIMINARY ENVIRONMENTAL RISK ASSESSMENT

## Introduction

4.1 The risk posed by any contaminants in soil or groundwater will depend on the nature of the hazard, the probability of exposure, the pathway by which exposure occurs, and the likely effects on the receptors. A contaminant is defined as a substance that has the potential to cause harm, while a risk is considered to exist if such a substance is present in sufficient concentration to cause harm and a pathway exists for a receptor to be exposed to the substance.

4.2 The following sections discuss all the identified potential on and off-site sources, pathways and receptors in the context of the proposed development and plausible pollutant linkages which may represent a risk to identified receptors such as human health and/or controlled waters. At this stage the assessment is qualitative and aimed to determine all pollutant linkages, irrespective of significance or allowing for uncertainty.

4.3 Three impact potentials exist for any given site; these are:

- The site impacting upon itself;
- The site impacting on its surroundings; and
- The surroundings impacting on the site.

4.4 All three impacts need to be considered in a risk assessment.

4.5 A Source, Pathway, Receptor analysis has been undertaken for the site, based on information contained within the Phase 1 Geo-Environmental Assessment (reference BMW2025/01/V2), which is presented as **Table 4:1** and further information about the risk classification scheme is included within **Appendix 2.**

4.6 Sources (S); These are potential or known sources of contamination that may relate to a former land use or present site feature or process (e.g. fuel storage tanks).

4.7 Pathways (P); A pathway is defined as a mechanism or route by which a contaminant comes into contact with, or otherwise affects a receptor. Pathways by which the identified receptors may be impacted upon in the context of the proposed development.

4.8 Receptors (R); Receptors are defined as people, living organisms, ecological systems, controlled waters, atmosphere, structures and utilities that could be adversely affected by contaminant(s).

4.9 Under the Construction Design Management (CDM) Regulations 2015, construction and maintenance contractors must undertake their own risk assessments and mitigation to protect their staff, other human receptors and the environment from potential contamination. By law potential risks to human health and the environment from construction activities must appropriately identified and all necessary steps taken to

eliminate/manage that risk. Therefore, construction / maintenance workers are excluded as a receptor in the CSM.

**Table 4:1: Preliminary Conceptual Site Model**

| Source | Pathway | Receptor | Con | Prob | Risk |
|---|---|---|---|---|---|
| **S1**: Potentially elevated heavy metals, petroleum hydrocarbons, pesticides and herbicides and asbestos in soils. | **P1:** Direct contact, incidental ingestion and inhalation of particulates. | **R1**: Construction/services personnel | Md | Lw | M/L |
| | | **R2**: Future site users (residential) | | | |
| | **P2:** Vertical migration of contaminants in the soil leachate. | **R3:** Underlying Secondary A Aquifer | Md | Lw | M/L |
| | | **R4:** Underlying Principal Aquifer | Md | Ul | L |
| | | **R5:** Newnes Brook | Md | Ul | L |
| **S2:** Potentially elevated ground gas concentrations from Made Ground and naturally organic soils. | **P3:** Migration into buildings through foundation cracks and service entry points. | **R2**: Future site users (residential) | Md | Lw | M/L |
| **S3:** Off-site sources of contamination associated with agricultural and industrial land uses in the surrounding area. | **P3:** Migration into buildings through foundation cracks and service entry points. | **R2**: Future site users (residential) | Md | Ul | L |

VH = Very High, H = High, M = Moderate, M/L = Moderate/Low, L = Low, VL = Very Low

KEY: Sv = Severe, Md = Medium, Mi = Mild, Mr = Minor Hi = High, Li = Likely, Lw = Low Likelihood, Ul = Unlikely

# 5. GEO-ENVIRONMENTAL GROUND INVESTIGATION

5.1 Intrusive ground investigation works were undertaken on 20th May 2021 and comprised the following works:

- Clearance of investigation locations by a specialist buried services tracing company;
- Collection of coordinates and elevations of exploratory hole locations;
- Advancement of five boreholes (WS01 to WS05 inclusive) by dynamic sampling drilling techniques, to a maximum depth of 3.00m bgl with completion of standard penetration testing (SPTs) and installation of gas and groundwater monitoring wells;
- Follow-on dynamic probing within all boreholes to a maximum depth of 5.50m bgl;
- The advancement of nine machine excavated trial pits (TP01 to TP09 inclusive) to a maximum depth of 3.50m bgl;
- Collection of environmental soil samples for chemical analysis at a UKAS and MCERTS accredited laboratory;
- Collection of bulk and disturbed soil samples for geotechnical analysis at a UKAS accredited laboratory; and
- Two post investigation ground gas and groundwater level monitoring visits.

5.2 An exploratory hole location plan, exploratory hole records and the post investigation gas and groundwater monitoring data are presented within the Factual Ground Investigation Report included as **Appendix 3**.

5.3 The site investigation works were carried out in general accordance with BS5930:2015 'Code of Practice for Site Investigations' and BS10175:2011 'Investigation of Potentially Contaminated Sites'.

## Chemical Sampling and Analytical Strategy

5.4 Exploratory hole locations were positioned across the site, to provide general site coverage in accessible areas. Soil samples were obtained from all exploratory hole locations from a variety of depths and strata in order to gain an understanding of ground conditions across the site.

5.5 Selected soil samples collected from exploratory hole locations were sent to i2 Analytical Ltd Services (UKAS and MCERTS accredited) for chemical analysis. The following chemical analytical testing was undertaken:

- Eight soil samples tested for a soil suite (BWB Standard Suite) comprising arsenic, barium, beryllium, water soluble boron, cadmium, chromium, hexavalent chromium, copper, lead, mercury, nickel, selenium, vanadium, zinc, water soluble sulphate (2:1 extract), total phenols, total cyanide, free cyanide, complex cyanide, fraction of organic carbon, pH, Polycyclic Aromatic Hydrocarbons (PAHs) (United States Environment Protection Agency priority 16 compounds) and Total Petroleum Hydrocarbons (TPH) C6-C40;
- Two soil samples tested for TPH speciated to the UK Criteria Working Group (TPHCWG) aliphatic and aromatic compounds;

- Three soil samples tested for pesticides and herbicides;
- Four soil samples for asbestos screening; and
- Four soil samples tested for a suite of common leachable contaminants, namely arsenic, barium, beryllium, water soluble boron, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium, zinc, water soluble sulphate (2:1 extract), sulphate, total cyanide and pH.

5.6 The results of the soil chemical testing are enclosed within the factual report presented within **Appendix 3**.

## Geotechnical Strategy

5.7 Exploratory locations were positioned across the site to assess underlying ground conditions for geotechnical purposes. In-situ soil strength testing comprising SPTs were undertaken with the dynamic sampler boreholes, with dynamic probing undertaken at the base of each borehole. SPT 'N' values are included on the exploratory hole logs presented as **Appendix 3**, alongside the dynamic probe logs.

5.8 Selected disturbed and bulk samples were collected from the investigation locations and sent to the geotechnical project laboratory (Exploration & Testing Associates Ltd), which is UKAS accredited. The following geotechnical testing was undertaken;

- Eight samples tested for moisture content;
- Four samples tested for Atterberg (liquid and plastic) limits;
- Six samples submitted for particle size distribution testing; and
- Six samples tested for BRE Suite comprising aqueous sulphate and pH.

5.9 The results of the geotechnical testing are enclosed within the factual report presented within **Appendix 3**.

# 6. GROUND CONDITIONS ENCOUNTERED

## Geological Summary

6.1 The ground conditions encountered confirmed the published geology and those reported during previous BWB investigations across the wider Ellesmere Marina site. Ground conditions were generally found to comprise Topsoil over Glaciofluvial Deposits, with Made Ground encountered in the south of the site and cohesive Alluvium encountered overlying the Glaciofluvial Deposits in the south-west. The bedrock geology of the Wilmslow Sandstone Formation was not encountered as part of this investigation.

6.2 The recorded ground conditions are summarised in **Table 6:1** below. Uncorrected SPT results collected from the borehole locations are presented on the exploratory hole records presented within **Appendix 3**.

**Table 6:1 : Summary of Ground Conditions**

| Stratum | Top Depth (m) | | Base Depth (m) | | Thickness (m) | | SPT N Value | |
|---|---|---|---|---|---|---|---|---|
| | Min | Max | Min | Max | Min | Max | Min | Max |
| Topsoil | 0.00 | 0.00 | 0.20 | 0.50 | 0.20 | 0.50 | NR | |
| Made Ground | 0.30 | 0.50 | 0.60 | | 0.60 | | NR | |
| Alluvium | 0.20 | 0.30 | 0.90 | 2.50 | 0.70 | 2.20 | NR | |
| Glaciofluvial Deposits* | 0.20 | 2.50 | >3.50 | | >3.20 | | 0 | 16 |
| *The base depth of the Glaciofluvial Deposits was unproven at all exploratory hole locations. | | | | | | | | |

## Geological Descriptions

### Topsoil

6.3 Topsoil was encountered within all exploratory holes between ground level and up to 0.50m below ground level (bgl). The Topsoil was generally encountered as a firm brown to dark brown slightly sandy to very sandy clay, with a brown very clayey sand recorded in TP03, TP06, WS01 and WS05. Quartzite gravels were recorded in TP07 and TP08 and brick fragments were recorded in TP09 and WS01.

### Made Ground

6.4 Made Ground was encountered within TP09 and WS05, adjacent to buildings in the south of the site. Made Ground was encountered from between 0.30m and 0.50m bgl to depths of 0.60m bgl and was recorded as a soft to firm dark brown or grey sandy clay with brick fragments.

### Alluvium

6.5 Alluvium was recorded within TP02 and TP03 in the south-west of the site beneath the Topsoil from depths of between 0.20m and 0.30m bgl to depths of between 0.90m and 2.50m bgl.

6.6 The Alluvium was generally recorded as cohesive in nature, as a firm brown to grey sandy clay with occasional quartzite gravels and rootlets. A band of brown slightly gravelly very clayey sand was recorded over the clay within TP03 between 0.20m and 0.70m bgl. Fine shell fragments were recorded below 2.00m bgl within TP02.

6.7 Moisture content testing undertaken within cohesive samples of Alluvium from TP02 at 1.50m and 2.30m bgl reported values of 19% and 35%, respectively, and plasticity index values of 15% and 21%.

Glaciofluvial Deposits

6.8 Glaciofluvial Deposits were encountered within all exploratory hole locations beneath either the Topsoil, Made Ground or Alluvium, with the exception of TP09, which was terminated within the Made Ground. The Glaciofluvial Deposits were encountered from depths of between 0.20m and 2.50m bgl to depths greater than 3.50m bgl. The base depth of the Glaciofluvial Deposits was not encountered during the investigation.

6.9 The strata was generally encountered as a brown, orangish brown or yellowish brown slightly gravelly slightly clayey to clayey sand, with gravels recorded as sandstone and quartzite. A low quartzite cobble content was recorded within TP05, TP07 and TP01 below 1.50m bgl.

6.10 A loose brown clayey very sandy gravel of mudstone, quartzite and sandstone was recorded between 1.30m and 2.70m bgl within WS02, underlain by a soft grey silt, the base depth of which was unproven to greater than 3.00m bgl. A yellowish brown to brown very sandy gravel of mudstone and sandstone was also encountered below 1.50m bgl within WS03 and below 2.10m bgl within WS04.

6.11 A band of peat was recorded within WS05 between 2.50m and 2.55m bgl.

6.12 Within TP03 a firm yellowish brown slightly gravelly sandy clay was recorded overlying the granular deposits between 0.90m and 1.50m bgl. Gravels were recorded as flint and quartzite. A firm slightly friable sandy clay was recorded between two bands of sand at 1.00m to 1.40m bgl within TP08.

6.13 SPT $N_{60}$ values within the Glaciofluvial Deposits were recorded in the range 0 and 21 blows. Very low SPT values have been recorded where very loose sands and gravels have been encountered alongside groundwater strikes, potentially indicating blowing sands to be present. A plot of corrected SPT $N_{60}$ Value Vs Depth is presented as **Figure 6:1** below.

6.14 Follow-on dynamic probing was undertaken at the base of each borehole, to a maximum depth of 5.50m bgl, into what is assumed to be the Glaciofluvial Deposit. SPT $N_{300}$ values have been calculated from the dynamic probe testing, which are presented as **Figure 6:2** below.

**Figure 6:1: Corrected SPT 'N' Value ($N_{60}$) Versus Depth within Glaciofluvial Deposits**

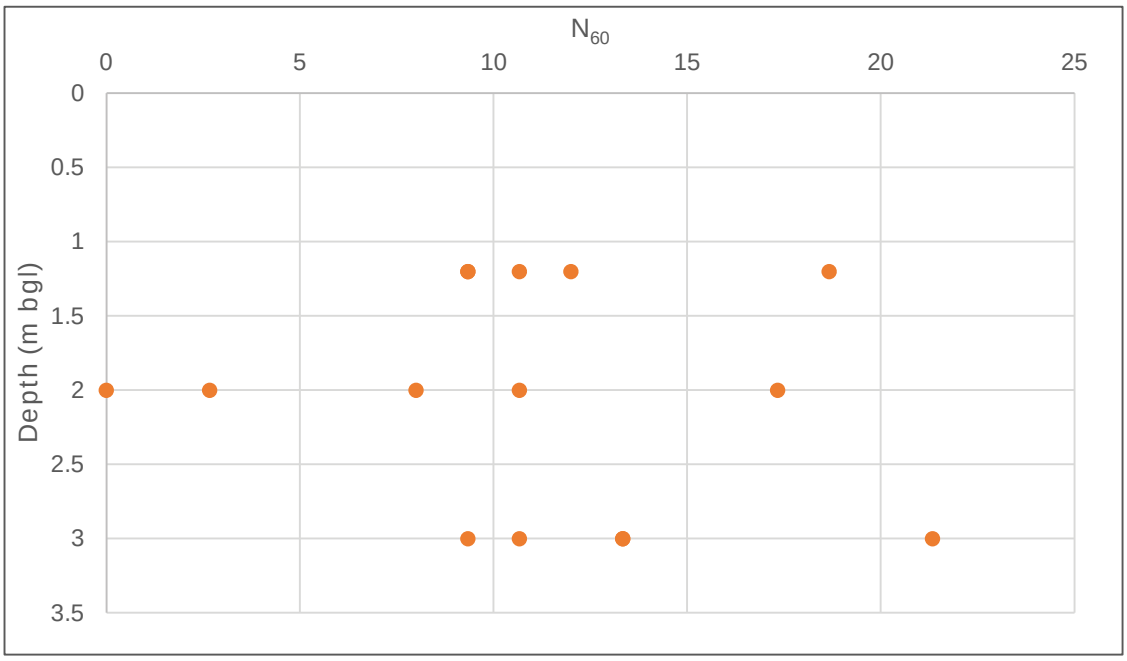
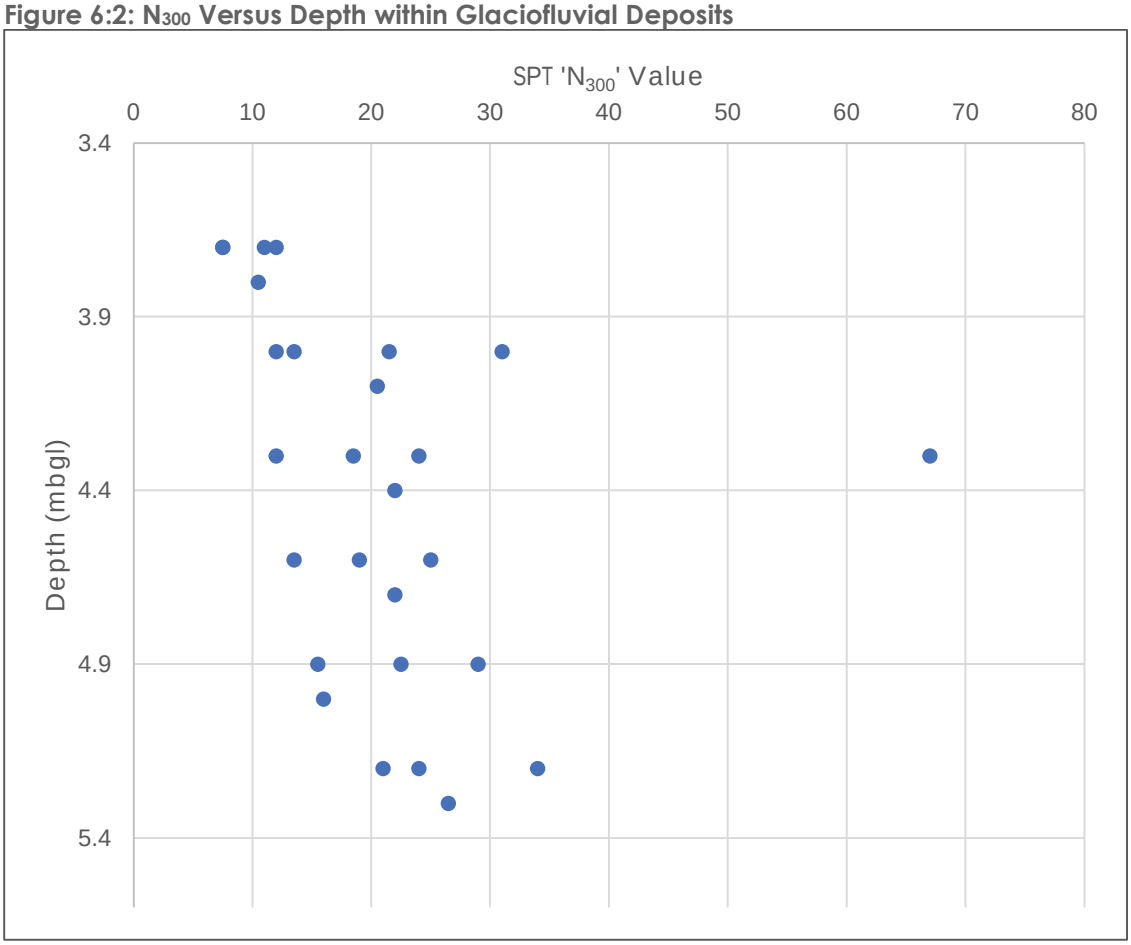



**Figure 6:2: $N_{300}$ Versus Depth within Glaciofluvial Deposits**



6.15 Results of the dynamic probing show that generally soil strength increases with depth, with the exception of a high $N_{300}$ value at 4.30m bgl within WS03, where the probe was terminated at 4.50m bgl on a possible cobble.

6.16 Moisture content testing undertaken on cohesive Glaciofluvial Deposits recorded values between 8.6% (within WS02 at 3.00m bgl) and 20% (within TP03 at 1.00m bgl) and on granular samples between 4.1% (within TP04 at 1.50m bgl) and 17% (within TP02 at 3.00m bgl). Plasticity index values have been recorded between 7% (within TP08 at 1.10m bgl) and 12% (within TP03 at 1.00m bgl).

6.17 Particle size distribution tests were undertaken on six samples of granular Glaciofluvial Deposits, a summary of the results is provided in **Table 6:2** below.

**Table 6:2: Glaciofluvial Deposits Particle Size Distribution Results Summary**

| Location | Depth (m) | Cobble Content (%) | Gravel Content (%) | Sand Content (%) | Clay/ Silt Content (%) | Earthworks Classification |
|---|---|---|---|---|---|---|
| TP01 | 2.60 | 0 | 56 | 35 | 8 | 1A |
| TP02 | 2.70 | 0 | 13 | 63 | 25 | 2A&2B |
| TP03 | 2.80 | 0 | 37 | 51 | 12 | 1A |
| TP05 | 1.00 | 18 | 33 | 46 | 4 | 1A |
| TP07 | 1.50 | 0 | 12 | 55 | 33 | 2A&2B |
| TP08 | 1.60 | 0 | 1 | 96 | 2 | 1A |

## Hydrogeology and Hydrology

6.18 Groundwater was encountered within seven exploratory holes at depths of between 2.00m and 3.00m bgl, generally within the Glaciofluvial Deposits. A summary of groundwater strikes is presented in **Table 6:3**.

**Table 6:3: Water Strikes**

| Location | Depth (m bgl) | Stratum |
|---|---|---|
| TP02 | 2.00 | Alluvium |
| | 3.00 | Glaciofluvial Deposits |
| TP03 | 2.80 | Glaciofluvial Deposits |
| WS01 | 2.00 | Glaciofluvial Deposits |
| WS02 | 2.00 | Glaciofluvial Deposits |
| WS03 | 2.00 | Glaciofluvial Deposits |
| WS04 | 2.00 | Glaciofluvial Deposits |
| WS05 | 2.00 | Glaciofluvial Deposits |

6.19 Standing water levels have been recorded within all boreholes during both monitoring visits on 25th May and 2nd June 2021. Groundwater levels were found to vary between 1.27m bgl (within WS05 on 25th May) and 3.29m bgl (within WS03 on 2nd June). Groundwater elevations were noted to vary between 86.97m above Ordnance Datum (AOD), within WS05 on 2nd June and 88.00m AOD within WS01 on 25th May.

6.20 The monitoring data has been used to infer the likely groundwater flow profile across the site. The data is indicated to flow in a southerly direction towards Newnes Brook.

6.21 No surface water monitoring was undertaken as part of this investigation.

### Contamination Observations

6.22 Possible asbestos containing materials were observed within a small stockpile at TP09. No additional contamination observations were noted during the ground investigation or subsequent monitoring period.

# 7. GEOTECHNICAL ASSESSMENT

## Introduction

7.1 The development of the wider Ellesmere Marina site is understood to involve the construction of a major mixed use development comprising a new marina, residential units, hotel, leisure pa, holiday cabins and a touring caravan site. A parcel of land known as 'The Nursery' has been acquired in addition to the larger Ellesmere Marina site. The intended use of the 'The Nursery' site is currently unknown though residential development and/or access to the wider site is most probable. A proposed masterplan for the wider Ellesmere Marina site is presented as **Appendix 1**.

7.2 At the time of writing the intended use for the site is unknown and as such there are no proposed loadings available. However, for the purpose of this assessment it is assumed that any development will comprise lightly loaded residential structures.

7.3 Ground conditions have generally been recorded as varying thicknesses of Topsoil over granular Glaciofluvial Deposits, with Made Ground encountered beneath the Topsoil in the south of the site and cohesive Alluvium encountered overlying the Glaciofluvial Deposits in the south-west. The bedrock geology of the Wilmslow Sandstone Formation was not encountered as part of this investigation.

7.4 Alluvium has been encountered in the south-west of the site, which is likely to be present along the length of Newnes Brook along the southern and eastern boundaries. Foundations loading into this material may be prone to excessive and/or differential settlements.

7.5 Groundwater has been encountered within the granular Glaciofluvial Deposits within the majority of exploratory holes, with standing water levels recorded between 1.27m and 3.29m bgl, at around 87.50m AOD. In addition to shallow groundwater, excavations are noted to have displayed poor stability within granular deposits.

## Shallow Spread Foundation Solutions

7.6 Consideration has been given to utilising traditional shallow spread foundations across the site.

7.7 It is recommended that foundations are not constructed bearing into Topsoil or Made Ground in order to avoid unpredictable and excessive total and differential settlements.

7.8 Based on the encountered ground conditions, the granular Glaciofluvial Deposits are likely to be suitable founding stratum, although localised low strength soils have been encountered where very loose sands and gravels have been recorded alongside groundwater strikes, potentially indicating blowing sands to be present. As such, once a detailed masterplan is available, additional ground investigation will be required to confirm a foundation solution and/or any zoning that may be required.

## Floor Slabs

7.9 NHBC guidance stipulates that a ground bearing floor slab is not permissible where Made Ground/fill exceeds 600mm. On the basis that an earthworks exercise will not be required on site, a lightly loaded ground bearing floor slab bearing onto the natural strata of either the Alluvium or Glaciofluvial Deposits should be suitable within maximum settlements of 25mm.

7.10 Prior to casting, building footprints should be proof rolled and inspected for soft spots by a suitably qualified geotechnical engineer. Where identified, soft spots should be excavated and replaced with granular engineered fill.

7.11 Should gas protection be required, this should be incorporated into ground bearing floor slabs.

## Roads and Pavements

7.12 Consideration to road or pavement design did not form part of the scope of this investigation. It is recommended that in-situ CBR tests at formation level should be carried out to confirm the strength of sub grade and finalise the required pavement construction thickness.

## Excavations

### Ease and Stability of Excavation

7.13 Based on the ground conditions encountered during the intrusive investigation, conventional plant and equipment is expected to be suitable for shallow excavations.

7.14 Excavations displayed poor stability during the site investigation within granular Glaciofluvial Deposits, although any excavation may become unstable if left open for any significant periods. Where personnel entry is required for inspection; excavations should be sufficiently enlarged and an assessment of safe temporary angles should be made. Alternatively, temporary shoring should be provided.

### Legislation on Personnel Entry to Excavations

7.15 It is recommended that no excavations should be entered without appropriate support and a full risk assessment should be completed prior to entry. Mitigation measures to protect from accumulating ground gases should be implemented.

## Groundwater and Drainage

7.16 Groundwater has been encountered within the granular Glaciofluvial Deposits within the majority of exploratory holes, with standing water levels recorded between 1.27m and 3.29m bgl, at around 87.50m AOD.

7.17 The presence of water has the potential to destabilise excavations and where groundwater is encountered during foundation excavations or the creation of

developable plateaus, it may require removal. It is considered that conventional dewatering techniques comprising a sump and submersible pump are likely to provide an adequate form of water abstraction from these areas. However, care must be taken to avoid pumping out fine material (i.e. silt) from granular strata as this could destabilise the localised ground.

7.18 A drainage assessment did not form part of the scope of this investigation although based on the ground conditions encountered, a soakaway drainage solution may be possible at the site in areas where the shallow groundwater table precludes their vaibility.

### Chemical Attack on Buried Concrete

7.19 Water soluble sulphate concentrations in soils varied from 6.4mg/l to 280mg/l with soil pH values ranging from 5.6 to 8.2. Total sulphur concentrations ranged from 0.00016% to 0.25%.

7.20 In accordance with the recommendations of BRE Special Digest 1, 'Concrete in Aggressive Ground' 2005, the conditions of the shallow soils at the site would be classified as Design Sulphate Class DS-1 and ACEC Class AC-1 (based on mobile groundwater and non-pyritic soils).

# 8. GROUND GAS ASSESSMENT

## Introduction

8.1 Ground gas assessment has been undertaken to assess the risks associated with ground gases and volatile vapours to new buildings and their occupants. The results obtained have been assessed in line with relevant guidance (notably CIRIA C665).

8.2 Based on the ground investigation undertaken, the following potential sources of hazardous ground gas have been identified:

- Limited Made Ground located in the south-west of the site; and
- Limited Alluvium located in the south of the site and potentially along southern and eastern boundaries.

8.3 BWB have undertaken two visits over a period of two weeks and therefore this assessment is considered to be preliminary and additional monitoring is expected to be required to support the proposed development.

## Methodology

8.4 The assessment of potential ground gas generation is based on the observation of trends and changes in gas evolution by the direct measurement of ground gases from gas wells. The works included measurement of methane, carbon dioxide, oxygen, hydrogen sulphide, carbon monoxide, gas flows and barometric pressure. A PID survey was undertaken to measure volatile organic compounds within the borehole response zones.

## Results

8.5 The minimum and maximum steady state concentrations recorded for borehole flow, oxygen, carbon dioxide and methane are summarised below in **Table 8:1**. The full ground gas monitoring results are presented within **Appendix 3**.

**Table 8:1: Summary of Recorded Ground Gas Results**

| Borehole ID | Targeted Geology | Steady Flow (l/hr) | | Carbon Dioxide (%v/v) | | Methane (%v/v) | |
|---|---|---|---|---|---|---|---|
| | | min. | max. | min. | max. | min. | max. |
| WS01 | Glaciofluvial Deposits | <0.1 | 0.3 | 2.6 | 3.1 | <0.1 | <0.1 |
| WS02 | | <0.1 | <0.1 | 0.1 | 2.1 | <0.1 | <0.1 |
| WS03 | | 0.2 | 0.2 | 0.3 | 2.8 | <0.1 | <0.1 |
| WS04 | | <0.1 | 0.2 | 1.7 | 3.0 | <0.1 | <0.1 |
| WS05 | | <0.1 | 0.3 | 4.4 | 5.5 | <0.1 | <0.1 |

8.6 Atmospheric pressure was recorded at 1005mB during both monitoring visits, both falling over the preceding 12 hours. On this basis, the monitoring may have captured the worst-case gassing scenario at the site as generally, ground gas emissions tend to increase when atmospheric pressure falls rapidly.

8.7 Hydrogen sulphide and carbon monoxide concentrations were generally not recorded above the limit of detection of the equipment during the monitoring visits, with the exception of marginally elevated concentrations (1ppm) of hydrogen sulphide within WS04 and carbon monoxide within WS01 and WS02 during the second monitoring visit.

8.8 PID concentrations were recorded between <0.1ppm (the limit of detection of the equipment) and a maximum of 5.2ppm within WS05 on the first monitoring visit.

## Risk Assessment

8.9 CIRIA Report 665 "Assessing Risks Posed by Hazardous Ground Gases to Buildings" presents current best practice on the assessment of ground gases for commercial and residential buildings (with the exception of low rise traditional housing). The report presents a risk based approach based on gas screening levels which depend on both the concentration and emission rate of gas from the ground. Gas screening levels are calculated as follows:

$$Gas\ screening\ value\ (l/hr) = \frac{gas\ concentration\ (\%)\ X\ measured\ borehole\ flow\ rate\ (l/h)}{100}$$

8.10 Maximum gas screening levels of 0.0165l/hr were recorded, calculated using a gas concentration of 5.5% v/v and a maximum flow rate of 0.3l/hr giving a classification of CS1. However, the guidance indicates that consideration should be given to increasing to CS2 (Amber 1 NHBC class) where carbon dioxide concentrations exceed 5%, for which gas protection measures would be required.

8.11 On the basis of the limited data set and localised presence of peat, it is recommended that for initial budgeting purposes gas protection measures in accordance with CS2 should be allowed for but this could potentially be downgraded if the risk is assessed in more detail following a longer period of monitoring.

8.12 For low rise traditional housing with a clear vented underfloor void NHBC "Guidance on evaluation of development proposals on sites where methane and carbon Dioxide are present" (2007) has been referred to. The guidance also adopts an approach based on comparison of gas screening levels to generic traffic lights. The traffic lights relate to typical maximum concentrations and gas screening values with recommended gas protection measure for each category.

## Recommendations

8.12 Marginally elevated carbon dioxide concentrations (5.5% v/v) have only been recorded within one borehole (WS05) where peat was recorded within the Glaciofluvial Deposits. Given the localised nature, it may be possible to demonstrate that the majority of the site can be considered as a CS1/Green site with a more comprehensive monitoring data set.

8.14 It is recommended that additional ground gas monitoring be undertaken prior to development to confirm the gas classification for the site.

# 9. CONTAMINANT DISTRIBUTION AND HUMAN HEALTH RISK ASSESSMENT

## Introduction

9.1 Contamination data have been compared to Land Quality Management Suitable for Use Levels (LQM S4Uls) for a residential end use. The soil chemical laboratory results are presented within **Appendix 3**, with a summary presented as **Appendix 4**. The criteria includes reference to the LQM/CIEH S4ULs for Human Health Risk Assessment Copyright Land Quality Management Limited reproduced with permission; publication number S4UL3271.

9.2 The screening criteria have been developed with the following assumptions which have been changed from the CLEA default parameter set. Soil type is a sandy loam with an organic matter content of 1%. This is considered to be more representative of shallow Made Ground found on most brownfield sites than the CLEA default of 6% organic matter.

## Pathways

9.3 The intended final use of the site is unknown at the time of writing, so a conservative approach has been utilised. For the purpose of this assessment, the site is considered to be developed for residential end use therefore the key receptor is considered to be a female child in the first six years of life and screening criteria for residential with plant uptake have been adopted.

9.4 Exposure pathways considered in this assessment are presented in **Table 9:1**.

**Table 9:1: Residential Exposure Pathways**

| Source: | Shallow Soils | | | Deep Soils |
|---|---|---|---|---|
| Pathway | Residential housing with private gardens | Residential housing with communal landscaped areas | Residential housing with hardstanding areas | Residential housing |
| Ingestion of soil | ✓ | ✓ | × | × |
| Ingestion of site derived household dust | ✓ | ✓ | × | × |
| Ingestion of contaminated vegetables | ✓ | × | × | × |
| Ingestion of soil attached to vegetables | ✓ | × | × | × |
| Dermal contact with soil | ✓ | ✓ | × | × |
| Dermal contact with site derived household dust | ✓ | ✓ | × | × |
| Inhalation of fugitive soil dust | ✓ | ✓ | × | × |
| Inhalation of fugitive site derived household dust | ✓ | ✓ | × | × |

| Source: | Shallow Soils | | | Deep Soils |
|---|---|---|---|---|
| Inhalation of vapours outside | ✓ | ✓ | ✓ | ✓ |
| Inhalation of vapours inside | ✓ | ✓ | ✓ | ✓ |

## Results Summary

9.5 The results of soil chemical analysis have reported all contaminants either below their relevant screening criteria or the level of detection.

9.6 Generally low levels of heavy metals have been recorded in samples obtained from Topsoil, Made Ground, Alluvium and Glaciofluvial Deposits. Very low hydrocarbon concentrations (including a total TPH concentration of 58mg/kg against a screening level of 500mg/kg) were recorded within a sample of Made Ground from WS05 at 0.50m bgl. All PAHs, pesticides and herbicides were recorded below the level of detection.

9.7 Soil samples submitted for asbestos screening did not report any asbestos containing materials to be present. A suspected asbestos tile fragment obtained from a small stockpile adjacent to TP09 in the south of the site was submitted for identification, which was reported to comprise a hard/cement type material of chrysotile.

9.8 It is considered that the stockpile contains asbestos tiles, which will require removal from site prior to development. It is considered that any risk to groundworkers can be mitigated by following guidance presented within the Control of Asbestos Regulations 2012, adopting damping down of soils, appropriate PPE and maintaining good hygiene practices. Additionally, visual vigilance should be maintained throughout any groundworks. The location should also be marked on the site Health and Safety File, to be retained on site following the development.

9.9 The risk to future site users is considered to be negligible as the removal of all asbestos tiles from site will remove the potential exposure pathway.

# 10. CONTROLLED WATERS RISK ASSESSMENT

10.1 No groundwater or surface water testing has been undertaken as part of this assessment. However, soil leachability has been undertaken for a number of metals, the results of which are presented within **Appendix 3**.

10.2 The controlled waters assessment considers the potential impact of on-site contamination to pertinent controlled waters receptors identified at the site including:

- Secondary A Aquifer beneath the site within superficial deposits – Alluvium and Glaciofluvial Deposits;
- Principal Aquifer beneath the site within the bedrock geology – Wilmslow Sandstone Formation; and
- Newnes Brook.

## Pathways

10.3 Controlled water risk assessment has been undertaken through assessment of leachable concentrations of contaminants in soil referring to exposure pathways considered and referencing **Table 10:1**.

**Table 10:1: Controlled Water Exposure Pathways**

| Controlled Waters Exposure Pathway | Receptor |
|---|---|
| Leaching of soil contamination into recharge infiltration | ✓ |
| Vertical migration of impacted pore water through unsaturated zone into underlying aquifer | ✓ |
| Horizontal migration of groundwater through aquifer to off-site receptors | ✓ |

10.4 The site is underlain by Alluvium and Glaciofluvial Deposits (Secondary A Aquifers) and the Wilmslow Sandstone Formation (Principal Aquifer). Given the sensitivity of the underlying aquifer, it is considered appropriate to adopt environmental quality standards (EQS) for freshwater when assessing groundwater quality and soil leachate concentrations. Where EQS are not available, World Health Organisation Standards (WHO) and UK Drinking Water Standards (DWS) have been adopted as the relevant screening criteria.

## Soil Leachability

10.5 A summary of the soil leachate concentrations and adopted guideline concentrations are presented within **Appendix 5**. A summary of leachate exceedances is presented in **Table 10:2** below.

**Table 10:2: Summary of Soil Leachate Exceedances**

| Contaminant | Number of Samples | Range of Concentrations (µg/l) | Generic Screening Level (µg/l) | Number of Exceedances |
|---|---|---|---|---|
| Chromium III | 4 | 1.60 – 11 | 4.70 | 1 |
| Copper | 4 | 12 – 75 | 1.00 | 4 |

| Contaminant | Number of Samples | Range of Concentrations (µg/l) | Generic Screening Level (µg/l) | Number of Exceedances |
|---|---|---|---|---|
| Lead | 4 | 2.30 – 7.50 | 1.20 | 4 |
| Nickel | 4 | 4 – 13 | 4.00 | 3 |
| Zinc | 4 | 9.50 - 27 | 10.90 | 3 |

10.6 Elevated concentrations of chromium III, copper, lead, nickel and zinc have been reported across the site. All concentrations are within an order of magnitude of the screening level and as such are considered to be marginal exceedances. Additionally, development of the site will reduce surface water infiltration and therefore reduce leachate mobility and further reduce the risk to controlled waters. No further assessment is required.

# 11. ENVIRONMENTAL RISK ASSESSMENT

11.1 The preliminary risk assessment presented in **Section 4** has been updated based on the findings of the ground investigation. An updated conceptual site model is presented in **Table 11:1**.

**Table 11:1: Updated Conceptual Site Model**

| Source | Pathway | Receptor | Con | Prob | Risk | Mitigation/Investigation |
|---|---|---|---|---|---|---|
| **S1**: Marginally elevated carbon dioxide concentrations in the south of the site. | **P1**: Migration and accumulation of ground gasses in enclosed spaces leading to asphyxiation (carbon dioxide). | **R1**: Future site users | Md | Ul | L | Maximum gas screening levels of 0.0165l/hr were recorded, calculated using a gas concentration of 5.5% v/v and a maximum flow rate of 0.3l/hr giving a classification of CS2/ Amber 1, for which gas protection measures would be required.<br>Marginally elevated carbon dioxide concentrations (5.5% v/v) have been recorded within one borehole (WS05) in the south of the site, where peat was recorded within the Glaciofluvial Deposits. Given the localised nature, it may be possible to demonstrate that the majority of the site can be considered as a CS1/Green site with a more comprehensive monitoring data set.<br>The gas monitoring dataset is preliminary in nature and additional ground gas monitoring will need to be undertaken prior to development to confirm the gas classification for the site. |
| **S2:** Asbestos tiles at ground surface in south-western corner of the site. | **P2:** Direct contact, incidental ingestion and inhalation of particulates. | **R1**: Future site users | Mi | Ul | VL | A suspected asbestos tile fragment obtained from a small stockpile adjacent to TP09 in the south of the site was submitted for identification, which was reported to comprise a hard/cement type material of chrysotile.<br>It is considered that the stockpile contains asbestos tiles, which will require removal from site prior to development. It is considered that any risk to groundworkers can be mitigated by following guidance presented within the Control of Asbestos Regulations 2012, adopting damping down of soils, appropriate PPE and maintaining good hygiene practices. Additionally, visual vigilance should be maintained throughout any groundworks. The location should also be marked on the site Health and Safety File, to be retained on site following the development.<br>The risk to future site users is considered to be very low as the removal of all asbestos tiles from site will remove the potential exposure pathway. |
| | | **R2**: Construction workers or groundworkers | Md | Lw | M/L | |

VH = Very High, H = High, M = Moderate, M/L = Moderate/Low, L = Low, VL = Very Low

KEY: Sv = Severe, Md = Medium, Mi = Mild, Mr = Minor Hi = High, Li = Likely, Lw = Low Likelihood, Ul = Unlikely

**Pollutant Linkage Assessment Summary**

When considered in the context of the conceptual site model, the proposed development is considered to pose a **MODERATE/LOW** risk to human health. It is considered that the main driver for the risk rating for human health is the presence of a stockpile of asbestos tiles in the south-west of the site, which pose a risk to construction workers or groundworkers. These can be easily removed to reduce the risk.

| Source | Pathway | Receptor | Con | Prob | Risk | Mitigation/Investigation |
|---|---|---|---|---|---|---|
| A risk to controlled waters has not been identified at identified at the site. | | | | | | |

# 12. ENVIRONMENT LIABILITY ASSESSMENT

### Statutory Liability

12.1 Under statutory guidance for definition of contaminated land site may be classified into 4 categories. Categories 1 and 2 would meet the definition of contaminated land and categories 3 and 4 would not meet the definition. Sites assessed under planning would normally be expected to fall within Category 4 as a minimum standard, to allow for a suitable factor of safety should standards change in the future.

12.2 It is considered that the site would fall within Category 4 based on the limited contamination identified at the site.

12.3 The contaminated land regime has implications for those who cause or knowingly permit land to be contaminated, or who own or occupy land that is contaminated. Contaminated land is defined in Section 78A(2) of Part IIA of the Environmental Protection Act 1990 as:

a) *Significant harm is being caused or there is a significant possibility of such harm being caused; or*
b) *Pollution of controlled waters is being or is likely to be, caused*."

12.4 Harm is defined in Section 78(4) of the Environmental Protection Act 1990 as:

"Harm to the health of living organisms or other interference with ecological systems of which them form part and, in the case of man, includes harm to property."

12.5 Once an area of land has been identified as contaminated land, appropriate persons will be identified as being responsible for the cost of cleaning up the land by the enforcing authority. The appropriate person will be liable for all or part of the remediation of the land. Two classes of appropriate person have been identified:

- Class A appropriate persons are those who cause or knowingly permit the pollutants to be in, on or under the land.
- Class B appropriate persons are the owners(s) or occupier(s) of the land.

12.6 Where no Class A appropriate persons can be identified, then Class B appropriate persons may become liable.

12.7 Based on the information available regarding the site, the potential for Statutory Authority action based on "*pollution of controlled water*" or "*significant harm*" as defined by Part IIA of the Environmental Protection Act 1990 is considered to be **low.**

### Third Party Liability

12.8 Based on the information contained in this report, it is the opinion of BWB that the potential for legal action by surrounding landowners, based on the potential for contamination to migrate off-site, is considered to be **low** when considering the limited contamination identified at the site.

### Public Relations

12.9 The likelihood of public relations being tarnished due to contamination issues at the site are considered to be **low**.

# 13. WASTE MANAGEMENT

## Waste Classification

13.1 Soil samples have been characterised against hazardous waste criteria using Hazwasteonline. The results of the waste classification are presented in **Appendix 6**. The assessment indicates that the soils analysed are likely to be classified as non-hazardous. The waste classification assessment only applies to those soils that have been tested (not including the asbestos-containing stockpile). If other soils are to be disposed of off-site then further analysis may be required.

13.2 Asbestos has been found at the site within the stockpile in the south of the site. The presence of visible asbestos containing materials in waste or at concentrations exceeding 0.1% by weight will classify the waste as mixed and require disposal as hazardous waste irrespective of the chemical properties of the waste.

13.3 Should any soils require disposal off site an assessment of waste classification of the soils for disposal should be made by a competent person. Further chemical analysis may be required to fully characterise waste soils for disposal to landfill or re-use off site. WAC analysis may be required for disposal of soils as inert or hazardous.

# 14. CONCLUSION AND RECOMMENDATIONS

14.1 The ground investigation has identified ground conditions at the site to generally comprise Topsoil over granular Glaciofluvial Deposits, with Made Ground encountered in the south of the site and cohesive Alluvium encountered overlying the Glaciofluvial Deposits in the south-west. Alluvium is likely to be present along the length of Newnes Brook, along the southern and eastern boundaries. The bedrock geology of the Wilmslow Sandstone Formation was not encountered as part of this investigation.

14.2 Groundwater has been encountered within the granular Glaciofluvial Deposits within the majority of exploratory holes, with standing water levels recorded between 1.27m and 3.29m bgl, at around 87.50m AOD. In addition to shallow groundwater, excavations are noted to have displayed poor stability within granular deposits.

14.3 Ground gas monitoring has identified low concentrations of carbon dioxide (up to 5.5% v/v), which has given the site a classification of CS2 or Amber 1. Marginally elevated concentrations above 5% v/v have been recorded within one borehole in the south of the site, where peat was recorded within the Glaciofluvial Deposits. Given the localised nature, it may be possible to demonstrate that the majority of the site can be considered as a CS1/Green site with a more comprehensive monitoring data set.

14.4 Soil chemical analysis has not reported any contaminants as exceeding their guideline screening criteria.

14.5 Asbestos tiles have been identified in a stockpile in the south of the site.

14.6 Soil leachate analysis has reported a number of heavy metals as exceeding their guideline screening levels. However, all concentrations are within an order of magnitude of their respective screening level and are considered to be marginal in nature. Additionally, development of the site will reduce surface water infiltration and therefore reduce leachate mobility and further reduce the risk to controlled waters.

14.7 Based on the encountered ground conditions, the granular Glaciofluvial Deposits are likely to be suitable founding stratum, although localised low strength soils have been encountered where very loose sands and gravels have been recorded alongside groundwater strikes, potentially indicating blowing sands to be present

14.8 Based on the encountered ground conditions, the granular Glaciofluvial Deposits are likely to be suitable founding stratum, although localised low strength soils have been encountered where very loose sands and gravels have been recorded alongside groundwater strikes, potentially indicating blowing sands to be present. As such, once a detailed masterplan is available, additional ground investigation will be required to confirm a foundation solution and/or any zoning that may be required.

14.9 In accordance with the recommendations of BRE Special Digest 1, 'Concrete in Aggressive Ground' 2005, the conditions of the soils at the site would be classified as Design Sulphate Class DS-1 and ACEC Class AC-1.

## Recommendations

14.10 Due to the localised nature of the marginally elevated carbon dioxide concentrations, it is recommended that additional ground gas monitoring be undertaken prior to development to confirm the gas classification for the site.

14.11 Due to the localised presence of low strength soils, once a detailed masterplan is available, additional ground investigation will be required to confirm a foundation solution and/or any zoning that may be required.

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# *APPENDICES*

# Appendix 1: Proposed Masterplan