

Our ref: 8512si-RevA

Site Investigation Report

for land at

Pottery Gardens

Cheadle

Planning Application No.:
SMD/2018/0180

Planning Reference Location:
Land to the East of Froghall Road and
North of Ayr Road and Cheltenham
Avenue, Cheadle

For: Persimmon Homes North West
1st Floor East
Chadwick House
Birchwood Park
Warrington
WA3 6AE

Date of Report: 17th March 2025
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Site Investigation Report for Land at Pottery Gardens, Cheadle

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1.0 Introduction

This report discusses the findings of the site investigation for a proposed residential development on land at Pottery Gardens, Cheadle. The site is proposed for residential development by our client Persimmon Homes North West, 1st Floor East, Chadwick House, Birchwood Park, Warrington. WA3 6AE.

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The accuracy of map extracts cannot be guaranteed and it should be recognised that different conditions on /adjacent the site may have existed between and subsequent to the various map surveys. Historical map extracts are produced as an appendix report by Groundsure under licence from Ordnance Survey. Coopers can reproduce and use these extracts of historical maps in this report under Ordnance Survey Licence No. AL100005579.

Where data supplied by others, including that from previous investigations, has been used it has been assumed that the information is correct. No responsibility can be accepted by Coopers for inaccuracies within the data supplied by others. We would advise that our client makes their own detailed enquiries to the Local Authorities to determine any additional planning constraints which may be applied to this site and which have not been identified within this report.

The results of the exploratory holes explorations are based upon the facts established from observations and field tests. It should be recognised that strata may vary considerably from point to point and the groundwater regime may be influenced by seasonal or other factors. While every attempt is made to assess the likelihood and extent of such variations, conditions may nevertheless exist which are undisclosed by this investigation.

This report has been prepared in accordance with the Building Regulations Part C (2004) and complies with the requirements associated with the planning guidance. This report should address the conditions placed within the planning conditions regarding the ground conditions and contamination. This report has been prepared in accordance with the requirements of the NHBC Standards, Chapter 4.1. The scope of this report complies with the criteria for certification under the Initial Assessment including the Desk Study (D1), the Walkover Survey (D2), and the Basic Investigation (D4). This report constitutes a Phase II report in accordance with LCMR. The report is also prepared in accordance with BS10175: 2011+A2:2017, and complies with Phase 2 (Exploratory Investigation) investigation.

The further actions deemed necessary to be completed prior to development of the proposed site for residential development have been listed in Section 26 of this report. The full extent of further actions may not be limited to those issues stated and, during the course of the development, additional further actions may be required.

The report should be read in its entirety, including all associated drawings and appendices. Coopers cannot be held responsible for any misinterpretations arising from the use of extracts that are taken out of context.

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Arboricultural Survey and advice on arboricultural issues are considered to be outside the scope of this report except for their effect on the foundations to the proposed buildings. Where identification of any species is made, especially invasive plants such as Japanese Knotweed, Himalayan Balsam or Giant Hogweed, this should only be considered as a preliminary assessment and subject to confirmation by a professional Arboriculturist. Coopers take no responsibility for failing to identify, or the incorrect identification of, any tree or plant species on site.

This report is prepared and written in the context of the purposes stated above and should not be used in a different context. Furthermore, new information, improved practices and legislation may necessitate an alteration to this report in whole or in part after its submission. Therefore, with any change in circumstances or after the expiry of one year from the date of this Report, the report should be referred to Coopers for reappraisal.

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2.0 Executive Summary

Grid Reference	SK 015 444 (Refer to Drawing No. 8512/L1 in Appendix 15).
Approximate Area	6.76 ha (16.7 acres)
Development Proposals (Section 3)	The proposed development forms Phase 2 of an adjacent development, comprising 134 No. residential dwellings, with associated private gardens, garages, parking bays, access roads, public open space with a balancing pond and soft landscaping areas. The development includes a combination of traditional detached, semi-detached and mews, 1 and 2 storey residential houses.
Site Investigation Data (Appendices 2 to 6 & 13)	Coopers supervised the excavation of 10 No. machine dug trial pits to supplement those completed in an earlier site investigation by E3P. Coopers also supervised the drilling 5 No. small diameter boreholes and installation with monitoring wells with subsequent ground gas monitoring on 3 No. occasions to date. Infiltration testing was also completed by Coopers in 1 No. location.
Site Description (Section 5)	The site consisted of 2 No. agricultural fields, bounded by further agricultural land, residential housing, a caravan park and a brook. 4 No. coal mineshafts lie within the vicinity of the site
Site History (Section 6)	The site has remained as 2 No. fields with a former tramway on the southern boundary now used as a footpath. 3 No. coal mine shafts were recorded to the west of the site boundary on historical mapping.
Hazardous Installations and Development Constraints (Section 7)	No identified hazardous installations or significant development constraints.
Utility Locations (Section 7.0)	High voltage below ground electricity cable crossing the site.
Geology, Hydrology & Hydrogeology (Section 8)	Drift – Alluvium along eastern site boundary, Glacial Till across majority of site. Drift absent between the Alluvium and the Glacial Till along the southeastern site boundary, along the northeastern site boundary and in the far north of the site. Bedrock – Pennine Lower Coal Measures (interbedded mudstone, siltstone and sandstone, with coal seams). One coal seam inferred to outcrop in the far north of the site. Geological Faults – No faults crossing the site, but numerous faults recorded in the vicinity of the site, the nearest being 35m to the east, dipping to the west. Groundwater – Th Glacial Till is a “Secondary Aquifer – undifferentiated”, the Alluvium and bedrock are “Secondary (A) Aquifers”. The site is not located within a groundwater source protection zone. 2 No. potable groundwater abstraction wells approximately 820m to the southwest of Phase 1 and 2 of the development. Hydrology – 1 No. surface water feature flowing along the south eastern site boundary, named Cecilly Brook. No surface water abstractions within 2km of the site. 2 discharge consents were recorded within 500m of the site relating to the discharge of domestic sewage. Compressible Ground and Subsidence Hazards – a negligible to low risk was recorded from ground dissolution, landslides, running sand, shrinking and swelling clays. There was a moderate potential risk posed by compressible ground.
Environmental, Archaeological, Ecological and Conservation Issues (Section 7)	2 No. Local Nature Reserves were recorded within 350m and 440m of the site boundary to the south and southeast, but there were no further records of environmental, ecological or archaeological protected sites within 500m of the proposed development. However, the former tramway following the southern boundary was deemed to be of archaeological interest.
Coal Mining and Brine Extraction (Section 9)	Brine Subsidence – The site is not within a zone of potential impact from brine subsidence. Coal Mining – The site lies within a defined coal mining reporting area. The northern tip and southern boundary of the site were recorded as being in a development high risk area. The development high risk area in the north related to the outcrop of the coal seam, dipping in a northerly direction with recorded coal workings and an extraction thickness of 860mm, to the north and northwest of the proposed development site, this recorded in excess of 48m depth. A seam was recorded below the southern area of the site, with a potential risk of unrecorded coal workings less than 30m depth. Site investigation found no coal seams within 30m depth in the south. An intact coal seam, 100mm thick, was encountered at 19.1m depth in the north. A cola mine risk assessment concluded that there was an adequate thickness of bedrock to remove the risk of ground instability. There are 3 No. mine shafts within close 60m and 85m to the west of the Phase 2 site boundary one 15m east of the site boundary.
Radon (Section 10)	The site is within an area where less than 1% of residential properties have radon levels above the action level. No radon mitigation measures are required for new buildings.

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Ground Conditions (Section 12)	Topsoil/madeground (similar to topsoil) across the general site – No topsoil only madeground (similar to topsoil) encountered across the site above drift, generally 0.3m/0.4m deep, but ranged between 0.2m and 0.5m. This was slightly sandy, slightly gravelly, silty clay, the gravel including natural lithologies and a very low proportion of brick and ceramic fragments. Madeground – a reworked natural clay where land drains were encountered. Natural Drift Strata – Generally glacial clay, in the main slightly sandy, slightly gravelly and silty, the gravel including sandstone, siltstone, mudstone and occasional coal. Locally the sand content increased to a moderate proportion. Localised bands of coal were also recorded within the clay in trial pits. The clay tended to be between firm and very stiff, providing equivalent bearing capacities between 102.8kPa and 376.93kPa, but locally, this was soft or soft to firm at depths up to approximately 1.5m bgl, providing equivalent bearing capacities of only 65.11kPa to 82.24kPa. The overall thickness of the clay strata was proven to be between 1.2m and at least 3.25m. A clayey silty sand was recorded in two trial pits, this being above the clay. Gravel was also recorded in three trial pits, being sandy in two locations and clayey in the third. The gravel was encountered at variable depths above and below the clay strata. Hardstanding and land drains – no hardstanding encountered. Land drains recorded in two trial pits. Bedrock – encountered between 1.2m and 3.1m bgl, this tending to be a very weak, weathered sandstone. SPT tests in the bedrock reached refusal. Groundwater – seepages were recorded, these generally being slight and encountered at depths between 0.9m and 2.6m bgl, at the head of the bedrock strata or in the clay immediately above the head of the bedrock. Slight accumulations of groundwater were recorded in only two exploratory holes. Visual and olfactory evidence of contamination - none encountered.
Contamination and Waste (Sections 13 & 16)	Preliminary Conceptual Model The majority of the site has been greenfield land, with madeground (similar to topsoil) on the site and a former tramway along the southern site boundary in the POS. The madeground (similar to topsoil) may contain slightly elevated concentrations of inorganic contaminants, speciated PAH (16) compounds and asbestos fibres, which may pose a negligible to very low risk to future residents. TPH compounds which may have been derived from the use of the tramway were considered likely to be present in limited concentrations in the heavier TPH ranges, which may pose a negligible risk to the future site users in the POS. TPH compounds potentially present around the offsite former coal shafts are likely to have a negligible potential to have migrated onto site posing a negligible risk to the development. Potential leachates of inorganic contaminants and PAH compounds from the madeground (similar to topsoil) and limited heavier range TPH compounds in the tramway are considered to pose a negligible to very low risk to Cecilly Brook and the underlying Secondary A Aquifer within the bedrock. Contamination Testing – None of the madeground (similar to topsoil), and natural clay and sand strata samples were reported to contain concentrations of determinands in excess of the available Tier 1 Threshold values for human health and no asbestos fibres were reported. One sample of madeground (similar to topsoil) did contain slightly elevated concentrations of copper and zinc above the phytotoxic threshold values. The majority of the EQS values for metals were not exceeded by the leachate concentrations. However, exceedances were reported for copper, lead and zinc, generic EQS values relating to bioavailability. Revised Conceptual Model – The chemical analysis has confirmed that the soils present on site pose a negligible risk to human health. Given the mean concentrations of copper and zinc in madeground (similar to topsoil) and no evidence of poor vegetation growth the risk to plant growth, the risk to plant growth is considered to be negligible to very low. A qualitative risk assessment concluded that the potential for leachates to be derived from the madeground (similar to topsoil) would not pose a significant risk to the controlled waters. Waste – Reuse of madeground (similar to topsoil) and imported natural materials transferred directly from other development sites would likely require a Material Management Plan registered with CL:AIRE by a Qualified Person, depending on the volume to be reused. Soil Disposal – Should soil disposal be required the majority of the soils would likely be designated as inert or non-hazardous waste. Potable Water – Potable water supply pipelines are expected to be standard polyethylene pipes (no volatile or mobile contaminants).
Landfill Sites & Ground Gases (Section 14)	No current or historical landfill site within 250m and no significant madeground on site. Ground gas monitoring undertaken to assess the moderate to high risk of ground gas emissions potential due to the potential presence of unrecorded shallow coal mine workings in the south and the close proximity of a coal mine shaft to the east. 3 No. monitoring visits to date have not identified any significant methane or carbon dioxide concentrations. Spurious carbon monoxide concentrations were recorded on the first visit considered to relate to the oxidation of carbonaceous matter in the clay. This will be reviewed following completion of the ground gas monitoring. To date it is likely that no ground gas protection measures will be required.

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Remediation and validation (Section 15)	No remediation envisaged. Validation would be required by a geo-environmental engineer of any imported soils, with chemical analysis required.
Sub-Soil Classification (Section 17)	<u>Concrete Classification (Based on BRE Special Digest 1 (2005))</u> Natural clay – DS-1, AC-1s, DC-1 Natural sand – DS-1, AC-1, DC-1 Natural gravel (assumed) - DS-1, AC-1, DC-1 <u>Shrinkage Potential</u> Clays – Medium Shrinkage Potential
Trees (Section 18)	Hedges and mature/semi mature trees noted lining the site and internal field boundaries with potential influence on foundations. 1 No. TPO was recorded on the eastern site boundary.
Ground Floor Slabs (Section 19)	Based upon our client's preferred floor slab construction plots are more likely to be constructed with a suspended cast in situ floor slab, with precast (block and beam) floor slabs used where plots are in the zone of tree influence with heave precautions required.
Anticipated Foundations (Section 20, Appendix 15)	Foundation Types The proposed foundation types are recorded on Coopers Drawing No. 8512/Fd01&02RevA. The main items influencing the foundation types will be tree influence, soft clays and bedrock depth. Foundation types based on construction from proposed ground level include: • Traditional strip foundations in clay strata, up to 1.2m deep at time of excavation. • Deep traditional strip foundations • Mass concrete trenchfill foundations (with and without heave precautions), typically up to 2.5m at time of excavation. • Piled foundations with associated ground beams and heave precautions where depth to suitable, moisture stable bearing strata >2.5m at time of excavation. Piles assumed to be anchored into shallow bedrock. Precast concrete driven piles unlikely to be suitable.
Dewatering and Trench Side Stability (Sections 21 & 22)	Trench Stability – Natural clays, sands and gravels expected to remain stable in the short term but may become unstable after being left open over longer periods of time. The sands and gravels may become unstable during or shortly after excavation. Dewatering – Service/drainage trenches may require dewatering locally with groundwater accumulation noted at the base of the trial pits in two locations. The extent of dewatering required will vary seasonally.
Potential Infiltration (Section 23)	Infiltration testing in the proposed balancing pond location confirmed that the clay on site will not be suitable for infiltration drainage systems. Infiltration systems would not be geotechnically suitable due to the shrink-swell behaviour associated with the clay.
Outline Summary of Earthworks Proposals (Section 24)	Following completion of cut and fill models a review should be undertaken to determine any requirements for a geotechnical design statement and earthworks specification to comply with NHBC Standards, Chapter 4.6.
Road Sub-Grade (Section 25)	The anticipated roads and car parking sub-grade materials are likely to comprise generally natural cohesive strata, with localised sand. Anticipated CBR values of 2.5-5.0% in cohesive strata and >5% in granular strata. It is estimated the loose to medium dense sand strata would provide a CBR of between 5% and 10%. Testing of formation recommended at time of construction.
Further Actions (Section 26)	Further action which Coopers consider will be required to progress the development status could include, but not necessarily be limited to: - • It had been recommended that any geotechnical test pits required along the former tramway following the southern site boundary should be monitored by an archaeologist and a geophysical survey should be conducted to locate the line of the tramway. • Further investigation may be required to assess the capabilities of laying the trenches for the sewers and potentially shallower services within the bedrock. • Submit this site investigation report to Staffordshire Council in support of the planning application and to the NHBC for approval. • An Earthworks Strategy Report may be required in respect of the cut and fill process on site, subject to finalised external works proposals. • If not already completed, undertake an invasive plant survey and an ecological survey concerning protected species if recommended by a specialist contractor. • Due to the presence of services within and adjacent to the site, consultations should be held with service providers regarding plans to adopt, divert, or abandon the services. It would be prudent to obtain a survey of all drains, manholes and subterranean structures, if present, to confirm their line, depth and condition prior to undertaking any works.

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Further Actions (Section 26) Continued ...	• Cable percussive boreholes and potentially rotary boreholes to determine pile designs, where pile foundations are required. • Completion of the ground gas monitoring and risk assessment for approval by the Local Authority and NHBC. • Should the direct transfer of subsoil or topsoil be required to the site, or reuse of site won made ground (similar to topsoil), this would require the application of either a U1 exemption or an MMP, depending on the volumes to be imported/reused. If surplus strata require offsite removal by direct transfer to another development site, they will require testing to confirm suitability for the intended end use at the receiving site. Where strata are intended for landfill they may require testing for Waste Acceptance Criteria (WAC).
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3.0 Basis of Assessments

The proposed development forms Phase 2 of an adjacent development to the west, known as Ayr Road, Cheadle. For the purposes of this report, Phase 2 is to be referred to as Pottery Gardens, Cheadle.

Phase 2 of the proposed development covers an area of 6.76 ha (16.7 acres) and comprises of 134 No. residential dwellings, with associated private gardens, garages, parking bays, access roads, public open space with a balancing pond and soft landscaping areas. The development includes a combination of traditional detached, semi-detached and mews residential houses 1 and 2 storeys in height. The proposed development layout is shown on the Persimmon Homes North West Planning Layout Drawing No. ARCH/PL/PH2 RevW presented in Appendix 15. It is assumed that all materials and workmanship will comply with the Building Regulations and the NHBC Standards.

Coopers were provided with previous site investigations pertinent to this investigation. Reference has been made to these reports for pertinent data to the interpretation in this report in the forthcoming sections.

- BWB – “Phase I Geo-environmental Desk Study. Land North of Cheadle. Froghall Road, Cheadle”. Report No. NTE2155/01/V1, dated October 2014. (Report refers to the whole of Phase 1 and Phase 2). This referenced previous investigation reports which covered the majority of Phase 1 and Phase 2 of the development to varying degrees but excluded the northeastern section of the development.
- E3P – “Phase I and Phase II Geo-environmental Site Assessment. Land off Ayr Road, Cheadle, Stoke-on-Trent”. Report No. 11-156-r1, dated July 2016. (Report refers to Phase 1 and the southwestern area of Phase 2).
- E3P – “Preliminary Site Investigation, Ayr Road, Cheadle, Phase 2”. Letter Report No. 11-156-L1, dated 28th November 2017. (Report refers to the north and southeastern area of Phase 2).
- E3P – “Coal Mining Desk Based Assessment. Land off Ayr Road (Phase 2), Cheadle, Stoke-on-Trent”. Report No. 11-156-L3, dated June 2018.
- Coopers – “Outline Proposals for Treatment of Mine Shaft at ‘Pottery Gardens – Phase 2’, Ayr Road, Cheadle”, Letter Report No. 8512PHNW250203L, dated 3rd February 2025.

4.0 Site Location

The proposed site was located on the northern periphery of Cheadle in Staffordshire, approximately 13.5km to the east of Stoke-on-Trent. The site was centred at National Grid Reference No. SK 015 444, as shown on Drawing No. 8512/L1 in Appendix 15. It was bounded by residential housing and a static caravan park adjacent to the northern end of the western site boundary and residential housing adjacent to the southern site boundary, and agricultural land around the remainder of the site. Land to the southwest (Phase 1) was under development with residential housing.

The topography of the site reduces in elevation from northwest to southeast, the site being at approximately 170.0m above Ordnance Datum (aOD) in the north and 155.5m aOD in the south.

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5.0 Summary of Site Description

The site was in agricultural use at the time of the site walk over by BWB, the fields being grazed by cattle. A ditchline followed the northeastern site boundary. A stream followed the southeastern site boundary.

6.0 Summary of Site History

The site has remained as two fields from the first available historical mapping dated 1880, until the pre-development phase, with a stream (Cecilly Brook) following the southeastern site boundary. A footpath was shown to be following the internal field boundary in 1954. A footpath was recorded more recently shown to be following an embankment along the southern site boundary, this previously having been a tramway in the 1800s in association with mining beyond the site boundary. An archaeological survey identified that this potentially dated back to the 18th Century, connecting to an offsite copper works (location unknown).

A disused coal shaft was recorded on Phase 1 of the development, approximately 85m to the west of Phase 2, with a second disused coal shaft on Phase 1, approximately 250m from Phase 2. A third disused coal shaft was recorded approximately 60m to the southwest of Phase 2 site boundary. The remainder of the surrounding land use was agricultural with occasional farm buildings, until the adjacent housing was developed from the 1970s, including over the third mineshaft location, and a caravan park was developed in the 1950s.

7.0 Summary of Potential Development Constraints Due to Surrounding Land Uses

The Groundsure Report commissioned by BWB, dated 7th October 2014, was reviewed for potential hazardous installations within 500m of the proposed development. Reference should be made to the BWB Report No. NTE2155/01/V1 for further details.

The report did not record any hazardous installations within 500m of the proposed development.

A haulage company was located approximately 350m to the west of the proposed development site. No fuel stations were recorded within 500m of the site.

No landfill sites or waste management facilities were recorded within 250m of the development site.

2 No. records of uncontrolled releases of an unnamed List 1 pollutant to the River Tean, 200m to the north of the site, occurred in May 2000. These releases caused a significant impact to the water course at the time.

There were no records of sites determined as contaminated land in accordance with Part 2A of the Environmental Protection act 1990.

Below ground high voltage electric power cables are known to cross the north of the site from east to west, the centre of the site north to south and in the southwest of the site, starting in the south, traversing north and then offsite to the west (see Drawing No. 8512/01).

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2 No. Local Nature Reserves were recorded within 350m and 440m of the site boundary to the south and southeast, but there were no further records of environmental, ecological or archaeological protected sites within 500m of the proposed development. However, the former tramway following the southern boundary (discussed in Section 6) was deemed to be of archaeological interest. Any remaining sleepers were to remain undisturbed and it had been recommended that any geotechnical test pits required should be monitored by an archaeologist and a geophysical survey should be conducted to locate the line of the tramway. It was noted that based on the current planning layout this will not impact on any of the plots.

It was recognised that Groundsure Report was 10 years old, such that changes may have occurred. However, given the location of the proposed development, it was considered that there would have been no significant changes to land uses which may impose constraints on the development.

8.0 Geology, Hydrology & Hydrogeology

8.1 General

The following section is based upon desk study information only. For details of the findings of the ground investigation and ground conditions refer to Section 12. The following sources of information have been assessed:

- BGS - 1:10,560 scale National Grid Series, Sheet SK04SW, 1985 edition, accessed through BGS Maps Portal
- British Geological Survey (BGS) - 1:50,000 scale maps (website)
- Groundsure Report presented in BWB report No. NTE2155/01/V1

8.2 Madeground

Madeground would not be expected on site.

8.3 Drift

The geological maps define the presence of Alluvium along the south eastern site boundary associated with Cecilly Brook. This is likely to comprise various strata of clay, silt, sand and gravel. Glacial Till was noted across the majority of the remainder of the site and immediately beyond the site boundary. This would be expected to generally comprise clay with pockets and bands of sand. Drift was shown to be absent between the Alluvium and the Glacial Till along the southeastern site boundary, along the northeastern site boundary and in the far north of the site, with these ground conditions extending generally beyond the site boundary and the Glacial Till immediately beyond the boundary.

The BWB Report No. NTE2155/01/V1 referenced previous investigation on the Phase 1 and Phase 2 site, which had identified topsoil overlying soft to stiff clay to bedrock, implied to be encountered within some trial pits.

8.4 Bedrock

Geological mapping records the bedrock underlying the site to be the Pennine Lower Coal Measures comprised of interbedded mudstone, siltstone and sandstone, with coal seams. One seam was inferred to outcrop in the far north of the site. Previous site investigation referenced in the BWB Report No. NTE2155/01/V1 with no specific locations of exploratory holes provided, encountered weathered sandstone, siltstone and mudstone at between 1m and 2.5m below ground level (bgl). One rotary borehole recorded a thin band of coal at 9.0m to 9.1m bgl. "Occasional bands/pockets of shaley, friable or interbedded coal" was recorded in some trial pits.

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8.5 **Geological Faults**

No faults were identified crossing the site, but numerous faults were recorded in the vicinity of the site, the nearest being 35m to the east, dipping to the west.

8.6 **Groundwater Vulnerability and Hydrogeology**

The alluvium and bedrock geology was defined as “Secondary (A) Aquifer”, described as “*permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.*”

The Glacial Till was defined at the time of the BWB Report as being unproductive, now termed as a “Secondary Aquifer – Undifferentiated Layer.”

The site was not located within a recorded Groundwater Source Protection Zone.

The Groundsure Report within the BWB Report recorded 2 No. potable groundwater abstraction wells approximately 820m to the southwest of the combined Phase 1 and Phase 2 development site.

1 No. current discharge consents to groundwater was recorded relating to domestic sewage outfall, 319m to the southeast of the site.

8.7 **Hydrology**

Cecilly Brook follows the southeastern site boundary in a south westerly direction. An unnamed brook flows in a south easterly direction within 350m of the site, the unnamed brook being a tributary of Cecilly Brook 450m to the south of the site.

There were no surface water abstractions recorded within 2km of Phase 2 of the site development.

2 No. current discharge consents relating to domestic sewage outfall were recorded to surface waters within 500m of the site, the receiving water body being Cecilly Brook.

8.8 **Subsidence Hazards**

The Groundsure Report within the BWB Report noted that the site was designated as a negligible to low risk from ground dissolution, landslides, running sand, shrinking and swelling clays. There was a moderate potential risk posed by compressible ground. These designations are generic, based upon regional mapping, without considering the site specific conditions, with aspects associated with geotechnical conditions and risks on the site detailed within the subsequent sections of this report.

9.0 **Mining and Brine Extraction**

9.1 **Brine Subsidence**

The Groundsure Report included within the BWB Report No. NTE2155/01/V1 defines the site as being outside of a zone of historical brine abstraction, with no soluble rocks identified. The site is therefore not at risk of brine subsidence.

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9.2 **Coal Mining Reports**

The site lies within a defined coal mining reporting area. A coal mine risk assessment was completed by E3P, presented within Report Nos. 11-156-r1 and 11-156-L3, which should be referred to for the details. A Ground Stability Non-residential Report was commissioned at a later date for the site as presented in Appendix 1.

The northern tip and southern boundary of the site were recorded as being in a development high risk area. The development high risk area in the north related to the outcrop of the coal seam, named the King Seam, referenced in Section 9.4. This was indicated to be dipping in a northerly direction with recorded coal workings and an extraction thickness of 860mm, to the north and northwest of the proposed development site. The seam was recorded to be present at depths in excess of 48m.

The Coal Authority nor the BGS mapping defined the presence of a coal outcrop in the south of the site, but archives held by the Coal Authority indicated the presence of the Diamond Seam beneath the southern area of the site. Therefore, the desk study identified that there was a potential risk of unrecorded coal workings less than 30m depth, which may result in subsidence at the surface. It was concluded further investigation was required. The investigation targeted the south of the site, with 2 No. rotary boreholes drilled to 30m bgl, with no coal seams encountered in 2 No. of the boreholes. 1 No. further rotary borehole targeted the far north of the site and the mapped coal seam subcropping across the site. An intact coal seam, 100mm thick, was encountered at 19.1m bgl in this borehole. Based on the thickness of the seam and the overlying rock, the report concluded that there is an adequate thickness of bedrock to remove the risk of ground instability.

There are two mine shafts within close proximity of the Phase 2 development, one 85m west of the Phase 2 site boundary (Ref. 401344-003) believed to be an air shaft which has been capped and the other located 15m east of the site boundary (Ref: 401344-006), not identified on the historical mapping. Coopers have assessed the risk posed by the shaft Ref. 401344-003, located on a section of the proposed development site to be redeveloped with a school. This was reported in letter Report No. 8512PHNW250203L. The shaft is known to be approximately 50m deep with standing water recorded to be approximately 5m below the surface level. This concluded that further treatment of this shaft, including filling, grouting and capping to mitigate against future disturbance will be required following further investigation works. The design of these works are to be proposed by Coopers.

10.0 Radon

- 10.1 The Groundsure Report included within the BWB Report No. NTE2155/01/V1 indicated that the site lies within an area where less than 1% of residential properties are affected by radon above the radon action level. The report was dated 2014 and hence predates the updated dataset from the BGS and UKHSA in December 2022. Coopers reviewed the interactive mapping on the web page: <https://www.ukradon.org/information/ukmaps>. This confirmed that there have been no significant changes to the categorisation, with the site still being in an area where less than 1% of residential properties are affected by radon above the action level, as shown in Figure 1. Therefore, no mitigation measures are required for the whole site in respect of radon.

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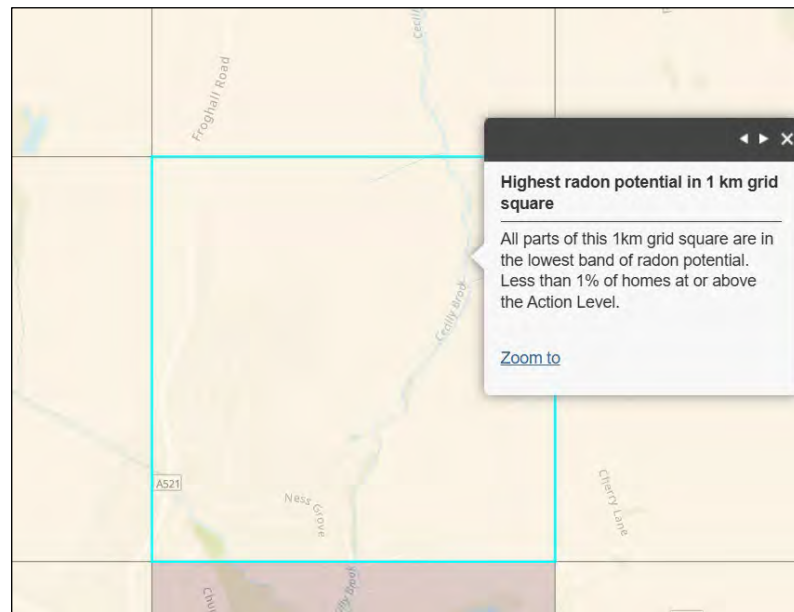


Figure 1: Extract from ukradon.org, showing radon potential for the site

11.0 Ground Investigation Methodology

11.1 General Scope

Coopers were commissioned by Persimmon Homes North West to undertake a site investigation to supplement the previous site investigation, to assess the potential geotechnical and environmental risks and constraints across the general site. It was also required to support the ground gas risk assessment.

11.2 Previous Site Investigation

E3P undertook site investigation in three stages across Phase 2 of the proposed development site. The first stage completed on 18th April to 20th April 2016 was undertaken primarily to target Phase 1 of the development, the boundary extending onto the southwestern area of Phase 2. 3 No. trial pits (TP109 to TP111), excavated to between 2.2m and 2.4m bgl and 1 No. small diameter borehole (WS113) was completed on the Phase 2 site, drilled to 3.45m bgl.

No samples were selected from these exploratory holes for chemical or geotechnical analysis.

The second stage of the investigation was completed on 5th October 2017, across Phase 2 of the proposed development and the area of the proposed school, adjacent to the west of Phase 2, excluded from this assessment. 15 No. trial pits (TP201 to TP203 and TP206 to TP217) were excavated to depths between 0.9m and 2.5m. Soil samples were selected for chemical analysis at i2 Analytical Limited, details of which are discussed in Section 13.7.

11.3 Coopers Investigation Design

Coopers supervised the excavation of 8 No. machine dug trial pits (TP301 to TP308) on 8th January 2025 and 2 No. additional trial pits (TP501 and TP502) on 29th January 2025, using a 9 tonne tracked excavator. 1 No. infiltration test pit was also excavated and 5 No. small diameter boreholes were drilled across the site using a drive-in windowless sampler rig on 29th January 2025.

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The trial pits were excavated to between 1.6m and 2.9m depth, the majority being approximately 3.0m deep. These were required to:

- Confirm ground conditions previously encountered during the E3P investigation to aid the foundation design; and
- permit additional soil sampling for chemical and geotechnical analysis.

The small diameter boreholes were drilled to depths between 2.02m and 3.45m and installed with monitoring wells to depths between 1.6m and 3m depending on the depth attainable in relation to the ground conditions. These were spaced across the site to enable ground gas monitoring to assess the potential risk posed by the underlying shallow coal seams and adjacent mine shafts.

The locations of the exploratory holes are depicted on Drawing No. 8512/01, presented in Appendix 15.

Copies of E3P and Coopers exploratory hole logs are presented in Appendices 2 to 6.

11.4 **In-situ Testing**

Hand shear vane tests were undertaken by E3P and Coopers on recovered samples of cohesive strata from the trial pits. Standard Penetration Test (SPTs) were completed in the small diameter boreholes completed by E3P and Coopers.

11.5 **Sampling**

Coopers selected soil samples, retrieved from the trial pits and small diameter boreholes for chemical analysis in order to supplement this previously taken by E3P and aid in the characterisation of the made ground (similar to topsoil) and natural soil strata. The samples were submitted to Normec DETS, an MCERTS accredited laboratory, for chemical analysis. All samples analysed were stored in appropriate containers supplied by the laboratory.

The chemical analysis appropriate to the environmental risk assessment was scheduled as discussed in Section 13.7. Samples were also scheduled for analysis applicable to the assessment of sulphate attack on concrete, as discussed in Section 18.

Subsoil samples were selected for geotechnical testing, as discussed in Section 17, these being submitted to Murray Rix.

Copies of the chemical analysis results are provided in Appendix 7 and the geotechnical testing in Appendix 8.

12.0 **Ground Conditions Encountered**

12.1 **General**

The data collated from the exploratory holes undertaken by E3P and Coopers was used to define the ground conditions across the site. The locations of the exploratory holes are illustrated on Drawing No. 8512/01, in Appendix 15. Coopers' exploratory hole logs are presented in Appendices 5 and 6.

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12.2 **Topsoil/Madeground (Similar to Topsoil)**

No natural topsoil was encountered on site. Madeground (similar to topsoil) was identified across the whole site at depths of 0.2m to 0.5m in depth, but generally at 0.3m and 0.4m depth. The madeground (similar to topsoil) was recorded to be a slightly sandy, slightly gravelly, silty clay, the gravel comprised of natural lithologies of sandstone, occasional siltstone and coal and anthropogenic fragments generally of brick but locally ceramics and fragments of plastic.

12.3 **Madeground**

Madeground was recorded in 2 No. trial pits (TP303 and TP307) this relating to reworked natural clay surrounding land drains, noted to 1.2m and 0.6m bgl. This comprised a slightly sandy, slightly gravelly, silty clay, the gravel being of mixed natural lithologies including sandstone and coal.

12.4 **Natural Strata**

Generally glacial clay was encountered below the madeground (similar to topsoil) across the site, the texture being in the main slightly sandy, slightly gravelly and silty, the gravel including sandstone, siltstone, mudstone and occasional coal. Locally the sand content increased to a moderate proportion. Localised bands of coal were also recorded within the clay in trial pits TP302 and TP308.

The clay tended to be between firm and very stiff but locally, this was soft or soft to firm at depths up to approximately 1.5m bgl. The overall thickness of the clay strata was proven to be between 1.2m and at least 3.25m.

A clayey silty sand was recorded in two trial pits, TP207 and TP212, below the madeground (similar to topsoil) to 0.9m and 1.4m bgl respectively. That in TP212 may be associated with the alluvial materials mapped by BGS and being located adjacent to Cecilly Brook. Coopers considered, based on additional exploratory holes around those completed by E3P, that the sand strata were very localised, the surrounding exploratory holes only identifying the clay strata typical of the site.

Gravel was also recorded in three trial pits, TP206, TP207 and TP214. The gravel was sandy in TP206 and TP207, the stratum being below the sand in TP207 and clay in TP206, encountered at 1.2m and 0.9m bgl respectively and extending to the bottom of the trial pits at 2.5m and 2.1m bgl respectively. This was considered to be a glacial deposit. The gravel in TP214, adjacent to Cecilly Brook, was clayey and encountered below the madeground (similar to topsoil) at between 0.3m and 0.9m, this likely to be associated with the alluvial deposits, mapped by BGS.

12.5 **Bedrock**

Bedrock was encountered within a number of the exploratory holes across the site, where the depth was progressed to greater than 2.0m bgl, the head of the bedrock being recorded between 1.2m and 3.1m bgl. The bedrock was generally a very weak, weathered sandstone, which could be excavated with the 9 tonne tracked excavator by between 0.5m and 1.0m. The rotary borehole logs recorded mudstone and siltstone at the head of the bedrock and the bedrock comprised interbedded strata of mudstone, siltstone and sandstone to the base of the boreholes.

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12.6 **In-situ Test Results**

E3P undertook hand shear vane tests in selected cohesive strata, generally at depths between 1m and 1.5m bgl. Coopers undertook hand shear vane tests at every 0.3m to 0.5m interval throughout the trial pits and every metre in the small diameter boreholes, where cohesive strata were present. In some locations hand shear vane tests either failed due to the sample breaking or provided spurious results due to the sample being too friable.

Many of the undrained shear strengths recorded by E3P were below 60kPa and did not reflect the qualitative assessment of the clay in the field which was described as between firm and very stiff. Coopers recorded occasional undrained shear strengths of 38kPa where the clay was described as soft and 48kPa where the clay was soft to firm. Where poor undrained shear strengths were recorded by E3P and Coopers these were noted to be in the upper 1.5m of strata, which overlay either clays with high undrained shear strengths or the bedrock.

In the Coopers exploratory holes, undrained shear strengths of between 70kPa and 78kPa confirmed the presence of firm clay, 92kPa to 118kPa in the firm to stiff clay and 90kPa to 220kPa in the stiff and very stiff clay.

Where the undrained shear strengths ranged between 60kPa and 220kPa these would provide an equivalent bearing capacity of between 102.8kPa and 376.93kPa. The lower undrained shear strengths in the soft and soft to firm clays would only provide between 65.11kPa and 82.24kPa equivalent bearing capacities.

The SPTs in the firm to stiff and stiff to very stiff clay ranged between SPT N values of 10 to 50 blows for 30mm. Stroud and Butler 1975 have stated that the undrained shear strength can be approximated from the SPT N values by a factor of 5. Therefore, the equivalent undrained shear strengths derived from the SPT N values range between 50kPa and at least 250kPa. A hand shear vane test was completed at the base of the SPT this recording an undrained shear strength of 100kPa, which indicates the conversion factor of the SPT N values may be conservative.

The SPT N values in the bedrock were in excess of 50, the tests reaching refusal.

12.7 **Hardstanding, Foundations and Land Drains**

No hardstanding or foundations were recorded on site. Land drains were recorded in two trial pits, TP303 at 1m bgl and TP307 at 0.6m bgl, these being clay and 75mm in diameter. Both were dry.

12.8 **Groundwater**

Groundwater seepages were recorded in 12 No. of the exploratory holes across the site. These were generally slight and encountered at depths between 0.9m and 2.6m bgl. The seepages tended to be at the head of the bedrock strata or in the clay immediately above the head of the bedrock. Accumulations of groundwater were recorded in ITP401 and TP307 where it was reported to rise by 0.1m prior to backfilling the trial pit.

12.9 **Visual and Olfactory Evidence of Contamination**

No visual or olfactory evidence of potential mobile/volatile contamination was recorded within the exploratory holes.

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13.0 Contamination Assessments

13.1 Conceptual Model

In accordance with current guidance and best practice, this risk assessment has been assessed in the form of potential sources of contamination and the pathways with which they may affect potential targets/receptors. The targets/receptors have been assessed to determine how they are likely to use the land and hence consider what actual risk is likely to be present associated with identified contamination on site. Recommendation for site investigation has been assessed in light of the land use and the form of possible contamination which may be encountered.

13.2 Potential Point Sources of Contamination

The source types listed below detail the potential contamination that could affect the receptors if present. A brief description of the potential pathways and receptors is included (where applicable) with each source type as these are intrinsically linked within the conceptual model. A more detailed assessment of the receptors and the method of pathway migration is listed in Sections 13.3 and 13.4 respectively.

Sources on site

The site has remained as greenfield land, since the first available mapping, latterly known to have been used for grazing. No indication of significant contaminative uses were recorded across the main development site. Only madeground (similar to topsoil) was recorded across the site due to low percentage inclusions of brick and ceramics in the exploratory holes and plastic fragments in one location. A former tramway followed the southern site boundary which will be in the POS. Locomotives may have been used along this in the 1800s, which may have resulted in minor spillages of oil.

Madeground identified in two trial pits related to reworked natural drift materials due to the presence of land drains at shallow depths of 0.6m, and 1.2m.

Based on the inclusions within the madeground (similar to topsoil) elevated concentrations of metals, semi-metal elements and compounds, speciated polycyclic aromatic hydrocarbon (PAH) (16) compounds and low frequency asbestos fibres may typically be found in association with such materials. Due to the limited inclusions, there is a very low potential for the concentrations of these contaminants to be elevated, such that they may pose a risk to human health, if a pathway is present to these receptors.

The total petroleum hydrocarbon (TPH) compounds which may have been present due to the oil spillages along the tramway would have significantly reduced in concentration, due to biodegradation over in excess of 100 years since deposition, such that concentrations would be very low and any remaining TPH compounds would be in the heavier TPH ranges. The potential to leach or mobilise will now be significantly limited.

The characteristics of the inclusions within the madeground (similar to topsoil) tend to have a low mobility and tendency to leach. As the inclusions are present in low frequencies in the thin madeground (similar to topsoil) stratum, this would provide a limited source of contamination to controlled waters.

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Ground Gas

The sources of hazardous ground gas and the risk posed to the development have been addressed within Section 14.0 of this report.

Adjacent land uses

4 No. coal shafts operated prior to 1880 within 15m and 250m of the proposed development site boundary. The remainder of the surrounding land use was agricultural with occasional farm buildings, until a caravan park was developed in the 1950s and housing was developed from the 1970s adjacent to the site boundary.

The operation of the mineshafts may have resulted in the spillage of petroleum range fuels/oils/lubricants, which being mobile would have had the potential to have migrated towards the site boundary. This potential for these contaminants to be present on site is considered to be negligible, based on there having been no visual or olfactory evidence of such contamination in the exploratory holes on the proposed development site.

13.3 Targets/Receptors

Proposed land use and future site users

The proposed development is likely to comprise residential properties with associated private gardens, car parking and public open space. The future site users will include the occupants and visitors to the residential properties.

Contractors may also come into contact with contaminants, if present, when undertaking maintenance work on the properties or in the road corridors, although exposure is deemed as short term and controlled under health and safety applications.

Adjacent Landowners

Should contamination be encountered, during dry periods on site when soils are exposed, contaminated dusts may be created by the development and be carried with the prevailing wind. We would advise that during dry periods, the site is dampened down to suppress the dust, in particular from the made ground.

Following the completion of the development, wind blown dusts may migrate from the gardens.

Controlled waters

The site is underlain by a Secondary (Undifferentiated) Aquifer associated with the Glacial Till and a Secondary A Aquifer within the Alluvium and underlying bedrock.

The site does not lie within a Groundwater Source Protection Zone. 2 No. potable groundwater abstraction wells were located approximately 820m to the southwest of the combined Phase 1 and Phase 2 development site.

Cecilly Brook follows the southeastern site boundary, with a tributary to this brook within 350m of the site boundary. There were no surface water abstractions recorded within 2km of the site.

While the Secondary A Aquifer within the bedrock has the potential to provide a local resource of groundwater, the likelihood of the aquifer being used is considered to be negligible, due to the reserves being within the coal measures, which would likely increase the acidity of the groundwater, potentially making it unpotable. However, the aquifer may provide a base flow to local surface water courses, with bedrock subcropping below thin drift deposits.

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The general topography of the site slopes gently down towards Cecilly Brook in the south east. It was considered that any potential shallow groundwater flow within the drift deposits, and shallow bedrock would follow this trend. Based on OS mapping, the topography to the east of Cecilly Brook dips in a westerly direction towards the brook.

Cecilly Brook would be considered to be the primary receptor. The Secondary A Aquifer within the bedrock would be considered to be a secondary receptor as it would not be considered to be a practicable resource, but may provide a base flow to Cecilly Brook.

13.4 Pathways

Below is a list of migration pathways for contaminants, should contamination be encountered on site.

Human Health

Exposure pathways are dependent upon the types of contaminants in the made ground (similar to topsoil). The greatest exposure to inorganic and PAH compounds for future residents is through ingestion via hand to mouth contact, or direct ingestion of soil or soil adhered to home grown vegetation and less likely absorption through dermal contact, where these materials are present in the growing medium. Airborne contaminants present in dust may be inhaled outdoors. Soils may also be tracked back into the house permitting the inhalation of indoor dust.

Should TPH compound contaminants have been present along the tramway or in the vicinity of the former mineshafts offsite, which had migrated across the site boundary, these may be taken up by absorption through dermal contact, ingestion via hand to mouth contact, or direct ingestion of soil or soil adhered to home grown vegetation, where the materials are present in the growing medium. Due to the age of the potential contamination, lower range hydrocarbon compounds would not be expected, which would have a level of volatility which may give rise to vapours, removing the potential for indoor inhalation, if the materials had been present below the house plots or in close proximity.

Only low concentrations of TPH compounds may be present along the tramway and the heavier range compounds would have a very limited mobility. Intervening clay and the distance to the proposed plots would attenuate any concentrations of TPH compounds which may leach. The uptake of such compounds would be limited further in the POS.

The likelihood of TPH compounds to have migrated to the site from off site sources would be negligible due to attenuation provided by:

- the distance to travel of at least 60m from the former mineshafts to the west of the site;
- the intervening brook between the nearest former mineshaft, 20m to the east of the site, would likely form a preferential pathway for any mobile contaminants;
- the intervening very low permeability clay. While sand and gravel bands may be present, these will be discontinuous within the clay strata reducing the potential for the mobile contaminants to reach the more permeable strata.

Where ground is bare of vegetation or only lightly vegetated, if contaminated soils or asbestos fibres are present, these could become windborne during dry periods of weather, thereby potentially transporting contaminants. Adjacent site users may become exposed to potential contaminants arising from the made ground (similar to topsoil).

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Controlled Waters

The drift strata generally comprised glacial clays, which were found to overlie a localised sandy gravel. Possible alluvial materials of slightly clayey gravel and a clayey silty sand were identified in close proximity of the Cecilly Brook, overlying the glacial clay. The glacial clay proven to be between 1.2m and at least 3.25m thick, this only being absent in one exploratory hole location.

The drift strata are expected to extend beyond the site boundary. The clay itself would provide a very limited pathway for groundwater migration due to its cohesive nature and therefore very low permeability. Any groundwater migration would be via the sand and gravel bands, but these were considered to be discontinuous within the clay so would only permit migration over a short distance laterally and vertically. As such this would attenuate any migration of the limited leachates, laterally from the overlying made ground (similar to topsoil), if generated, to Cecilly Brook. The clay would also significantly attenuate the migration of limited leachates to the underlying Secondary A Aquifer within the bedrock.

13.5 Summary of preliminary risk assessment for human health

The preliminary conceptual site model has shown that the majority of the site has been greenfield land, with made ground (similar to topsoil) on the site and a former tramway along the southern site boundary. The made ground (similar to topsoil) may contain slightly elevated concentrations of inorganic contaminants, speciated PAH (16) compounds and asbestos fibres. Predominant exposure pathways would be ingestion of contaminated soils within the growing medium, via hand to mouth or plant uptake and inhalation of dust indoors and outdoors, with a low to moderate risk to human health, where these materials are present in the growing medium. TPH compounds which may have been derived from the use of the tramway were considered likely to be present in limited concentrations in the heavier TPH ranges. These would pose a negligible risk to the future site users in the POS.

While spillages of hydrocarbons may have occurred in the vicinity of offsite former coal shafts the potential for these contaminants to have migrated onto site is considered to be negligible.

A negligible to very low risk would be posed to future site users in plots where the made ground (similar to topsoil) is used within the garden growing medium.

Made ground (similar to topsoil) would pose a negligible to very low risk to adjacent site users, should any of these materials become airborne as dust. Off site sources of contaminants were deemed to pose a negligible risk to the proposed development.

13.6 Summary of preliminary controlled waters risk assessment

The generation potential for leachates of inorganic contaminants and PAH compounds from the made ground (similar to topsoil) and limited heavier range TPH compounds in the tramway is considered to be negligible very low. The attenuation provided by the glacial clay would result in a negligible to very low risk to Cecilly Brook and the underlying Secondary A Aquifer within the bedrock.

13.7 Sampling Strategy

E3P had previously submitted 6 No. soil samples to i2 Analytical Limited as indicated in Table 1. The range of soils included the made ground (similar to topsoil), natural clay and natural sand. One natural clay sample and one made ground (similar to topsoil) sample were scheduled for leachability analysis of metals, speciated PAH (16) compounds and TPHCWG and BTEX compounds. The chemical analysis results are presented in Appendix 7 and have been included within the risk assessment.

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Coopers scheduled 7 No. soil samples from the exploratory holes including the madeground (similar to topsoil) and natural clay to supplement the sampling undertaken by E3P. The numbers of samples per strata and chemical analysis scheduled is summarised in Table 1. The samples were submitted to Normec DETS, the results of which are presented in Appendix 7. The testing scheduled included the Coopers standard human health suite (CLR metals, cyanide, phenols, speciated (16) polycyclic aromatic hydrocarbon (PAH) compounds) and asbestos fibre identification on all the samples.

Table 1 – Chemical Analysis Scheduled

	Strata	CLR metals, cyanide, phenols, sulphate BRE SD1 2:1 extract, pH	PAH (16) compounds	Banded TPH compounds	Asbestos ID
E3P	Madeground (similar to topsoil)	3	3	3	2
	Clay	2	2	2	1
	Sand	1	1	1	1
Coopers	Madeground (similar to topsoil)	5	5	-	5
	Clay	2	2	-	2
	Total	13	13	6	11

13.8 Contamination Results

13.8.1 Human Health Risk Assessment

Assessment of soil results

The justification for human health risk assessment concerning chemical contaminants is included in Appendix 9.

The chemical analysis results relating to the soil samples taken were assessed by Coopers against the Soil Tier 1 Threshold values applied for residential properties with plant uptake for all samples taken, although these criteria are more conservative than required for the POS. The Soil Tier 1 Threshold Values applied, include the C4SLs where available. For other criteria, the S4ULs were applied except for copper, nickel and zinc, for which the phytotoxic threshold values are more conservative than those applicable to human health. These are relevant in assessing whether the materials on site may be detrimental to plant growth. The Soil Tier 1 Threshold Values are presented in Appendix 9. Where threshold values are not readily available for the organic compounds, the soil concentrations were assessed in respect of the level of detection (LOD) in the first instance. The chemical analysis results are presented in Appendices 7. At the time of issuing the report the analysis results relating to one madeground sample were pending.

None of the madeground (similar to topsoil), and natural clay and sand strata samples were reported to contain concentrations of determinands in excess of the available Tier 1 Threshold Values for human health and none of the samples tested for the possible presence of asbestos fibres were reported to contain asbestos fibres.

The determined concentrations within these materials would pose a negligible risk to human health.

While the results relating to the madeground (similar to topsoil) were shown to be chemically suitable for human health, one sample taken from TP209 at 0.2m, was reported to contain concentrations of copper and zinc present slightly in excess of the phytotoxic threshold values, based on the pH of the soil of 6.5 units, as presented below:

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- Copper in sample 160mg/kg (phytotoxic threshold value 135mg/kg)
- Zinc in sample 340mg/kg (phytotoxic threshold value 200mg/kg)

It should be noted that while the concentrations within this soil sample appear to exceed the threshold value, copper and zinc often tend to be bound in compounds which are not readily available to plants to absorb. The bioavailability of these elements has been seen in the laboratory analysis of numerous samples using the nitric acid extract process. It was also noted that the total soils concentrations in the made ground (similar to topsoil) across the site were generally not elevated and the mean concentrations (copper – 54.67 mg/kg and zinc 119.22 mg/kg) including those in TP209 at 0.2m were all well below the phytotoxic threshold values. There was no evidence of poor vegetation growth during the site visits. It is therefore considered that the made ground (similar to topsoil) should be suitable as a growing medium, posing a negligible to very low risk to plant growth.

Revised Conceptual Site Model in Relation to Human Health and Plant Growth

The soil sampling has indicated that the determinand concentrations in the made ground (similar to topsoil) and underlying natural strata were not elevated and would not pose a significant risk to human health if left within the growing medium in the proposed residential properties or below the plots. The use of the made ground (similar to topsoil) was shown to pose a negligible to very low risk to plant growth, such that this soil would be suitable for use in the growing medium across the site.

Based on the logged descriptions in the field, the made ground (similar to topsoil) would be physically suitable for use in accordance with the British Standard BS 3882:2015 “Specification for topsoil and requirement for use”.

13.8.2 Controlled Waters Risk Assessment

Assessment of Chemical Analysis Results

No significant sources of total soils concentrations were identified in the soil samples taken from the made ground (similar to topsoil) and the natural strata. The total soils concentrations generally were not elevated. Therefore, the potential for leachates to be generated in significant concentrations by the general materials were expected to be negligible.

E3P had scheduled for the sample TP208 at 1.6m taken from natural clay and the sample TP213 at 0.2m taken from the made ground (similar to topsoil) for leachate analysis. The results of the analysis are presented in Appendix 7.

As discussed in the preliminary conceptual site model, the surface waters were considered to be the primary receptor from the site. The results of the leachate analysis were therefore screened against the Environmental Quality Standards (EQS), presented in Appendix 9. None of the levels of detection (LOD) for the PAH, TPH and BTEX compounds, phenol and cyanide were exceeded. It was noted that the LODs exceed the EQS values for the following:

- PAH compounds exceeds the “annual average EQS for inland surface waters”;
- Phenol exceeds the “long term (mean) for fresh waters”;
- Cyanide exceeds the “long term (mean) for fresh waters” and “short term (95th percentile) for fresh waters”.

As the total soils concentrations were not elevated in any of the samples, it was considered that the concentrations of the PAH compounds, phenol and cyanide would not be contaminants of concern to the surface water course.

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The majority of the EQS values for metals were not exceeded by the reported concentrations. However, exceedances were reported as summarised in Table 2 for copper, lead and zinc, all with EQS values relating to bioavailability. These are therefore generic values which tend to be the most conservative for a water course. Where relevant data is available to the specific water course likely to be a receptor, site specific screening values (SSSVs) can be calculated for these metals. For the purposes of this assessment, the data was not available to calculate the SSSVs, but experience has shown that these are generally higher than the generic values, such that the leachate concentrations may not exceed the SSSVs, particularly for copper in TP208 at 1.6m.

Table 2: Leachate concentration exceedances of EQS values

		Sample location	
		TP208 at 1.6m	TP213 at 0.2m
EQS value	Copper long term (mean) for fresh waters - 1µg/l	4.9	24
	Lead annual average for inland surface waters - 1.2µg/l	n/a	6.1
	Zinc long term (mean) for fresh waters – 10.9µg/l	n/a	19

If following the calculation of the SSSVs, the leachate concentrations were found to still be above the SSSVs, consideration should be given to the characteristics of the soil strata. TP208 at 1.6m was taken from within the natural clay, which would not be considered as posing a significant risk to surface waters, the concentrations being deemed to be natural background levels.

TP213 at 0.2m was taken from the made ground (similar to topsoil), this being a natural topsoil, but defined as made ground due to inclusions of very low frequencies of gravel sized brick and ceramic fragments. While mining has taken place adjacent to the site, the site itself appears to have always been in agricultural use, without any potential contaminative activities. The metal elements will be bound within the brick and ceramic fragments, such that they have a lower potential to leach in the natural environment compared with the leachability analysis in the laboratory. The nature of the soil having a high clay content will provide a high surface area for potential contaminants to be adsorbed to the soil particles. It is considered that the leachate results may not be representative of the potential concentrations of leachates generated on the site.

Revised Conceptual Site Model in Relation to Controlled Waters

The total soils concentrations within the made ground (similar to topsoil) and natural strata on site have been shown to be low, with no significant leachates expected from the natural strata. Based on the characteristics of the made ground (similar to topsoil), while a leachate sample results indicate the potential for copper, lead and zinc to leach above the generic screening value it is considered that the actual leachability of these metals in the field will not be elevated. Intervening clay strata between the made ground (similar to topsoil) and the primary receptor, Cecilly Brook, will provide attenuation to any leachates, should they be generated such that there will not be a significant risk posed to the surface water course. Similarly, the intervening clay strata will attenuate potential leachates migrating to the underlying Secondary A Aquifer within the bedrock, such that there is not a significant risk to the aquifer.

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13.9 **Water Supply Pipe Risk Assessment**

The UK Water Industry Research (UKWIR) procedures, published in 2011, for assessments of potable water supplies on brownfield sites have been adopted by water supply providers and referenced in the “Contaminated Land Assessment Guidance”, published by Water UK, together with a risk assessment form. The procedures include a phased approach to risk assessment including preliminary risk assessment, and specifications for types of contaminants being tested.

Where sources of potential contaminants that could impact potable water supply are identified within the desk study or intrusive investigation these are assessed to determine the impact on selection of pipe materials.

All strata within the site have been appraised and characterised. No mobile contamination has been identified within the site and concentrations would not be considered to be above thresholds for standard PE pipes for mobile contaminants. The completed risk assessment form has been presented in Appendix 10.

13.10 **Summary**

The site investigation has shown that the made ground (similar to topsoil) and natural strata will not pose a significant risk to human health, plant growth and controlled waters. Therefore, no remedial measures will be required due to contamination, subject to approval by the regulatory authorities. It will be feasible to use standard PE water supply pipes.

14.0 Initial Ground Gas Assessment

14.1 **General**

All information and advice regarding requirements for gas precaution measures are considered to be provisional until approval from statutory bodies has been granted. The assessment within this report includes a desk-based assessment and initial monitoring results with further monitoring proposed. The approaches to ground gas investigations and assessments of risks are detailed within the following British Standards:

- BS 8485:2015+A1:2019 ‘Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings.’
- BS 8576:2013 ‘Guidance on investigations for ground gas – Permanent gases and Volatile Organic Compounds (VOCs).’

The British Standards references numerous specific papers regarding ground gas research. Papers referenced in this report include publications released after the latest updates to the British Standard. Of particular relevance to this site are the following publications, discussed and referenced in subsequent sections:

- CIRIA C735 (2014) “Good Practice on the Testing and Verification of Protection Systems for Buildings Against Ground Gases.”
- CL:AIRE (2021) “Good Practice in the Risk Assessment for Coal Mine Gas Emissions”.
- Lucas, S., and Wilson, S. (2020) “Corrosion and Puncture Resistance of Aluminium Foil Gas Membranes beneath Concrete Slabs” in Geosynthetics International, Vol. 27-4.
- NHBC Foundation, Report No. NF94 (2023) “Hazardous Ground Gas – An Essential Guide for Housebuilders”.

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Coopers have appraised the potential risk of ground gases to provide an initial conceptual model in terms of source-pathway-receptor, following current standards and guidance. Based upon this conceptual model it was determined that gas monitoring was required (ongoing at the time of this report) to assess potential risks associated with potential ground gas associated with mine workings.

14.2 **Initial/Preliminary Conceptual Model**

General: - In accordance with BS 8485:2015+A1:2019, Clause 4, “*To complete an assessment of the risks posed by the presence of permanent and other ground gases, the potential sources of gas in and around a site should be identified; guidance on the collection of the relevant information is provided in BS8576.*”

In accordance with BS8576, Clause 6, the development of a preliminary conceptual site model is the first stage in determining the requirements for a program for gas monitoring. The initial stage of which is identification of “*Potential sources of hazardous gases based on a review of the current and previous uses of the site and neighbouring land, and the underlying natural and man-made geology and hydrogeology;*”

The following sections include a more detailed discussion of the risks posed by known and common sources of hazardous ground gases, the pathways for gas mitigation and the potential impact to the receptors. To aid classification of the risk of different sources of hazardous ground gas a decision matrix has been provided in BS8576, Clause 8.7, Figure 7, which classifies the generation potential of sources of hazardous ground gas from very low to very high.

The initial conceptual model has defined the site as having high risk sources of hazardous ground gas and therefore monitoring is required.

14.3 **Initial Conceptual Model - Potential Sources**

The below information includes a detailed appraisal of common sources of hazardous ground gases, with the associated potential migration pathways to reach receptors specific to each source.

Historical Landfills (on and off site): - A review of multiple sources of information have been undertaken to assess the potential for landfill gases to impact the proposed development generated by current or former landfill sites identified within 250m of the site. No current or former landfill sites have been identified within this zone and therefore are not considered to be a potential source of ground gas which may impact the proposed development site.

Former Ponds and Natural Organic Rich Material (on/off site): - As detailed in Section 6, the historical OS maps have not identified any former ponds on site or within the vicinity of the site boundary. These features have been discounted as a potential source of ground gas.

Deep Madeground (on site): - The investigations did not identify any deep madeground on site. the only madeground recorded related to reworked natural ground where land drains were installed.

Common Hazardous Ground Gas Source Identification – Coal Mine Workings (on / off site): As detailed within Section 9, the site is within a defined coal mining reporting area, with assessments identifying the presence of shallow mine workings greater than 30m deep in the vicinity of the north of the site, the potential for unrecorded worked seams greater than 30m below the southern area of the site and mine shafts in close proximity to the site.

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Coal is commonly associated with trapped hazardous gases within pore spaces, primarily comprising of methane and carbon dioxide, although other gases including carbon monoxide can be present. Numerous historical coal mining disasters are attributed to the release of mine gas. Following abandonment of former coal mines these gases can migrate towards the surface where they can pose a significant risk to human health.

BS8576 details that the risks posed by underground coal mine working varies by depth and age. The primary risks are where abandoned open workings fill with hazardous mine gas which can then be forced to the surface under pressure (particularly via water ingress or mine treatment works).

Ground gas, in particular methane, would have been generated due to desorption from the coal, generated shortly after extraction. Where workings have taken place, mine gas emissions reduce and may even cease 15 to 20 years after mining has finished. Carbon dioxide may also be generated by oxidation of the coal on exposure to air, until the oxygen is depleted.

The higher risks are posed for shallow and recent workings where it is less likely to have water returning to equilibrium and more likely to have pathways to reach the surface via cracks and fissures. Other preferential pathways for mine gas release to the surface require consideration such as migration via mine entries, geological faults and proposed construction (foundations, deep sewers, etc).

The procedures defined in CL:AIRE (2021) follow the same initial approach outlined in BS 8485:2015+A1:2019 with regards to the formation of an initial conceptual site model through desk study data, determining source-pathway-receptor relationship and investigations to monitor gases based upon the model. The main variations are that the interpretation and designation of gas risks requires specific classification based upon the nature of the mine workings, and that adoption of gas screening values within BS 8485:2015+A1:2019 may not be appropriate, particularly where pathways of gas migration bypass the shallow soils, such as mine shafts, faults or future development pathways. The initial appraisal coal mine gas risk classification within CL:AIRE (2021) is summarised in Table 3.

Table 3: Summary of Risk Designations of Coal Mine Gas Emissions based upon CL:AIRE Guidance (2021)

Risk Designation	Criteria	Requirements
No Risk	Outside of Coal Authority Coal Mining Reporting Area.	No mitigation measures required for coal mine gases.
Negligible Risk	- Mine Entries >50m from site boundary. - Workings >150m depth. - No faults or other potential pathways connecting surface to deeper unflooded mine workings. - Outside area of past or probably shallow workings on Coal Authority viewer.	- Findings of assessment to be provided in report. - No mitigation measures required for coal mine gases.
Low Risk	- Workings 30-150m but permanently flooded or covered by 10m+ of low permeability ($<1 \times 10^{-6}$ m/s hydraulic conductivity) superficial deposits. - Mine Entries >50m from site boundary	- Findings of assessment to be provided in report. - No mitigation measures required for coal mine gases. - Review of assessment once development designs are finalised.
Moderate Risk	None of the high risk criteria below.	- Detailed mine gas risk assessment required. - Findings of assessment to be provided within a report. - Assessment of mitigation measures based upon risk-based design. - Review of assessment once development designs are finalised.
High Risk	- Mine Entries on site or within 20m of site boundary. - Workings below site at <30m depth and unflooded or variable water levels. - Faults or other pathways connecting surface to deeper unflooded workings. - Within area of past or probable shallow workings on Coal Authority viewer.	- Assess if mine gas risks can be mitigated, if not there will be requirements to change the development proposals. - Detailed mine gas risk assessment required. - Findings of assessment to be provided within a report. - Assessment of mitigation measures based upon risk-based design. - Review of assessment once development designs are finalised.

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An initial appraisal of the risk designation, details that the site would be initially defined as a moderate to high risk, the risk becoming high due to the location of the mine entry 15m from the eastern site boundary. However, this is to be 50m from the nearest part of construction, the footpath around the balancing pond. The risk assessment has also taken into consideration the age of the mine workings, with the generation of mine gas in seams below the site considered likely to have ceased based on the workings having occurred in the 1800s or before. The shallow mine workings at between 30m and 60m bgl in the south of the site and any deeper workings are likely to have flooded once the working ceased decades ago, based on the age of the workings dating back to the 1800s or earlier, so reducing the potential for further mine gas generation. A coal seam subcrops below the far north of the site known to dip to the north and north west. Intact coal, 100mm thick, has been proven in a rotary borehole, on the far north of the site, at 19.1m bgl, likely to be associated with this subcrop. It is considered unlikely to have been worked under the site due to the seam thickness being thin and of low economic importance. Shallow mine workings are recorded at 48m bgl most probably offsite to the north of the site, based on the rotary borehole findings. The designation would define the site requires monitoring and a detailed mine gas assessment needed, followed by reviews of the development proposals to account for future pathways.

Radon (on site): - As detailed in Section 10, the site lies within an area where <1% of properties are above the radon action level and no radon mitigation measures are required for new residential buildings.

Petroleum Hydrocarbons/Volatile Substance Vapours (on site): - Sections 13.2 and 13.4 discussed the likely absence of identified volatile petroleum range hydrocarbons. Where present the vapours from petroleum range hydrocarbons will commonly require a higher level of protection than other forms of hazardous ground gas. Given the ground investigation this common source of hazardous vapours can be determined as not applicable.

Future Filling (on site): - It is proposed to raise ground levels across much of the site to facilitate the development. Materials to be used for this purpose will be required to be inert, with low degradable organic material to mitigate settlement, gas generation and risks to human health and the environment. Testing for imported materials will be required to verify the materials are suitable and do not pose an unacceptable level of risk for generating hazardous ground gas. Further details of testing criteria for imported soils are provided in Section 15.2 and outline earthworks proposals within Section 24.

14.4 Potential Pathways

The pathways for migration of ground gases can be highly varied, influenced by the permeability of strata, built environment and groundwater.

There do not appear to be any shallow mine workings at less than 30m bgl on site. The sources of hazardous ground gases associated with mine workings at depths greater than 30m are commonly limited by the overlying lower permeability strata, with preferential pathways formed by the connected mine shafts. The bedrock was proven to be comprised of interbedded strata of mudstone, siltstone and sandstone, the mudstone and siltstone generally have a low permeability in comparison with the generally more fissured sandstone, thereby providing vertical attenuation to ground gases from deeper coal workings.

The mine workings are likely to have become flooded, having displaced ground gases at the time of flooding.

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The site has been identified as having relatively thin glacial deposits, generally of clay, which have a low permeability, but affording some attenuation to possible ground gas migration should limited ground gas concentrations reach the surface of the bedrock. The intervening clay, mudstone and siltstone between the mineshafts and the proposed development will attenuate the lateral flow of potential ground gases to the plots. The distance of the mineshafts from the proposed development construction will attenuate the lateral ground gas concentrations if the mineshafts did provide a source.

The presence of shallow groundwaters perched at the head of the bedrock and within the clay strata would further significantly limit the potential for vertical and lateral migration of ground gases. Foundation construction, ground improvement, mine treatment works and service trenches can change the existing ground gas migration pathways and create preferential pathways to the subfloor of the buildings which would not be identified during gas monitoring. These construction methods would require consideration of a precautionary design where hazardous ground gases are present.

Once gases generated have reached the surface they will dissipate rapidly through atmospheric diffusion unless confined by buildings, as summarised in Figure 2 (below), or low points such as trenches. Hazardous gases beneath buildings can migrate through cracks or spaces in the floor slab and collect within the buildings. Any work in a confined space (including trenches) must assess the potential for hazardous gases to be present and health and safety provisions should be applied in accordance with HSE guidance.

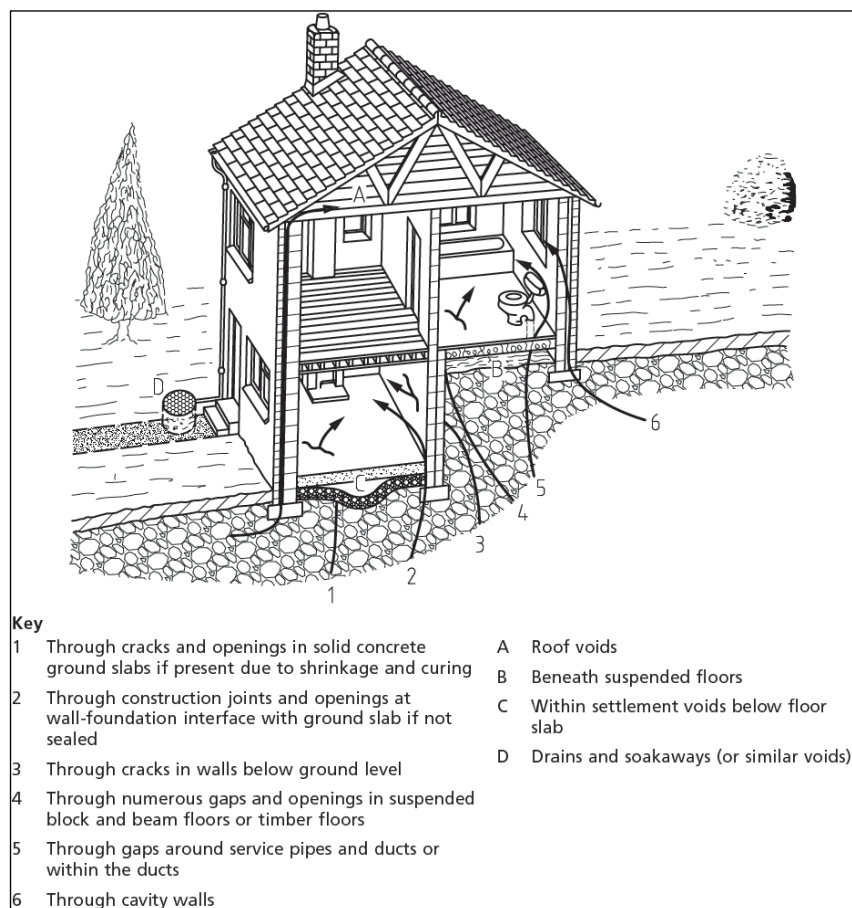


Figure 2: Potential pathways for hazardous ground gas to ingress into residential buildings (from BS 8485:2015+A1:2019)

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14.5 **Receptors**

Future Occupants: The primary receptors are anticipated to be the future occupants of the residential houses via the build up and ingress of potential hazardous gases through the ground floor slabs of the properties. These are considered highly sensitive receptors for the purposes of the conceptual model.

Adjacent residents: These can be exposed to hazardous gas if sources of gas are generated on site and migrate beyond the site boundary or preferential pathways exist for the lateral migration of gases beyond the site boundary. The likelihood of this occurring is minimal due to the low potential for gas generation on site and pathways for gas migration being primarily vertical.

Construction/Maintenance Workers: Other receptors include construction workers, primarily through work within trenches or excavations where preferential pathways for the migration and collection of gases could occur. HSE guidance on safe work in confined space details potential dangers from gases within trenches, assessments required and precautions to take prior to entering a confined space. The appointment of a supervisor to ensure the necessary procedures and precautions are in place where construction workers intend to enter a confined space is advisable in accordance with HSE guidance.

14.6 **Conceptual Model Summary**

The conceptual model has demonstrated that the primary risk is related to coal mining activities alone. A summary of the sources, gas generation potential, pathways and risks to receptors is shown in Table 4.

Table 4: Summary of Initial Conceptual Model Associated with Hazardous Ground Gases

Sources	Gas	Receptor	Pathway	Risk
Historical Landfills/Filling (off site)	N/A	N/A	N/A	No known landfill sites identified within 250m of the site. Negligible risk source potential.
Coal Mining (on site)	Methane, carbon dioxide, & carbon monoxide	Future occupants, construction/ maintenance workers/off site residents	Potential discrete pathways through weathered bedrock and shallow drift from moderately shallow mine workings. Mine shafts close to the site have potential to provide a preferential pathway for release of mine gas.	1 No. mineshaft within 20m of the site boundary but 50m from the nearest part of the proposed construction. Mineworkings between 30m and 60m bgl, likely to be flooded. Moderate to high risk source potential.
Former Ponds and Natural Organic Rich Material (on/off site)	N/A	N/A	N/A	No former ponds on or in vicinity of the site. Negligible Risk Source Potential.
Deep Madeground (on site)	N/A	N/A	N/A	No deep madeground on site. Negligible Risk Source Potential.
Radon (on site)	Radon	Future Residents	Exposure to radon gases migrating into buildings through floor slab construction.	No Radon Precaution measures required for new buildings.
Petroleum Hydrocarbons (on site)	N/A	N/A	N/A	No TPH contamination identified. Negligible Risk Source Potential.

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14.7 **Investigation Strategy and Monitoring**

Investigation Approach

The initial conceptual model defined the potential risks from hazardous ground gas which requires a program of monitoring. The investigation strategy is required to be designed with cognisance to the conceptual model and objectives for the investigation.

BS8576 (2013) describes in detail the approaches to investigation of hazardous ground gas, monitoring well construction and methods of gas monitoring. This included specific reference that prescriptive grid based spacing of monitoring wells in earlier guidance (CIRIA C665, 2007) is commonly unsuitable, and targeted monitoring is generally required.

The investigation strategy requires consideration of the preferential pathway for gas migration in relation to the identified sources. To determine the variations of shallow gas risk a targeted investigation would be required (for example installation of monitoring wells in areas close to a defined offsite source).

Monitoring Well Construction

The gas monitoring wells were constructed with 50mm HDPE pipe with slotted sections within a targeted response zone, geosoc surround to prevent silting up and inert gravel surround. Bentonite seals were constructed above the response zone to limit atmospheric gas ingress. A rubber bung with dual valve system and downfeed was installed to homogenise stratified gases, compliant with BS8576 (2013), as shown in Figure 3. A flush stopcock cover was used to protect the valves.

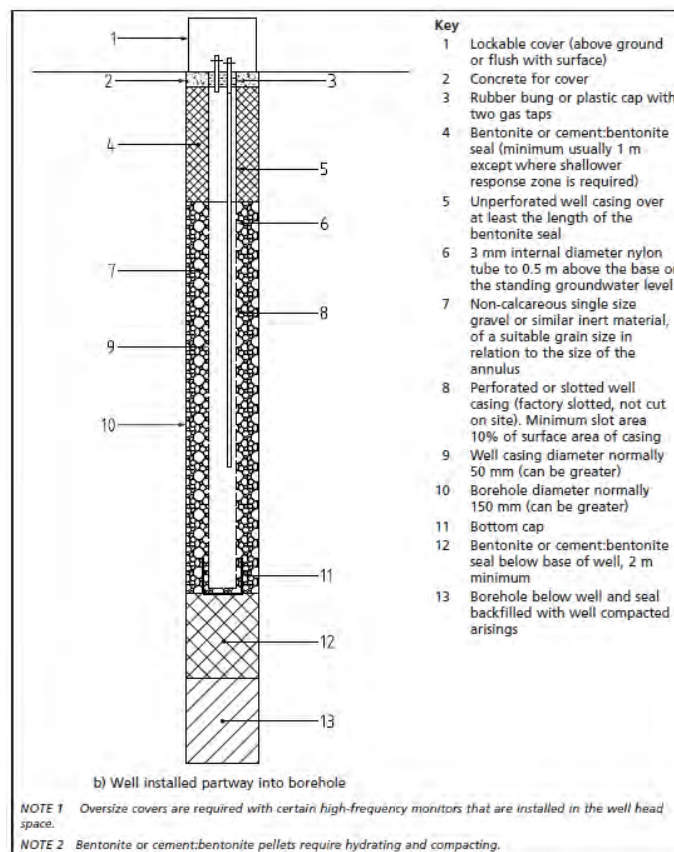


Figure 3: Extract of borehole monitoring well installation as recommended by BS8576

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Ground Gas Monitoring Frequency and Duration

As detailed in BS8485(2015)+A1:2019, the gas monitoring procedures are to follow BS8576 (2013). This removes prescribed monitoring periods and frequencies with the onus transferred to the consultants to justify that their monitoring data is sufficient to characterise the site. Specific guidance on the requirements for gas monitoring duration is detailed within BS8576, Clause 8.6, in which the consultants should assess and appraise the risks based upon the levels of protection, as follows “*Gas monitoring does not necessarily need to be carried out under worst case conditions. It does not necessarily need to be at low or falling atmospheric pressure, but rather should be continued until it is unlikely that additional data will change the interpretation of the data, the outcome of the risk assessment, and the proposed remedial actions. This requires continued assessment of data as the monitoring progresses. One of the main considerations is to assess whether gas flow rates or concentrations could possibly increase and thereby affect the risk assessment and hence the choice of protective measures.*”

The approach to determining the sufficiency of the data is provided within BS8576, Annex F: Assessment of Whether Sufficient Gas Monitoring Data Have Been Collected. Table F.1 to F.3 within the BS8576 provide a decision matrix to appraise the sufficiency of the gas data.

For the purposes of practicality, it is common to undertake a predefined set of monitoring visits to establish the ranges and variations that occur under different conditions and times. The monitoring is proposed to include 6 No. visits over a period of circa 3 months, which would be commonly considered appropriate for initial appraisal purposes.

Calibration certificates and/or laboratory testing of recovered bulk gas samples is required to confirm accuracy of the monitoring data.

Ground Gas Monitoring

Coopers monitoring was undertaken with GA5000 gas analyser, manufactured by QED (formerly Geotechnical Instruments). Manufacturers certificates of calibration are provided in Appendix 11.

The monitoring procedures by Coopers include an initial flow reading recorded at 10 second intervals over a period of 1 minute (to allow rates to stabilise), followed by continuous monitoring of gas concentrations at 15 second intervals over a period of at least 5 minutes, as recommended within BS8576. Following completion of the monitoring the bung is removed, water levels measured, followed by replacement of the bung and closing of valves.

Where groundwater levels were above the top of the response zone the monitoring ceases to identify ground gas and becomes head space testing above a water table to identify dissolved gas. Various papers discuss the false impressions of ground gas given where shallow water is present and Coopers therefore bail the groundwater to permit ingress of ground gas prior to repeat monitoring. The resultant ingress of ground gas being displaced by water will commonly result in a falsely high flow rate (due to the gas flow being pressure driven by recharge of the water), as recorded during the monitoring to date.

The summary of peak and steady concentrations, flow rates and any relevant notes relating to the monitoring are contained on a table in Appendix 11. The range of results identified to date are summarised in Table 5 below.

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Table 5: Summary of Ground Gas Monitoring

Borehole	Target Source/Strata	Response Zone (m bgl)	Pressure Range (mbar) (*1)	Peak Carbon Dioxide (% by Vol.)	Peak Methane (% by Vol.)	Min. Oxygen (% by Vol.)	Hydrogen Sulphide (ppm)	Carbon Monoxide (ppm)	Water Level (m bgl)	Steady Flow (l/h)
WS301	Mineshaft to the east/ clay above bedrock	1.0-2.0	983-1020	0.2-0.8	0.0-0.0	18.4-21.0	0	0-8	0.81-1.16	-3.8 to 9.1
WS302	Mineshaft to the west/ clay	1.0-3.0	984-1019	1.4-2.1	0.0-0.0	19.3-20.1	0	0-14	0.48-0.74	1.1-15.3
WS303	Coal subcrop in the north/clay	1.0-3.0	986-1022	0.6-1.3	0.0-0.0	16.7-20.5	0	0-1	1.61-2.39	6.1 to 14.7
WS304	Mineshaft to the east/ clay above bedrock	1.0-0.6	984-1021	0.4-0.7	0.0-0.0	20.1-21.2	0	0-1	0.71-0.76	2.5 to 9.0
WS305	Mineshaft to the west/ clay	1.0-2.0	985-1018	0.5-0.8	0.0-0.1	18.7-20.7	0	0-75	1.15-1.47	-0.5 to 0.4

Notes to Table 5:

- All monitoring wells, except for WS305, were identified as having flooded response zones on the first visit and WS302 to WS304 had flooded response zones on the second and third visits. Water levels represent the levels following bailing and monitoring to allow ingress of ground gas.
- Flow rates for purged monitoring wells are not reliable.
- Site is located between approximate 155m and 170m aOD - atmospheric pressure is circa 10mb lower for each 100m aOD.

14.8 Ground Gas Assessment

As outlined previously there are specific recommendations for a detailed ground gas assessment provided within CL:AIRE (2021), which differ from the approaches of other forms of hazardous ground gas assessed in accordance with BS 8485:2015+A1:2019. The requirements for the detailed report are:

- Detailed mine gas risk assessment will require suitable site investigation and use of a multiple lines of evidence approach to risk assessment.
- Consider - depth and permeability of drift deposits and if >5 m to rockhead from underside of foundations and drainage trenches (including any deep soak away or attenuation tanks).
- Model and assess gas migration rates through the ground using approaches in the Ground Gas Handbook (Wilson et al., 2009).
- Assess whether shafts or other pathways are connected to unflooded deep or shallow workings.
- Assess risk of gas migration from shaft or adit (consider filling, capping type, any venting and geology and relationships between flow rates and meteorological conditions).
- Detailed assessment of gas monitoring data looking for correlations of flow rates with barometric pressure, temperature, groundwater levels and whether elevated flows are likely to be associated with mine gas emissions, consideration of gas ratios and other potential sources of gas.
- Assess volume of potential gas reservoir that could accumulate in workings.
- Assess impact on the gas risk of any grouting works to shallow mine workings. Consider relevant uncertainties.
- Consider credible future changes that could impact on mine gas risk (water level changes or grouting in connected workings).
- Consider risk to external areas (gardens, landscaped areas) e.g. sheds. The rate of gas emissions from open fractures or shafts can overcome the ventilation in these types of buildings.
- Consider floor construction and resistance to gas ingress.

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The gas monitoring to date has identified negligible methane, hydrogen sulphide, and very low carbon dioxide concentrations. A spike of carbon monoxide was identified within 1 No. monitoring well on the first monitoring visit, this being 75ppm. Whilst occasional spikes in concentrations of hazardous ground gases can occur on initial monitoring following ground disturbance, often due to oxidation of the carbonaceous components within the soil, the concentration may be of concern if it were persistent. The concentration is above the World Health Organization recommended carbon monoxide concentration for indoor air levels, with an average of below 9ppm for any eight hour period, and below 25ppm for any one hour period. The value recorded was also above the Health and Safety Executive published long-term exposure limit (LTEL – 8 hour period) of 30ppm for work related situations, but below the short-term exposure limit (STEL – 15 minute period) of 200ppm.

Where carbon monoxide concentrations are present without other elevated hazardous ground gases the source would typically correspond to partial combustion of organic carbons, but no known or probable source for this exists. The monitoring wells displayed high groundwater which would indicate the potential for the gases to be saturated, but this was not further displayed in subsequent visits to allow corroboration.

The steady flow rates recorded where the response zones were found to be masked by groundwater were elevated as expected due to the barometric pumping effect of the high groundwater level. Therefore, these results were discounted from the risk assessment. Where the response zones were not flooded, either negligible flow rates were recorded or slightly negative flow rates were recorded. It was noted that negative flow rates prevailed where the groundwater levels within the monitoring well were almost completely masking the response zone. Where groundwater levels had dropped lower, a positive flow rate was recorded. It appeared that the groundwater levels were causing erroneous values. The marginal flow rates would be expected for the site where a negligible source of ground gas would be expected.

The monitoring data is initial, and trends may materialise with additional data over the further proposed gas monitoring visits. The interpretations and assessments should therefore be considered as provisional.

The monitoring wells are demonstrating the presence of perched groundwater, which is likely to be providing a limit to migration of hazardous ground gases. The proposed development would reduce infiltration to the ground (through hard surfacing and surface water drainage) which will likely lower the groundwater levels and enable gases to mobilise which would not be viable to be determined in monitoring prior to development. The bedrock is shallow with proposed regrading of ground resulting in most of the site levels being raised, helping to reduce a pathway to the bedrock through the excavation of foundations. Foundations incorporating reinforced concrete spread foundations or raft foundations would not provide a significant preferential pathway. Vibro stone columns to support doubly reinforced strip foundations, have not been recommended, so not creating a direct pathway for potentially migrating ground gases to the subfloor. Piles are recommended where tree influence depths require deeper foundations, these likely to be CFA piles anchored into the bedrock. Pathways for ground gas would be very limited due to the concrete construction of these piles creating a seal within the bedrock. Deep sewer trenches with granular fills would provide a preferential pathway.

There are no properties to be constructed close to the offsite mine shafts, being well beyond the development offset. As previously discussed, no shallow mining has occurred below the proposed development area, any mine workings likely to be at depths greater than 30m.

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Based upon the monitoring data to date, it is considered that the ground gases will not pose a significant risk to the proposed development. However, this assessment will need to be confirmed following completion of the gas monitoring and foundation designs.

The conceptual model and gas data correlate well. The current monitoring data is showing that no preferential pathways exist for hazardous ground gas to reach the site. This is in part due to the depth of the mine workings below the site, which are likely to be flooded and distance to the mine shafts. In addition, the low permeability of the strata and the presence of perched groundwater will attenuate the migration of any potential migrating ground gases. However, as detailed previously, the reliance on the groundwater and the permeability of the strata requires careful consideration of the potential variations caused by development to create pathways.

For initial appraisal purposes it is assumed that no gas mitigation measures will be required, although it is recommended that there are suitable contingencies, should future works identify the potential for risks of mine gas displacement. Cognisance will be required of proposed sewer depths and foundation proposals which may require further monitoring.

Conclusions

The initial conceptual model identifies the presence of a moderate to high risk gas source, with the potential to impact the site, relating to mine workings. The monitoring data to date identifies that no significant concentrations/flow rates of hazardous ground gas is present. As such there appear to be either no significant sources and/or pathways to allow hazardous ground gas to migrate to the shallow soils on site. However, these pathways can be changeable, due to construction works creating pathways, with a precautionary approach required.

15.0 Remediation and Validation

15.1 Remediation Measures

No remediation measures have been identified as being required to date.

15.2 Soil Testing

It is likely that the inert subsoil and made ground (similar to topsoil) won on site will be placed within the gardens and POS and there will be a sufficient volume for this. However, should topsoil or subsoil need to be imported to site, these would require chemical testing by a qualified geo-environmental consultant, to ensure these do not introduce contaminants to the site and are suitable for use.

In accordance with Coopers generic guidance for garden validations the chemical testing quota presented in Table is recommended, once the soils have been imported to the site. The type of testing and sample frequency is dependent upon the provenance of the materials and has been approved by numerous councils and the NHBC on previous residential developments. A minimum number of samples would be taken for each source to ensure that there is sufficient data to assess the soils at the appropriate frequency as shown in Table 6.

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Table 6: Sampling frequency and analysis of imported soils

Strata Type	Origin	Sample quota (*4)	Testing Suite
Imported Subsoil (*2)	Unverified/Brownfield	1:50m ³ (min. 6 samples)	Full CLEA suite (inorganics and PAH) incl. TPH-CWG, and asbestos (*1)
	Greenfield	1:250m ³ (min. 3 samples)	Full CLEA suite (inorganics and PAH) incl. asbestos
	Quarried source	No requirement for testing	
Imported Topsoil (*3)	Unverified/Brownfield	1:50m ³ (min. 6 samples)	Full CLEA suite (inorganics and PAH) incl. TPH-CWG, and asbestos (*1)
	Greenfield	1:100m ³ (min. 3 samples)	Full CLEA suite (inorganics and PAH) incl. asbestos
Imported Crushed Brick/Concrete	N/A	1:500m ³ (min. 3 samples)	Asbestos identification

Notes to Table 6:

*1 - Additional suites of testing may be required, subject to provenance and observations as to the nature of the imported soils. This may include suites such as VOCs, SVOCs and PCBs. Justification of the testing scheduled for unverified or brownfield sources would be required within the verification reporting.

*2 – All imported subsoil needs to be fit for purpose and meet general textural requirements in accordance with BS 8601 “Specification of Subsoil”. These materials cannot include hazardous materials such as glass.

*3 – All imported topsoil needs to be fit for purpose and meet general textural requirements in accordance with BS3882 “Specification of topsoil”. These materials cannot include hazardous materials such as glass.

*4 – The referenced sample volumes are considered applicable for the anticipated volumes of soils typically delivered/generated in stages. If large volumes of soils from a single, consistent source are proposed it may be acceptable to agree reduced quotas for sample testing, subject to prior agreement with the NHBC and Local Authority.

*5 – All testing should be completed on the site of use to ensure the materials to be used are as reported. Where imported soils are proposed to be used these should have indicative source testing to confirm the materials are suitable prior to importation.

Confirmation of the volume of material imported to site must be provided to ensure that representative sampling has been undertaken in accordance with the required testing frequency.

Screening criteria for imported soils are defined in Coopers Tier 1 Thresholds in Appendix 9. The copper, nickel and zinc threshold values in British Standard BS3882:2015 ‘Specification for Topsoil and Requirements for Use’ are significantly lower than the human thresholds and it is advised that these should be adopted for imported materials placed in gardens and areas of landscaping.

Should elevated concentrations be identified within the imported soils additional testing or assessments may be appropriate.

The testing of soils for validation must be taken from the construction site to ensure these are representative of the soils actually used within the gardens. The samples can be taken from stockpiles on site or in situ following placement within gardens and landscaping. Where soils are being kept within tested stockpiles on site it is imperative that good stockpile management practices are adopted. This can include segregation of stockpiles from different origin, fencing or warning signs to prevent inadvertent cross-mixing, and not placing stockpiles on tarmac roads, contaminated made ground (if encountered) or adjacent to areas of heavy plant traffic.

Should soils be imported to site, a qualified geo-environmental consultant would be required to prepare a verification report for submission and approval in support of the planning application. This would include laboratory analysis and photographic records.

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16.0 Management of Materials and Waste

16.1 Disposal and Control of Excavated Materials

Where materials are excavated for construction purposes, if possible, these should be retained on site, where considered suitable for use, to ensure sustainability of the development. Where suitable materials are excess to requirement, it is recommended that they are transferred for reuse rather than sent to landfill. The developer may complete the works under the CL:AIRE Development Industry Code of Practice for the Definition of Waste, Version 2 (or superseding versions if relevant).

Should the madeground (similar to topsoil) require reuse or additional soils need to be imported from another development to raise site levels, depending on the volume, a U1 exemption or a Materials Management Plan (MMP) may be required in accordance with DoW-CoP. An MMP must be reviewed by an independent Qualified Person (QP) for subsequent registration with CL:AIRE.

The intended use of soils excavated from the site would be detailed within the MMP for implementation within the construction phase. The MMP would require the identification and classification of materials intended for reuse or disposal off-site (including classification as inert, non-hazardous, stable non-reactive hazardous, or hazardous waste) and volume targets for disposal of each type.

Each soil type which is intended for removal will be classified with one of the following EC waste designation codes, as detailed within Environment Agency “*Technical Guidance WM3 - Hazardous Waste*”. Generally, the soils would be classified as:

- **17 05 04 soil and stones other than mentioned in 17 05 03 – not containing dangerous substances.**

Based upon the chemical analysis of the samples taken to date, Coopers can advise the waste characteristics of natural strata and madeground (similar to topsoil) would likely be:

Non hazardous waste, likely to be inert following testing for Waste Acceptance Criteria (WAC) if intended for landfill.

It is recommended that the chemical analysis results obtained to date plus WAC analysis are provided to a waste disposal site for confirmation of the disposal route, to enable the detailed assessment and full characterisation of the waste.

Within the DoWCoP, there are two paths which may guide the documentation required for the form of soil management systems. The initial path expects a Remediation Strategy to be produced for the site (assuming it to be potentially contaminated) to determine which strata or areas of the site are considered to be contaminated with regard to the proposed land use (Route A). The second path expects a Design Statement to be utilised for those sites where there is no contamination per se (Route B). Based on the characteristics identified at this site, a Design Statement would be applicable, with this report fulfilling this purpose.

Direct transfer of naturally occurring soils may be undertaken, however a robust assessment of the materials has to be undertaken to confirm this material is suitable for use and uncontaminated. It should be noted that the degree of threshold for contamination will be judged on the receiving sites requirements (based on the proposed end use).

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The Code of Practice requires 4 No. factors to be addressed within the MMP:

- (1) Protection of human health and protection of the environment;
- (2) Suitability of use, without further treatment;
- (3) Certainty of use; and
- (4) Quantity of material.

With regard to Box A within the Code of Practice (c.3.7, p.13), the material types encountered have been classified to determine the 'Categorisation of materials within the ground'. Areas and volumes of strata noted below, will require assessment by a qualified quantity surveyor. These volumes would not represent the volumes of soils likely to be excavated through any part of the construction phase of the site redevelopment, rather the anticipated total volume of that stratum.

Table 7 - Categorisation of Materials within the Ground in Accordance with CL:AIRE Code of Practice

(1)	Material that is capable of being used in another place on the same site without treatment*;
(2)	Material that is capable of being used in another place on the same site following ex-situ treatment on site*;
(3)	Material that is capable of being used in another development site without treatment (Direct Transfer);
(4)	Material that is capable of being used in another development site following ex-situ treatment on another site e.g. Hub site*;
(5)	Material that is not capable of being used on the site or elsewhere and requires recovery or disposal off site as waste; or
(6)	Material that will be surplus to requirements and requires recovery or disposal off site as waste.
*	Having regard to the conceptual model (receptors and pathways) and appropriate risk assessment of the location where materials are to be used. We do not consider damping down to be treatment.

Made ground (similar to topsoil) across the site - (1), (4) and (6) proven to be suitable for use

These made ground (similar to topsoil) would be suitable for reuse in the gardens and POS on site as a growing medium. These materials may be transferred to a permitted Hub Site for subsequent use on other sites following appropriate treatment. Alternatively, if surplus to requirement on the site, this may be transferred as waste to a permitted landfill site.

Natural subsoils - (1), (3) and (6) proven to be suitable for use

Natural subsoils would be suitable for reuse in gardens and POS as a growing medium, and where geotechnically suitable for use beneath buildings, roads, or as up fill (subject to suitable compaction for the designated end use). These materials if proven geotechnically and chemically suitable for use on other sites may be transferred under an MMP for the receiving site. Surplus materials would need to be sent to a permitted landfill site.

16.2 Risks to Groundworks Contractors

We do not anticipate that groundworks contractors will be detrimentally affected by the materials present on site assuming basic site hygiene is followed comprising; wearing gloves, overalls, steel toe capped boots and hard hat on site, and basic welfare facilities are present within the site.

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17.0 Sub Soil Classification

17.1 General

Selected soil samples were scheduled for chemical and geotechnical analysis by Coopers. Chemical analysis comprised sulphate testing in accordance with BRE SD1, at Normec DETS laboratory. The results for the BRE SD1 testing scheduled by E3P at i2Analytical Limited were also used. Cohesive samples were scheduled for plasticity index and moisture content testing at Murray Rix. Copies of the chemical and geotechnical results received are provided within Appendices 7 and 8.

In situ testing of soil strengths were also undertaken on the site during the ground investigation, using a hand shear vane, as discussed in Section 12.

17.2 Results of Laboratory Analysis

Table 8 - Summary of Chemical Analysis

Strata	No. of samples for analysis	SO ₄ (2:1) (water soluble)	pH	Mobile/ Static
		mg/l	-	
Natural clay	5	Mean of two highest values 28.7 (range <10 to 31.6)	Mean of minimum value 6.35 (range 6.1-6.8)	Static
Natural sand	1	23.3	6.6	Mobile

Table 9 - Summary of Geotechnical Analysis

Strata	No. of samples analysed	Plasticity Index (modified)	Passing <425 micron
		%	%
Clay	8	20.46 – 25.38	93 - 100

18.3 General Interpretation

Groundwater Mobility

Natural clay – Static
Natural sand – Mobile
Natural gravel - Mobile

Frost Susceptibility

Natural sand – assumed potential for more than 10% of silt within granular samples – frost susceptible

Shrinkage Potential

Clay – Medium

Soil/Groundwater Classification

Based upon Table C1 and D1 of BRE Special Digest 1 (2005), the Design Sulphate (DS) class, Aggressive Chemical Environment for Concrete (AC) class, and Design Concrete (DC) class for each of the strata types, except pyritic mudstone is given below: -

Natural clay – DS-1, AC-1s, DC-1
Natural sand – DS-1, AC-1, DC-1
Natural gravel (assumed) - DS-1, AC-1, DC-1

Any fill material to be imported onto the site should be tested and should not exceed the classifications given above.

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Based upon the above classification, the ready-mixed concrete (designated mix) appropriate for Design Class DC-1, for the natural ground would be as detailed in Table 10.

Table 10 - Sub-Structure Ready Mix Concrete Designations by End Use Over the Entire Site

<u>Use as substructure and ground floors</u>	<u>Ready-mixed concrete (designated mix)</u>
General Use:	
• Rough blinding (non-structural)	- GEN1
• Infill	- GEN1
• Unreinforced oversite concrete below timber floors	- GEN1
• Structural blinding and overbreak	- GEN1
• In situ external concrete for drives and paths	- PAV1
• In situ external concrete foundations for precast concrete paving slabs	- GEN1
• Fill to wall cavity	- GEN1
• Solid filling under steps	- GEN1
Floor Slabs:	
• House or garage with reinforced concrete floor slab, either suspended or precast.	- RC35
• House with non-reinforced slab (ground bearing) with either:	
a) Permanent finish to be added, e.g. screed or floating floor.	- GEN1
b) No permanent finish to be added, e.g. carpet.	- GEN2
• Garage with non-reinforced slab (ground bearing)	- GEN3
Foundations:	
• Strip foundations	- GEN1
• Trench fill	- GEN1
• Other mass concrete foundations	- GEN1
• Reinforced concrete footing	- RC35

Notes:

- 1) Worst case sulphate conditions over the entire site are ACEC Class AC-1/AC-1s, and Design Chemical Class DC-1.
- 2) Classification and designation in accordance with NHBC guidance, Section 2.1 – Table 1, and BS8500-1, 2006.
- 3) The above conditions represent the worst case conditions identified within the testing of soils on the site.
- 4) Any fill material to be imported onto the site should be tested and should not exceed the classifications given above.

18.0 Trees

- 18.1 Hedges and mature/semi mature trees were noted lining the site and internal field boundaries, these having been surveyed by Urban Green, in a tree survey, Reference No. UG2898, dated 18th February 2025 (see Appendix 12). The assessment was completed in order to inform the design layouts and aid in the proposed impact of the development on the trees and vegetation. 1 No. TPO was recorded on the eastern site boundary.
- 18.2 Clay was encountered across the majority of the site below the made ground (similar to topsoil), with localised sand and gravel strata, some overlying the clay others below the clay. Shallow bedrock was encountered in many of the exploratory hole locations. Based on the general nature of the clays, they may be subject to influence by changing moisture content associated with tree roots. The soils may be affected where existing tree roots are removed or their roots severed by construction foundations, which would cause rehydration of clay subsoils and subsequent swelling of the clay or 'heave' in clays with plasticity. Likewise, they may be impacted by the growth of immature or semi-mature trees, where the root ball expands and can cause the clay beneath foundations to shrink causing subsidence.
- 18.3 The geotechnical results demonstrated the clay to have a medium shrinkage potential, based on the modified plasticity index results. The deeper sand and gravel strata and shallow bedrock may reduce the depth of tree influence in places.

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19.0 Ground Floor Slabs

19.1 General Requirements

Based upon the developer's general commercial preferences for floor slab construction, plots are more likely to be constructed with a suspended cast in situ floor slab, with precast (block and beam) floor slabs used where plots are in the zone of tree influence with heave precautions required.

19.2 Gas Precaution Measures

Based on the ground gas risk assessment undertaken to date and the current planning layout (see Persimmon Homes North West Planning Layout Drawing No. ARCH/PL/PH2 RevW, presented in Appendix 15), no ground gas precaution measures will be required for any of the plots on site.

19.3 Heave Precautions

Based upon the ground conditions and assuming the clay has a medium shrinkage potential, properties may be liable to heave. Should these be constructed with a suspended precast floor slab, these will require a sub floor void of 250mm.

20.0 Foundations

20.1 General

The locations of the exploratory holes are shown on Coopers Drawing No. 8512/01 in Appendix 15. Copies of the exploratory hole logs are presented in Appendices 2 to 6.

20.2 Development Proposals

The future development is proposed to consist of 134 No. residential dwellings of traditional detached, semi-detached and mews residential houses, 1 and 2 storeys in height. A proposed site layout is recorded on Persimmon Homes North West Planning Layout Drawing No. ARCH/PL/PH2 RevW, presented in Appendix 15.

Clay will provide a suitable bearing capacity of at least 100kPa below the made ground (similar to topsoil) across the majority of the site, with some localised shallow clays providing equivalent bearing capacities below this. Depending on the proposed site levels, localised mixed bearing strata comprising sand interbedded within the clay may be founded on for some plots. Where tree influence draws the foundations down, foundations may be taken to bedrock. In such cases, it will be required to ensure that the whole foundation is on the bedrock, in order to avoid differential settlement.

It is assumed that all materials and workmanship will comply with the Building Regulations and the NHBC Standards. Site levels are to be increased across the majority of the site. Therefore, foundation recommendations have been based on proposed ground levels.

Where private drainage is proposed to be laid, careful consideration must be given to the relative levels of the foundations and the drainage pipework. This information needs to be reviewed to ensure that no foundations are being undermined by drainage pipework and that no foundation loads are being applied to the drainage pipework.

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20.3 Tree Influence

As outlined in Sections 18.0 and 19.0, the clay strata, where present, are subject to volumetric change associated with trees with special precautions required for heave, where plots are located within the zone of tree influence.

20.4 Bearing Strata and Safe Bearing Capacities

Based upon the findings of the intrusive investigation and subject to finalised layout proposals we would anticipate that bearing strata would consist of the following:

- Assumed loose to medium dense sand – 100kPa
- Firm clay – 100 kPa
- Firm to stiff clay – 125 kPa
- Stiff clay - 150 kPa
- Very stiff clay - >150 kPa
- Weathered bedrock - >250kPa

For design purposes, an allowable safe bearing capacity of 100kPa has been used for all strata types.

20.5 Minimum Formation Depths

The assumed minimum foundation depths relative to proposed ground level should be assumed for the following strata types:

- Foundations on natural clay strata – 900mm
- Foundations on natural sand, gravel and bedrock – 600mm

20.6 Foundation Recommendations

All foundations and floor slabs for the plots should be specifically designed by a Structural Engineer once the planning layout, external works and slab level requirements have been finalised. Reference will need to be made to the specific house type drawings once completed for details. The following options are conjectured for the proposed development area based upon depth to bearing strata relative to proposed ground level. It should be noted that the proposals have not accounted for deeper remnant land drains. Drawing No. 8512/Fd/01RevA and 8512/Fd/02RevA have been included within Appendix 15 which illustrate the specific proposed foundation types based on the current planning layout and externals drawings. Reference should also be made to specific house type /plot footing plans to be prepared by the Structural Engineer.

The foundations have been recommended as follows:

- For properties founded entirely on **firm, firm to stiff and stiff clay at less than 1.2m depth from proposed ground level**, we would recommend the adoption of the following: -

Traditional Strip Foundations

- o Safe bearing capacity limited to 100kPa in firm, firm to stiff and stiff clay, taking account of the general structural design, although the clays may provide a greater safe bearing capacity in places.
- o Formation must be consistent strata (not partially founding on sand).
- o Minimum foundation depth of 0.9m below proposed ground level, (due to medium shrinkage potential clays - although deeper foundations will commonly be required to take account of services over strip foundations).

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- o Where foundation depth varies the foundations should be stepped in accordance with NHBC Standards.
- o Footing widths/thickness subject to engineering designs for house types by structural engineers.
- o The strength of the clay sub-grade is critically dependant on its moisture content and is likely to deteriorate and soften quickly if allowed to become wet, with a resultant reduction in undrained shear strength and safe bearing capacity.
- For properties founded entirely on **firm, firm to stiff, stiff and very stiff clay at less than 1.2m depth from current/existing ground level and >1.2m to proposed slab level**, where additional blockwork is required to raise levels, we would recommend the adoption of the following: -

Deep Traditional Strip Foundations

- o Safe bearing capacity limited to 100kPa in firm, firm to stiff, stiff and very stiff clay, taking account of the general structural design, although the clays may provide a greater safe bearing capacity in places.
- o Formation must be consistent strata (not partially founding on sand).
- o To be used where the depth from existing ground level to formation level is less than 1.2m but from slab level, due to land raising, is greater than 1.2m but less than 3.0m.
- o Blockwork to be built up to proposed ground level, backfilling either side of the blockwork in even layers no more than 450mm thick, in accordance with NHBC guidelines.
- o Where foundation depth varies the foundations should be stepped in accordance with NHBC Standards.
- o Footing widths/thickness subject to engineering designs for house types by structural engineers.
- o The strength of the clay sub-grade is critically dependant on its moisture content and is likely to deteriorate and soften quickly if allowed to become wet, with a resultant reduction in shear strength and safe bearing capacity.
- For properties founded on **firm, firm to stiff, stiff or very stiff clay OR bedrock at greater than 1.2m depth but generally less than 2.5m from proposed ground level, with no heave precautions**, we would recommend the adoption of the following:

Mass Concrete Trench Fill

- o Safe bearing capacity limited to 100kPa in firm, firm to stiff, stiff and very stiff clay or bedrock taking account of the general structural design, although the clays and bedrock may provide a greater safe bearing capacity in places.
- o Foundation widths subject to engineering designs for house types by structural engineers.
- o The viability for deeper mass concrete trench fill is largely determined by trench stability.
- o If difficult to construct deeper trenches due to side wall instability then contact Coopers to advise on alternative options.
- o Where influenced by trees the formation depths should take into consideration the minimum depth required in cohesive strata due to tree influence.
- o Where foundation depth varies the foundations should be stepped in accordance with NHBC Standards.
- o It is considered feasible to step up from trenchfill foundations into traditional strip foundations of less than 500mm thickness. Alternatively, if the trenchfill is continued throughout the foundation, this would need to be a minimum thickness of 500mm.
- o Where bedrock is encountered in the foundation then the foundations should be taken to bedrock across the whole plot.

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- For properties based on founding strata of **firm, firm to stiff, stiff and very stiff clay at depths greater than 1.2m and generally less than 2.5m from proposed ground level, in the zone of tree influence**, we would recommend:

Mass Concrete Trench Fill with Heave Precautions

- Safe bearing capacity limited to 100kPa in firm, firm to stiff, stiff and very stiff clay, taking account of the general structural design, although the clays may provide a greater safe bearing capacity in places.
 - Foundation widths subject to engineering designs for house types by structural engineers.
 - The viability for deeper mass concrete trench fill is largely determined by trench stability.
 - If difficult to construct deeper trenches due to side wall instability then contact Coopers to advise on alternative options.
 - Where influenced by trees the formation depths should take into consideration the minimum depth required in cohesive strata due to tree influence.
 - Where tree heave influence is recorded, due to medium shrinkage potential clay, compressible materials to allow for 25mm compression against the mass concrete trench fill foundation will be required. A 250mm minimum void will be required beneath the block and beam floor slab.
 - Where foundation depth varies the foundations should be stepped in accordance with NHBC Standards.
 - It is considered feasible to step up from trenchfill foundations into traditional strip foundations of less than 500mm thickness. Alternatively, if the trenchfill is continued throughout the foundation, this would need to be a minimum thickness of 500mm.
 - Should bedrock be encountered in the foundation then the foundations should be taken to bedrock across the whole plot.
- For properties where the **depth to suitable bearing strata is typically >2.5m below proposed ground level, and within areas of tree influence with heave potential**, we would recommend:

Piled foundations and associated ground beams with heave precautions:

- The determination of the number of piles (and therefore the loads) against pile length is largely commercial and typically determined by the contractors. It is assumed that piles would need to be anchored into the shallow bedrock encountered. Therefore, precast concrete driven piles are unlikely to be suitable.
- Cable percussive boreholes with possible follow on rotary boreholes are likely to be required for pile design purposes to 5m depth below the predicted pile length.
- Piling platform to be designed in accordance with BR470 and subject to the rig specifications.
- Confirmation should be sought from the local authority regarding noise or vibration issues associated with driven piles.
- Heave precautions required, including installation of compressible material under the ground beams to be designed for 100mm of compression and 25mm compressible material on the inside face of external ground beams.
- Floor slabs require the inclusion of subfloor heave mitigation (250mm minimum void beneath block and beam floor slab).

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21.0 Trench Side Stability

- 21.1 The natural clays, sands and gravels encountered would be expected to remain stable in the short term but may become unstable after being left open over longer periods of time. The sands and gravels may become unstable during or shortly after excavation. This will also be highly dependent on the weather conditions at the time of excavation as well as the period of time the trench is left open.
- 21.2 Should trenches need to remain open for longer periods or require manned entry then they should be supported at all times or, where suitable, battered to the angle of repose of the soil. Battering of excavations should be avoided in the proximity of trees proposed for retention and existing structures without assessment from experienced engineering personnel.
- 21.3 Trench excavations for foundations/services must be adequately supported at all times and should be in accordance with the recommendations of CIRIA Report 97: Trenching Practice.
- 21.4 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.
- 21.5 Shallow excavations, even within the bedrock, are likely to be within the capacity of conventional hydraulic plant. However, the capability for a conventional hydraulic excavator to excavate deeper into bedrock is unknown. This may require further investigation to assess the capabilities of laying the trenches for the sewers and potentially shallower services.

22.0 Dewatering

- 22.1 Deep excavations and service/drainage trenches may require dewatering in areas where water ingresses are likely to occur. Groundwater accumulation at the base of the trial pits was encountered in ITP401 and TP307.
- 22.2 If former/existing drainage runs are encountered during the excavation of either foundations or service/drainage trenches these will need to be immediately diverted around the excavation and proposed plot footprints, and the excavations may require localised dewatering where breached.
- 22.3 It is anticipated that surface runoff from the site itself may accumulate in open excavations and trenches, and may require dewatering.
- 22.4 Groundwater should not be discharged into the existing sewer system or Cecilly Brook without prior agreement from the Environment Agency and the Local Authority. Precautions will need to be taken to prevent run off containing silt from the site into the brook.
- 22.5 It should be noted that seasonal factors may affect changes in groundwater levels at the site. Consequently, dewatering may be necessary in the winter or at times of prolonged rainfall for shallow foundations or drainage trenches.
- 22.6 Further guidance can be obtained from the CIRIA Report 113 entitled “Control of Groundwater for Temporary Works”.

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23.0 Potential Infiltration

The glacial clays are characterised by having a very low permeability, where traditional soakaways for surface water drainage is not viable. This was confirmed by the Coopers undertaking an infiltration test pit at ITP401 in the area of the proposed balancing pond. Reference should be made to Appendix 13 for the details of the test undertaken. In summary, the first of three tests failed, with the water not draining from the pit but in fact increasing in depth, either from surface water drainage or from the ingress of groundwater seepage.

In addition, it can be justified that infiltration systems would not be geotechnically suitable due to the shrink-swell behaviour associated with changes in moisture content in the clays, causing settlement problems, as detailed in CIRIA C753 “SuDS Manual 2015”.

24.0 Outline Summary of Earthworks Proposals

- 24.1 The external drawing has indicated that there is likely to be temporary cutting and filling required in areas of the site. Should upfill be greater than 1.0m, the NHBC will commonly require an earthworks specification and testing to ensure settlement is not significant.
- 24.2 Where it is proposed to raise ground levels, consideration should be given to the suitable compaction of soils to facilitate the end use, in accordance with NHBC Standards Chapter 4.6. Placement of an engineered fill typically requires a site-specific earthworks specification, based upon the tested physical properties of the intended soils for use and the type of compaction plant.
- Additional geotechnical testing is required for classification of either site won or imported soils to aid in the preparation of the earthworks specification. Materials intended for reuse or importation and use within the earthworks will need to be classified in accordance with Series 600.
- 24.3 Where cohesive materials are intended for placement, we would advocate these are placed shortly after excavation or placed during summer months (as suitable compaction requires soils to not exceed their optimum moisture content).
- 24.4 Upon completion of cut and fill models we would recommend holding discussions with the NHBC to determine what information would be required for any intended earthworks and provide this information at least 8 weeks prior to the intended start of works.

25.0 Road and Parking Bay Sub-Grade

- 26.1 Following the made ground (similar to topsoil) removal, the anticipated access roads and car parking sub-grade materials are likely to generally comprise between firm, firm to stiff and stiff clay. Depending on the final site levels, localised loose to medium dense sand, gravel or bedrock may also provide a sub-grade material.
- 26.2 In accordance with Volume 7, Section 2 of the Department of Transport, Departmental Standard Interim Advice Note 73/06 Revision 1 – Design Manual for Roads and Bridges, and Plasticity Index values of firm, firm to stiff and stiff clay on this site, the clay subgrade is estimated to have a CBR of between 2.5% to 5%. It is estimated the loose to medium dense sand strata would provide a CBR of between 5% and 10%. Where soft and soft to firm clays be encountered, these would require removal. Testing is recommended at time of construction, following attainment of site levels.

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- 25.3 Proposals are subject to the review by the Staffordshire Council Highways Department. However, we would recommend that all sub-grade materials are in situ CBR tested at proposed road formation level prior to final pavement design.
- 25.4 It is recommended that if initial roads and sewer construction is proposed to commence during the winter months then a longer period should be allowed for construction due to the potential for weather disruptions to the site.

26.0 Further Actions

- It had been recommended that any geotechnical test pits required along the former tramway following the southern site boundary should be monitored by an archaeologist and a geophysical survey should be conducted to locate the line of the tramway.
- Further investigation may be required to assess the capabilities of laying the trenches for the sewers and potentially shallower services within the bedrock.
- Submit this site investigation report to Staffordshire Council in support of the planning application and to the NHBC for approval.
- An Earthworks Strategy Report may be required in respect of the cut and fill process on site, subject to finalised external works proposals.
- If not already completed, undertake an invasive plant survey and an ecological survey concerning protected species if recommended by a specialist contractor.
- Due to the presence of services within and adjacent to the site, consultations should be held with service providers regarding plans to adopt, divert, or abandon the services. It would be prudent to obtain a survey of all drains, manholes and subterranean structures, if present, to confirm their line, depth and condition prior to undertaking any works.
- Cable percussive boreholes and potentially rotary boreholes to determine pile designs, where pile foundations are required.
- Completion of the ground gas monitoring and risk assessment for approval by the Local Authority and NHBC.
- Should the direct transfer of subsoil or topsoil be required to the site, or reuse of site won made ground (similar to topsoil), this would require the application of either a U1 exemption or an MMP, depending on the volumes to be imported/reused.
- If surplus strata require offsite removal by direct transfer to another development site, they will require testing to confirm suitability for the intended end use at the receiving site. Where strata are intended for landfill they may require testing for Waste Acceptance Criteria (WAC).