

Phase 1&2 Site Investigation

Land at New Farm, Warminster



E05548

Barratt Homes Bristol

Phase 1 & 2 Ground Investigation

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Land at New Farm, Warminster

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Executive Summary

Client	Barratt Homes Bristol
Site	Land at New Farm
Location	Westbury Road, Warminster, BA12 0AL. NGR 386797, 146843.
Approximate area	9.9Ha total site area.
Topography	Elevations range from approximately 125m OD in the south east to 114m OD in the north west.
Current land use	Farmland.
Proposed development	Low rise residential with associated highways, drainage and public open space.
History of Site & Surroundings	In summary the site has been agricultural farmland since earliest available maps from 1886. Key off site features included the Warminster Gas Works from 1886 to 1992. Continual development of residential housing to the south from 1941 to present day. Also, continual expansion of Calloway Farm from 1941 until it became New Farm circa 1973 to present day.
Geology	Superficial deposits of Alluvium in the north west over West Melbury Marly Chalk Formation.
Radon	No radon protective measures are required.
Hydrogeology	Bedrock Geology: Principal aquifer Superficial Deposits: Secondary A aquifer The site lies within a source protection zone. The nearest licensed groundwater abstraction lies 334m north east. Groundwater is considered to be of high sensitivity to any potential on site contamination.
Hydrology	Surface water features include two adjoining minor inland rivers in the north west section of the site. Therefore, the potential sensitivity of these receptors is deemed to be high.
Landfill sites	No landfills located within 250m of the site.
Previous site investigations	Clarkebond have not been made aware of any previous investigations undertaken at this site.
This site Investigation	Six windowless sampler boreholes with 3 x 50mm gas and groundwater monitoring wells. Twenty-Five machine excavated trial pits with six infiltration tests.
Monitoring	One gas and groundwater level monitoring visit.
Ground conditions	A thin mantle of soft to firm clay and silt over medium dense to dense gravel of the weathered West Melbury Marly Chalk Formation or intact chalk bedrock.
Foundations	Traditional foundations should be suitable, constructed in the gravel or chalk bedrock. Bearing capacity of 120kPa in gravel and 200kPa in bedrock.
Shrinkable soils	Shallow clay and silt soils are medium volume change potential.
Buried concrete	DS1 & AC1.
Floor slabs	Suspended floors recommended.
Gas protection	No gas protection measures required. No radon protection measures required.
Slope stability	Gradients are considered generally stable but careful assessment of changes of elevation or construction near existing slopes would still be needed.
Pavement	Design CBR value of 5% in gravel and bedrock, less than 2.5% in clay and silt.
Soakaways	Underlying geology unlikely to be suitable for soakaway drainage.
Contamination Considerations	No risks to human health, plants, or groundwater have been found on site. PE and PVC water supply pipes should be acceptable.

1 Introduction

1.1 Brief

Clarkebond (UK) Limited was commissioned by Barratt Homes to undertake a Phase 1 & 2 Ground Investigation on a site known as New Farm, Westbury Road, Warminster, BA12 0AW.

The client's brief was to carry out a Phase 1 Desk Study for the site, followed by a Phase 2 investigation to identify foundation requirements and whether any significant contamination is present.

The objectives of the investigation were to determine the sub-surface conditions in respect of:

- Foundations for proposed structures.
- Floor slabs.
- Design guidance for road construction.
- Soakaway potential.
- Contamination assessment to consider potential significant pollutant linkages arising from the historic land uses on and off site.

1.2 Proposed Development

It is understood that the site is being considered for residential redevelopment circa 200 properties of traditional construction together with associated infrastructure. A provisional development layout has been provided by Barratt Homes (reference drawing number 0736-1002 dated February 2021) and is presented in Appendix A.

1.3 Previous Investigations

Clarkebond have not been made aware of any previous investigations that have been undertaken at this site.

1.4 Limitations

This report is provided for the benefit only of the party to whom it is addressed, and we do not accept responsibility to any third party for the whole or any part of the contents and we exercise no duty of care in relation to this report to any third party.

Where intrusive investigations have been completed, information, comments and opinions given in this report are based on the ground conditions encountered during the site work and on the results of laboratory and field tests performed during the investigation. However, subsoils are inherently variable and hidden from view such that no investigation can be exhaustive to the extent that all soil conditions are revealed. Conditions may therefore be present beneath the site that were not apparent in the data reviewed as part of this assessment. In particular, it should be noted that groundwater levels vary due to seasonal and other effects, and may at times differ to those measured during the investigation.

This assessment has been based to a large extent on data acquired from Third Parties. This data has been taken at face value and has not been subjected to any third party validation.

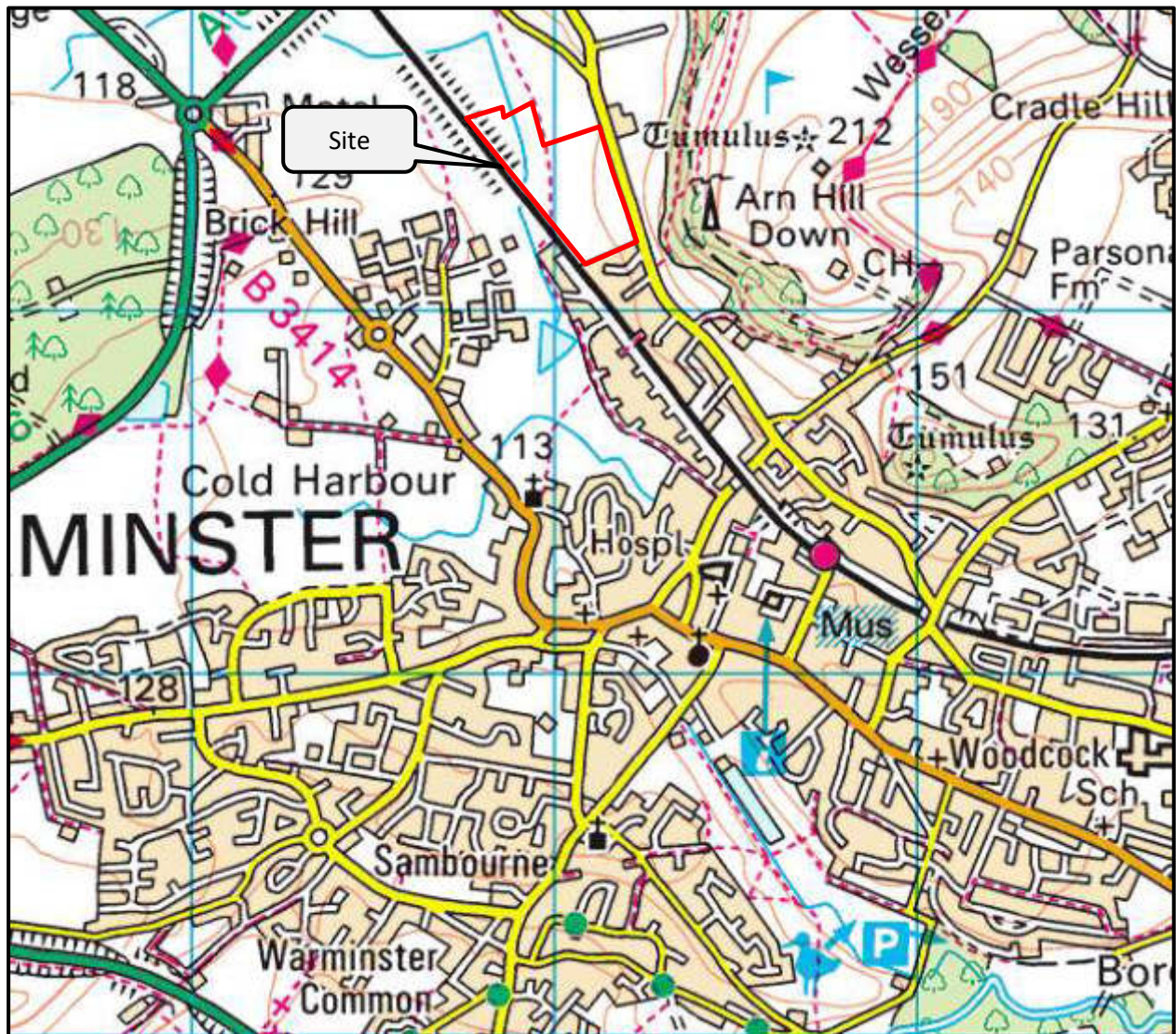
Unless specifically noted to the contrary, it should be assumed that this report has not been submitted to any regulatory authorities for approval. Redevelopment sites in particular may have planning conditions attached in respect of contaminated land assessment. Where we are made aware of such conditions in advance of scoping the works, we can tailor the report to the regulatory authority requirements. Where we are not made aware of any such requirements there can be no certainty that our investigation will meet any or all of the regulatory authority requirements.

2 Site Setting

Site Address:	New Farm, Westbury Road, Warminster, BA12 0AW
National Grid Reference:	E387072, N146323

The site is located approximately 1km north of Westminster town centre Figure 2.1 below.

Figure 2.1 Site Location



2.1 Site Description

A site walkover survey was undertaken in January 2021 by Clarkebond. Access to the site is gained via the field gate directly opposite New Farm along Westbury Road.

- The site consists of three separate agricultural crop fields divided by hedge lines and covers an area of approximately 9.9Ha.
- The site generally slopes down to the west towards the adjacent railway line.

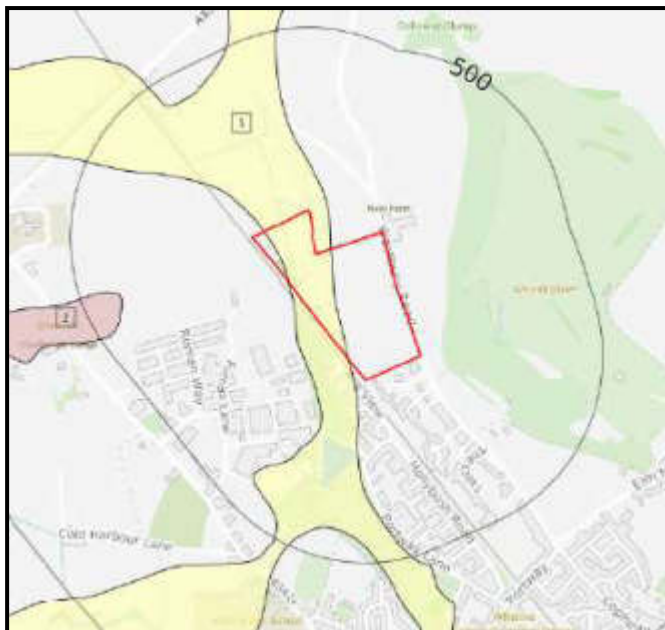
- The current surface comprises exposed topsoil and/or grassland.
- A stream was noted intersecting the north west corner of the site.
- A pond fed by the stream is located in the north west corner of the site surrounded by trees and shrubs.
- A number of unidentified mature trees are located around the field boundaries.
- The site is bounded to the north by further agricultural farmland, to the east by farmland with a golf course beyond, to the south by residential housing and to the west by a railway line with an industrial estate beyond.

2.2 Geology

The geology of the site is shown on maps obtained from the Groundsure report which are extracted from the British Geological Survey Digital Geological Map of Great Britain at 1:50,000 scale.

This indicates that the site is directly underlain by Alluvium (Superficial) in the north western part of the site, as shown in Figure 2.2 below.

Figure 2.2 Superficial Strata (Groundsure Report)



The bedrock geology of the site consists of the West Melbury Marly Chalk Formation. This is of Cenomanian Age.

Historical exploratory hole records available from the BGS show that a recorded borehole is located on site toward the northern boundary. This borehole encountered natural topsoil over Alluvium comprising light grey, brown friable silty clay to 2.00m. This was underlain by moderately weathered light grey silty chalk to >6.0m.

2.3 Hydrology and Hydrogeology

Surface water features include two adjoining minor watercourses in the north west part of the site. Therefore, the potential sensitivity of these receptors is deemed to be **high**.

It is estimated that groundwater flows under the site from approximately north to south.

Guidance from the Environment Agency indicates that the bedrock formation is designated as a Principal Aquifer and the superficial strata as a Secondary A aquifer. As such the groundwater sensitivity is regarded as **high**.

The site is located within a Source Protection Zone (SPZ) (Zone 2), the nearest licensed groundwater abstraction lies 334m north east and thus is of moderate sensitivity.

2.4 Radon

The Groundsure report states that the site is in an area where the estimated probability of homes being above the action level of 200Bqm^{-3} is less than 1%. Therefore no radon protective measures are required in the construction of new buildings.

2.5 Site History

Historical maps of the site area have been obtained via Groundsure. Pertinent information determined from review of these maps, as well as other publicly available aerial imagery, is set out in Table 2.1 and the maps are contained in Appendix B.

Table 2.1 Historic Mapping Review

Date	On-site	Off-site
1886	The site is occupied by agricultural farmland.	- A railway line running adjacent to the western site boundary. 'Warminster Gas Works' located approx 300m south west. 'Warminster Lime Kiln' located approx 400m south east. - A 'Well' located approx 50m west beyond the railway line.
1899	No significant changes.	The 'Well' noted to be no longer indicated on mapping.
1941	No significant changes.	'Calloway Farm' located just 20m north east of the site boundary. - Residential housing noted adjacent to the southern site boundary.
1973	No significant changes.	'Calloway Farm' now identified as 'New Farm'. 'Poultry House' is identified 200m west. - A large unidentified cutting/pit is located adjacent to 'Poultry House'. - Pumping stations identified approx. 400m north east of the site.
1992	No significant changes.	Further expansion of residential dwellings to the south of the site.

		• 'Warminster Gas Works' noted to be no longer present.
2010	No significant changes.	• Development of an industrial estate approx. 150m south west.
2021	No significant change.	• Further expansion of the industrial estate.

In summary the site has been agricultural farmland since earliest available maps from 1886.

Key off site features included the Warminster Gas Works from 1886 to 1992. Continual development of residential housing to the south from 1941 to present day. Also, continual expansion of Calloway Farm from 1941 until it became New Farm circa 1973 to present day.

2.6 Environmental Database

An environmental data report was commissioned from Groundsure to provide an indication of the site history and surrounding land uses available on the public registers. The reports provide data from a number of service providers, including the British Geological Survey, Environment Agency and Natural England. The Groundsure report is included in Appendix C.

The location of data point references is provided relative to the site boundary and the search radius extends 1km from it.

The following table provides a summary of which data reference points are considered significant, together with an indication of the potential hazard type.

Table 2.2 Environment Data Review

Data Type	Distance from site	Potentially Significant Hazard
Discharge consents	24m SE	Residential treated Sewage to Soakaway
	103m SE	Residential treated Sewage to Soakaway
	132m SE	Residential treated Sewage to Groundwater via Soakaways
	174m SE	Residential treated Sewage to Soakaway
Groundwater Abstractions	334m NE	Wessex Water – Active Borehole abstraction – potable water supply.
	356m NE	Wessex Water – Active Borehole abstraction – potable water supply.
Licensed Waste Management Facilities	218m NW	Twyford House – Active Waste Transfer Station
	239m SW	Furnax Lane -Active Household/Commercial/Industrial Waste Transfer Station.
Historical Mining	On Site	Chalk Mining – Sporadic underground mining may have occurred, however potential for difficulty ground conditions is unlikely.
	347m E	Warminster Quarry – Surface Chalk mining – ceased.
	476m E	Arn Hill Down Quarries – Surface Chalk mining - ceased.
Surface ground workings	24m SW	Unspecified heap
	48m SW	Refuse Heap

	55m SW	Refuse Heap
	110m SW	Refuse Heap
	137m SE	Cuttings
	146m SE	Cuttings
Potential for collapsed ground stability hazards	On Site	Very Low Risk
Potential for compressible ground stability hazards	On Site	Moderate Risk – Relating to the superficial deposits on site.
Potential for shrinking or swelling ground stability hazards	On Site	Very Low risk

2.7 Soil Geochemistry

The Groundsure report includes “Normal Background Concentrations of Contaminants in English Soils which indicates the typical estimated concentrations of each determinant in topsoil in the locality of the site, as shown in Table 2.3.

Table 2.3 Summary of BGS Estimated Soil Geochemistry

Determinant	Concentration (mg/kg)
Arsenic	15
Cadmium	1.8
Chromium	60-90
Lead	100
Nickel	15

None of the elements exceed the Land Quality Management Generic Assessment Criteria (LQM GAC) for "Residential with Plant Uptake" end use.

3 Site Investigation

The intrusive investigation was proposed by Clarkebond. No contamination or geotechnical risks that required specific investigation were identified from the desk study and site walkover. Consequently, the positions of the exploratory holes were intended to provide a reasonable coverage of the site for an assessment of general ground conditions.

The investigation was undertaken in January 2021. The intrusive works comprised the following:

- Six windowless sampler boreholes.
- Ground & gas monitoring wells installed in three boreholes.
- Twenty-five machine excavated trial pits.
- Seven BRE soakaway tests.

The procedures followed in this site investigation are based on BS 5930:1999 + Annex 2:2010 - Code of Practice for Site Investigations. The soils and rocks encountered have been described in accordance with BS5930:1999 + Annex 2:2010 and BS EN ISO 14688-1:2002 and BS EN ISO 14689-1:2003.

The approximate positions of the exploratory holes are shown on the Exploratory Hole Location Plan Drawing E05548-CLK-XX-XX-DR-GE-0001 P01 in Appendix D and the exploratory hole records are included in Appendix E.

3.1 Windowless Sampler Boreholes

Six boreholes (WS01 to WS06) were formed to depths of between 1.0m and 2.10m bgl using windowless sampling techniques in order to obtain samples for laboratory testing and to provide geotechnical information for foundation design.

Representative disturbed small (1kg) and environmental (identified on the borehole logs as D and ES) samples of the soils encountered were obtained at regular intervals.

Standard Penetration Tests (SPTs) were carried out at metre intervals using either a split spoon sampler or a solid 60° cone. The results of these tests are given as a Standard Penetration “N” value or as a blow count for a given penetration on the borehole logs.

A detailed description of all strata and groundwater encountered, samples, in situ tests and other pertinent information observed are included on the borehole logs in Appendix E.

3.2 Trial Pits

Twenty-five trial pits (TP01 to TP25) were excavated to depths varying between 1.65m and 2.30m below ground level (bgl) using a wheeled backhoe excavator.

The profiles of strata or other features were recorded as excavation proceeded and measurements taken from ground level. Representative samples were taken, where appropriate, for laboratory analysis. Detailed descriptions of the strata encountered, groundwater observations and excavation stability notes, together with any other pertinent information observed, are included on the trial pit records, which are included in Appendix E.

3.3 Infiltration Testing

In order to determine the permeability of the ground to assess the suitability of soakaways for drainage at the site, infiltration testing was undertaken in six machine excavated trial pits (TP03, TP04, TP05, TP06, TP07, TP16).

Each pit was partially filled with water with the rate of inflow sufficiently rapid so that the pit was filled in a short time. The rate of dissipation was then monitored to obtain a plot of water level over time. Three full cycles of testing were undertaken, in accordance with BRE 365 (2016).

Variations in soil conditions, areas of filled land, preferential underground seepage routes, variations in the level of groundwater and any geological factors likely to affect the long-term percolation and stability of the area surrounding the soakaway were assessed.

The results of the infiltration testing are presented in Appendix F.

3.4 Installations

Gas / Groundwater monitoring wells were installed into three of the six boreholes on completion, as detailed in Table 3.1. The wells were designed to allow monitoring of shallow groundwater within the bedrock. The response zone comprised slotted pipe with a 10mm inert gravel surround. The strata above the response zone were sealed with bentonite.

Table 3.1 Summary of Monitoring Installations

Hole	Base (m bgl)	Dia. (mm)	Response Zone (m bgl)	Headworks
WS02	2.00	50	1.00 to 2.00	Gas valve, flush locked cover
WS05	1.00	50	0.50 to 1.00	Gas valve, flush locked cover
WS06	1.00	50	0.50 to 1.00	Gas valve, flush locked cover

All remaining exploratory holes were backfilled with arisings and the ground surface reinstated.

The monitoring results are included in Appendix G.

4 Laboratory Analysis

Samples obtained during the investigation were subjected to a range of geotechnical and chemical testing at appropriate accredited laboratories.

Samples were submitted for geotechnical laboratory testing to characterise the engineering properties of the soil. The following testing was scheduled:

- 7 x Atterberg Limits
- 6 x Particle Size Distribution
- 14 x Moisture Content
- 1 x 4.5kg compaction
- 10 x BRE SD1 sulphate suite

Testing was carried out in accordance with the procedures outlined in BS EN ISO 14688-1:2018, 14688-2:2018 and 14689:2018 (i.e. Eurocode 7). Geotechnical laboratory test data is presented in Appendix H.

Soil samples were sent for chemical analysis to i2 Analytical laboratories to be analysed for:

- 4 x Full suite comprising arsenic, cadmium, copper, chromium, lead, mercury, nickel, selenium, zinc, Speciated PAH, speciated Total Petroleum Hydrocarbons (TPHCWG), Soil organic matter content (SOM), pH and soluble sulphate.
- 4 x Screen suite comprising arsenic, cadmium, copper, chromium, Chromium VI, lead, mercury, nickel, selenium, zinc, Speciated PAH, TPH banded, Soil organic matter content (SOM), pH and soluble sulphate.
- 5 x Metal Suite
- 2 x Organophosphorous Pesticides and Herbicides

The chemical laboratory test results are presented in Appendix I.

5 Ground Conditions

5.1 General

The results of this investigation were consistent with the anticipated geology.

A summary of the strata encountered is presented in Table 5.1 and discussed in sections 6.1 to 5.7. For full details of the strata encountered reference should be made to the exploratory hole logs in Appendix E.

Table 5.1 Ground Conditions – depth to base

Hole	Topsoil	Made Ground (TP23 only)	Silty/sandy gravelly clay (Head Deposits)	Clayey silty/sandy gravel (Weathered West Melbury Marly Chalk)	Chalk (bedrock)	Ground water
WS01	0.20		0.80	1.00*	-	Dry
WS02	0.20		1.10	2.00*	-	Dry
WS03	0.20		-	1.50*	-	Dry
WS04	0.30		-	1.30*	-	Dry
WS05	0.20		0.70	1.00*	-	Dry
WS06	0.15		0.90	1.10*	-	Dry
TP01	0.15		1.60*	-	-	1.50
TP02	0.15		0.80	1.80*	-	1.20
TP03	0.20		1.40	1.80*	-	Dry
TP04	0.30		0.60	-	1.50*	Dry
TP05	0.30		0.50	-	1.70*	Dry
TP06	0.25		1.00	-	1.90*	Dry
TP07	0.20		0.80		1.60*	Dry
TP08	0.20		0.80	1.80	2.00*	Dry
TP09	0.20		1.30	-	2.30*	Dry
TP10	0.15		0.70	-	2.00*	Dry
TP11	0.20		-	0.90	1.60*	Dry
TP12	0.10		0.80	2.00*	-	Dry
TP13	0.20		-	0.70	2.00*	Dry
TP14	0.10		1.70	-	1.80*	Dry
TP15	0.10		0.70	-	1.70*	Dry
TP16	0.15		0.80	-	2.00*	Dry
TP17	0.20		1.80	-	1.90	Dry
TP18	0.15		1.10	1.80*	-	1.80
TP19	0.20		0.80	1.60*	-	Dry
TP20	0.15		0.90	-	1.20	Dry
TP21	0.20		1.00	2.10*	-	Dry
TP22	0.15		0.80	1.40*	-	Dry
TP23	-	0.20	1.30	2.50*	-	Dry
TP24	0.15	-	-	2.00*	-	Dry
TP25	0.20	-	0.80	2.00*	-	Dry

* Base of hole

5.2 Topsoil

Topsoil was encountered in all of the exploratory holes to between 0.15 and 0.30m below ground level (bgl). The material generally consisted of a dark brown sandy silt with occasional rootlets.

5.3 Made Ground

Made Ground was only encountered in TP23 to a depth of 0.20m below ground level. The material consisted of dark brown sandy silt with brick fragments.

5.4 Head Deposits

The topsoil was underlain by the superficial geology of the Head Deposits. This material generally comprised soft to firm silty gravelly friable clay encountered to depths of 0.50m to 1.80m bgl.

5.5 Weathered West Melbury Marly Chalk Formation

The Topsoil and Head Deposits were underlain by the weathered solid geology of the Weathered West Melbury Marly Chalk Formation. This material was weathered to a dense to very dense silty/sandy clayey gravel (Grade Dc chalk). The base was encountered at depths ranging from 0.70m to 2.50m bgl.

5.6 West Melbury Marly Chalk Formation

The solid geology of the West Melbury Chalk Formation was present as intact chalk bedrock being encountered at depths of 0.90m to 2.50m bgl. This typically comprised moderately to highly weathered closely fissured very weak to weak light grey silty chalk with lenses of friable chalky clay (Grade C4).

5.7 Groundwater

Groundwater was only encountered in TP1, TP2 and TP18 during the intrusive works, at depths of 1.50m, 1.20m and 1.80m bgl respectively. These three pits are located in the lower lying north west of the site.

Monitoring of groundwater levels within the standpipes installed was undertaken on the 25th February 2021. The results are presented in Table 5.2.

Table 5.2 Groundwater Monitoring Results

Hole	WS1	WS2	WS6
Depth to water	0.71m bgl	Dry to 1.40m	Dry to 2.50m

5.8 Field Observations of Contamination

No visual or olfactory evidence of contamination was encountered.

6 Geotechnical Assessment

6.1 Proposed Development

It is understood that the site is being considered for redevelopment with low rise residential properties together with access roads, infrastructure and open spaces. A preliminary proposed development layout plan was provided by Barratt Homes, a copy of this is presented in Appendix A.

6.2 Summary of Ground Conditions

The investigation identified a thin mantle of soft to firm clay and silt over medium dense to dense gravel of the weathered West Melbury Marly Chalk Formation or intact chalk bedrock.

During subsequent monitoring of the standpipes, groundwater was recorded at a depth 0.71m in WS01 in the lowest part of the site. Boreholes WS2 and WS6 were dry to the base at 1.40m and 2.50m bgl respectively.

6.3 Shrinkable Soils

Cohesive soils (clay and silt) may undergo volume change when subject to changes in moisture content. This can cause ground movement of soils where seasonal changes or tree root action affect the moisture content. Where foundations are constructed in such soils these movements can lead to damage of the superstructure. These movements are greatest where trees are removed or tree root systems are severed as this allows the soils to regain their equilibrium moisture content resulting in expansion.

The NHBC (National House Building Council) has derived minimum foundation depths and other precautions relating to ground movements in shrinkable soils. These standards are set out in NHBC Chapter 4.2 "Building Near Trees" (2017) and are commonly adopted for both residential and non-residential structures.

The Modified Plasticity Index is related to volume change potential. Shrinkable soils are generally considered as clays having a modified plasticity index (I_p) of 10% or greater. The Modified Plasticity Index is defined as the Plasticity Index (I_p) of the soil multiplied by the percentage of particles less than 425 μ m. Soils containing less than 35% fine particles ($< 63\mu$ m) are non-shrinkable.

The modified plasticity indices of seven soil samples of the natural clay strata ranged from 17% to 33%.

On the basis of the modified plasticity index the shallow cohesive soils would therefore be considered to be of **medium volume change potential** with respect to NHBC Chapter 4.2 "Building Near Trees" (NHBC, 2017).

6.4 Foundation Design

Based on the ground conditions encountered, conventional spread foundations would be suitable for the proposed structures. These should be taken down through any Topsoil, Made Ground or soft clay and silt deposits and constructed within either the gravel of the weathered chalk or intact bedrock (whichever is present at founding depth). These strata typically were present at less than 1m depth, but locally (TP3, 9, 14 & 23) the competent strata were deeper (1.30m to 1.70m bgl).

The depth to founding strata at each investigation location is shown on Drawing E05548-CLK-XX-XX-DR-GE-0002 in Appendix D.

The founding strata of gravel or chalk are non-shrinkable and therefore there is no requirement to deepen foundations near trees. Although the overlying cohesive soils are shrinkable, these are not suitable for founding on and therefore will not affect foundation depths.

A safe bearing capacity of 120kPa would be appropriate within the weathered deposits of gravel, increasing to 200kPa in intact chalk.

Total settlements for foundations designed to the above pressures should be no greater than 25mm. There would be a reduction in settlements with foundation depth, as the soil strength increases. Imposing a lower bearing pressure than the safe bearing capacity would also reduce settlement.

Where foundations span from gravel to intact chalk bedrock these should be reinforced over the transition zone to resist differential settlements.

All foundations should be inspected by a suitably qualified and competent person to ensure that foundations are placed in competent material capable of supporting the intended loads and below any desiccated clay soils.

6.5 Floor Slabs

The underlying soils near surface soils were shrinkable (medium volume change potential) therefore a suspended floor slab is recommended with an appropriate underfloor void.

No radon or ground gas protection measures are considered to be necessary.

6.6 Concrete Protection

Buried concrete classification is based on guidelines provided in BRE Special Digest 1 (BRE, 2005).

Chemical Analysis was undertaken on ten soil samples for pH and a total potential sulphate suite (water soluble sulphate, total sulphate and total sulphur).

An assessment for total potential sulphate indicates that the soils are not considered to be pyritic and the design class should be based on soluble sulphates.

The pH values were 7.8 to 8.5 with water soluble sulphate concentrations of <10mg/l to 22mg/l. Therefore it is recommended that a Design Class of DS1 and AC1 should be assumed for buried concrete in accordance with BRE Special Digest 1 assuming natural ground and mobile groundwater conditions. For low rise residential on mass concrete foundations, this corresponds to a concrete type of GEN1.

It is recommended that the concrete supplier / foundation designer confirm the necessary concrete type based on its intended use and the chemical test results in Appendix H.

6.7 Pavement Design

Equilibrium CBR values for various materials are given in Interim Advice Note 73/06 "Design Guidance for Road Pavement Foundations (Draft HD25)" produced by the Highways Agency and these are summarised in Table 6.1 assuming a high water table and thin pavement construction.

Table 6.1 Typical CBR Values

Soil Type	PI (%)	Equilibrium CBR (%)
Heavy clay	50-70	2
Silty clay	30	3
Sandy clay	10-20	3-4
Silt	-	1
sands and gravels		> 5%

The near surface soils will comprise either soft clay / silt or chalk bedrock or gravel. The clay and silt soils are of low strength and a design CBR of less than 2.5% would be appropriate at their moisture contents. Where the gravel or chalk is present at formation level a design CBR of 5% can be adopted. are predominantly gravel.

The construction thickness within the clay soils can be reduced by the use of a basal geo-grid, although detailed design would be required, specific to the loads and geo-grid used.

All Topsoil should be removed and the formation level should be lightly proof rolled to identify any loose or soft spots, which should be removed and replaced with compacted granular fill.

The clay and silt soils will be vulnerable to overworking and rolling should be kept to a minimum to avoid deterioration of the formation. Trafficking over the formation should be minimised and avoided in wet conditions.

The conditions prevailing at the time of construction will affect the CBR of the sub-grade soil and its strength. Research has shown the importance of the equilibrium moisture content of the sub-grade. The relationship between soil suction and the moisture content shows that a soil that becomes wet during construction will retain water and will therefore be weaker under the pavement in the equilibrium condition than a foundation that has remained dry, particularly for soils of low to medium plasticity. Consequently, the formation level will also need to be protected during inclement weather from deterioration; all slopes should be trimmed to falls to shed rain water and the surface sealed to limit infiltration.

6.8 Excavations

Conventional mechanical backhoe excavators should prove suitable for excavation within the weathered West Melbury Marly Chalk Formation. Deeper excavations into the chalk bedrock is likely to require heavier plant for ease of excavation.

Groundwater was only encountered in TP01, TP02, TP18 and WS06 during the investigation undertaken in 2021. During subsequent monitoring of the standpipes, groundwater was recorded at a depth 0.71m in WS01 in the lowest part of the site. Boreholes WS2 and WS6 were dry to the base at 1.40m and 2.50m bgl respectively. Groundwater was only encountered in TP1, TP2 and TP18 during the intrusive works, at depths of 1.50m, 1.20m and 1.80m bgl respectively. These three pits are located in the lower lying north west of the site.

6.9 Soakaway Drainage

Infiltration testing was undertaken in accordance with BRE 365 (2016) in six locations (TP03, TP04, TP05, TP06, TP07, TP16). The stratum tested was the weathered superficial strata and solid West Melbury

Marly Chalk Formation. Only TP7 recorded sufficient infiltration to obtain a result. An infiltration rate of $2.8 \times 10^{-5} \text{m/s}$ was calculated.

Within the remaining five location negligible infiltration was recorded and it was not possible to undertake one cycle of testing. However, the very low dissipation of water would suggest infiltrations rates are likely to be less than $1 \times 10^{-6} \text{m/s}$ and therefore efficient soakaway drainage is unlikely to be feasible.

Soakaways should be positioned a minimum of 5m from any proposed structure to avoid the risk of inducing ground dissolution and collapse near buildings.

The results of the infiltration testing are presented in Appendix F.

7 Contamination Assessment

7.1 Tier 1 Generic Quantitative Risk Assessment - Soil Risks to Humans

7.1.1 General

The redevelopment is a low rise residential development therefore the analytical data has initially been compared against the relevant available guidelines residential with plant uptake end-use to identify chemicals of potential concern.

The results have been used for subsequent comparison with:

- Cl:AIRE/EIC/AGS Soil Generic Assessment Criteria for Human Health Risk assessment, January 2010 and
- The LQM/CIEH S4ULs for Human Health Risk Assessment. Ref: S4UL3269, released January 2015, Land Quality Press, Nottingham and
- EA Science Report SC050021.

7.1.2 Metals

None of the results exceeded the GAC values for residential without plant uptake end-use.

7.1.3 Organics – Soil Organic Matter

SOM tests were undertaken on three samples. The resulting average value is 2% and so a conservative figure of 1% SOM has been adopted when selecting the Generic Assessment Criteria (GAC) screening values for organics in the following sections.

7.1.4 Organics – TPH

None of the results exceeded the GAC values for residential without plant uptake end-use.

7.1.5 Organics – PAHs

None of the results exceed the GAC values for residential without plant uptake end-use.

7.2 Pesticides and Herbicides

Two samples were tested for Organophosphorous Pesticides and Herbicides. No determinants were recorded above the laboratory limit of detection.

7.3 Soil Risks to Plants (Phytotoxicity)

Copper, nickel and zinc can inhibit plant growth. The GAC for this pollutant linkage have been taken from Department of the Environment Publication, Code of Practice for Agricultural Use of Sewage Sludge, 1996.

The pH results varied from 7.5 to 8.1, as such, concentrations did not exceed the guidelines for any of the three phytotoxic elements.

7.4 Soil Risks to Water Supply Pipes

To assess possible risks to proposed water supply pipes, the laboratory test results have been subject, to initial assessment against the GAC presented in UKWIR. Full testing has not been undertaken to determine the suitability of metallic pipe materials.

It is assumed that water pipes will be placed no deeper than 1m below existing ground level and results that relate to strata below 1m are not considered in the following table. Assessment of the results versus the GAC is summarised in Table 7.1 as follows:

Table 7.1 GAC for Water Supply Pipes

Parameter	GAC (mg/kg)		Results exceeding the GAC (mg/kg)	
	PE pipes	PVC pipes	PE pipes	PVC pipes
BTEX (<C11)	0.1	0.03	None	None
Mineral Oil C11-C20	10	Suitable	None	None
Mineral Oil C21-C40	500	Suitable	None	None

Other parameters within UKWIR have not been assessed since they are not potential contaminants of concern for this site. The investigation and assessment has indicated no elevated concentrations of contaminants with the potential to attack plastics and as such standard pipework may be suitable for the site. It is recommended that this assessment be given to the relevant water supply company at an early stage to confirm its requirements, which may not necessarily be the same as those recommended by UKWIR.

7.5 Tier 1 Generic Quantitative Risk Assessment – Risks to Water Resources

No sensory evidence of significant soil contamination was noted during the investigation. The results of the chemical analysis confirm this visual assessment and consequently the ground conditions present at the site are unlikely to pose a significant risk to controlled waters.

7.6 Summary

No elevated concentrations of contaminants were recorded therefore no risks to human health or environmental receptors have been identified.

8 Ground Gas Assessment

8.1 Radon

The Groundsure report states that the site is in an area where the estimated probability of homes being above the action level of 200Bqm^{-3} is less than 1%. Therefore no radon protective measures are required in the construction of new buildings.

8.2 Landfill Gas

No current or historical landfills are known to exist within 250m of the site. No organic soils, evidence of buried biodegradable materials or other potential sources of ground gas were identified.

Developing a ground model in accordance with guidance in BS8485 indicates that the site is unlikely to present a source of permeant ground gases, given the identified natural ground conditions.

Consequently, the risks to end users from permeant ground gases at the site is considered to be very low. One confirmatory gas monitoring visit was undertaken.

A summary of the gas monitoring results are presented in Table 8.1 with the full results presented in Appendix G.

Table 8.1 Gas Monitoring Results

Max values recorded		WS1	WS2	WS6
Flow rate	l/hr	-0.1	-0.2	-0.2
BH Pressure	mb	-4.4	< 0.1	-1
Methane	%	0.2	0.2	0.2
Carbon dioxide	%	1.2	2.8	0.9
Oxygen	%	20.2	17.2	20.1

The results suggest that the site is not being significantly affected ground gas and no gas protection measures are required.

9 Conceptual Model and Risk Assessment

The method used for risk evaluation is qualitative based on interpretation of the available geo-environmental and geotechnical data in order to provide an overall impression of the potential risks present at the site. This is described in terms of two variables as follows:

- **“Probability”** – being the likelihood that a hazard is present on site or in the surroundings.
- **“Consequence”** – being the potential outcome of the hazard.

The combination of these is used to define the risk. Clearly if a hazard is not present there can be no consequence. Similarly hazards that are potentially present will have different degrees of potential consequence. The combination of the presence of a hazard, and the potential severity of outcome of such a hazard within any event, can be used to manage the approach to management of the risk.

The **probability** (likelihood) of an event can be classified on a four point system using the following terms and definitions based on CIRIA C552:

- **Highly likely:** The event appears very likely in the short term and almost inevitable over the long term, or there is evidence at the receptor of harm or pollution;
- **Likely:** It is probable that an event will occur, or circumstances are such that the event is not inevitable, but possible in the short term and likely over the long term;
- **Low likelihood:** Circumstances are possible under which an event could occur, but it is not certain even in the long term that an event would occur and it is less likely in the short term;
- **Unlikely:** Circumstances are such that it is improbable the event would occur even in the long term.

The **consequence** (severity) can be classified using a similar system also based on CIRIA C552. The terms and definitions relating to consequence are:

- **Severe:** Short term (acute) risk to human health likely to result in ‘significant harm’. Short-term risk of pollution of sensitive water resources. Catastrophic damage to buildings or property. Short term risk to an ecosystem or organism forming part of that ecosystem;
- **Medium:** Chronic damage to human health (‘significant harm’), pollution of sensitive water resources, significant change in an ecosystem or organism forming part of that ecosystem;
- **Mild:** Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services (‘significant harm’). Damage to sensitive buildings, structures or the environment; and
- **Minor:** Harm, not necessarily significant, but that could result in financial loss or expenditure to resolve. Non-permanent human health effects easily prevented by use of personal protective clothing. Easily repairable damage to buildings, structures and services.

Once the probability of an event occurring and its consequence have been classified, a risk category can be assigned as in the Table 9.1 overleaf.

Table 9.1 Risk Classification System (CIRA 552)

		Consequence			
		Severe	Medium	Mild	Minor
Probability	Highly likely	Very high	High	Moderate	Moderate/Low
	Likely	High	Moderate	Moderate/Low	Low
	Low likelihood	Moderate	Moderate/Low	Low	Very Low
	Unlikely	Moderate/Low	Low	Very Low	Very Low

Risk Level	Action
Low to Very Low	None
Moderate to Moderate/Low	Undertake appropriate mitigation measures to reduce the risk level by appropriate on-site practice at little additional cost.
High to Very High	Designers should take such risks into account and avoid or reduce risk level to acceptable levels. Additional resources required.

A summary of the potential sources, receptors and pathways, together with an indication of the probability, consequence and degree of risk is presented in Table 9.2 below.

Table 9.2 Source Pathway Receptor Model

Potential Source and Pollutant	Receptor	Pathway	Potential Pollutant Linkage?	Probability	Consequence	Potential Risk
No potential sources of soil or groundwater contamination identified.	Human Health – future residents.	Direct contact - Dermal contact, soil ingestion and dust inhalation.	Unlikely – no sources identified.	Unlikely	Medium	Low
		Indirect Contact - Vapour inhalation.	Unlikely – no sources identified.	Unlikely	Medium	Low
		Hydrocarbon tainting of potable water supply pipes.	Unlikely – no sources identified.	Unlikely	Medium	Low
	Human Health – Construction workers	Direct contact - Dermal contact, soil ingestion and dust inhalation.	Unlikely – no sources identified.	Unlikely	Medium	Low
		Indirect Contact - Vapour inhalation.	Unlikely – no sources identified.	Unlikely	Medium	Low
	Controlled Waters – groundwater (Principal Aquifer)	Leaching and percolation.	Unlikely – no sources identified.	Unlikely	Minor	Very Low
	Controlled Waters – adjacent water courses	Groundwater migration & run-off to surface waters.	Unlikely – no sources identified.	Unlikely	Minor	Very Low

Potential Source and Pollutant	Receptor	Pathway	Potential Pollutant Linkage?	Probability	Consequence	Potential Risk
	Buried structures – Aggressive ground conditions	Direct contact and/or leaching (sulphate, pH).	Unlikely – underlying geology not expected to be aggressive.	Unlikely	Mild	Low
	Ecology - existing trees and landscaping on site.	Plant uptake.	Unlikely – no sources identified.	Unlikely	Minor	Very Low
Ground gases.	Human Health – future residents.	Permeation through ground and intrusion into buildings and structures.	Unlikely – no sources identified.	Unlikely	Severe	Low
	Flora	Displacement of oxygen from root systems	Unlikely – no sources identified.	Unlikely	Mild	Low
Radon.	Human Health – future residents.	Permeation through ground floor.	No protection measures required.	Unlikely	Medium	Low

10 Material Reuse

Clean and natural soils may be re-used on site without any materials management plan (MMP).

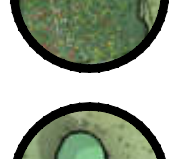
The soils on site are natural and based on the GQRA carried out the soils sampled do not pose a potential risk to human or environmental receptors and would be considered to be clean and suitable for re-use.

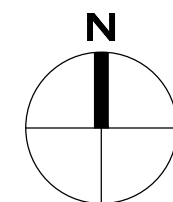
Appendices

A Proposed Development Plan



LEGEND

-  SITE BOUNDARY
-  VEHICULAR ACCESS
-  HIGHWAY
-  SHARED SURFACE FEATURE SPACE
-  SHARED SURFACE MEWS / LANE
-  FOOTPATH
-  DEVELOPMENT BLOCK
-  EXISTING VEGETATION
-  PROPOSED TREE
-  PLAY SPACE
-  ATTENUATION FEATURE
-  POTENTIAL LOCATION FOR ALLOTMENTS
-  SPORTS AND RECREATION
-  20M MINIMUM BUFFER FROM RAILWAY LINE
-  EXISTING BUS STOP



NDA -	4.304Ha
UNITS -	Up to 190
Policy POS - (Allotments, Play, Parks and Sport & Recreational)	1.33Ha minimum
POS	Aprx 3.1Ha