Ground Investigation Report (desk-based)

Bull Green Road House, Longwood, Huddersfield

SOIL AND STRUCTURES

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Report Status

Project Number	20493
Report Number	001
Revision	V01 – Issue for information
Date Issued	05 February 2025 (V01)

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Contents

Appointment

Soil and Structures Ltd were instructed by Northlight Architectural Consultants Ltd (*the Client*) on behalf of Rose Taylor in November 2024 to prepare an intrusive Ground Investigation Report (*this Report*) to support development of a plot of land located to the north of Bull Green Road, Longwood, Huddersfield (*the Site*).

Development proposals include for the construction of a single dwelling with associated hardstanding (driveways) and soft landscaping (private gardens to rear on the upper level of the Site and small area to the lower-level) as illustrated on the appended development plan and within this Report.

The development is covered under planning application ref. 2020/90259.

Reliance on the advice presented herein rests solely with the Client.

Ground Investigation Reports

In the ground everything is inter-related: from the strength of soils to their potential to transport pollution; through to, stability and drainage characteristics. Any groundworks completed as part of a development project will therefore influence, and be influenced, by all these inter-related elements.

This Report presents: an overview of the Site setting, the anticipated ground conditions and, where structures are present, the anticipated foundations. The Report also offers more specific advice as discussed below.

Scope and Context

This Report considers all ground-related hazards as set out within the 'Background Threat' annex but was specifically triggered in response to Conditions 8 to 12 the above planning application.

These conditions relate to 'contaminated land' hazards specifically and, given this focus, the Report is commonly referred to as a "Phase 1 Report" noting that, at this stage, no intrusive investigation fieldworks have been completed.

The legal context of this advice relates to an assessment of:

i) The suitability of the Site for its proposed end use that is rooted within national planning policy guidance (the National Planning Policy Framework) that is governed by planning law (various acts). The assessment of suitability is an assessment of specific, ground-related hazards; contamination and pollution.

In practice, this necessitates acceptance of this Report and its findings by the Local Planning Authority's contaminated land team, a statutory consultee on planning applications who have provided a consultation response (ref. WK/202003282) that flags the presence of a nearby landfill and former quarry.

References

The Ground Investigation Report (intrusive) has been written with reference to various sources of information. These are either appended or referenced as footnotes throughout this report.

Background to this Report

This Report is not preceded by any ground-related reporting for the Site.

Whilst titled 'intrusive' this Report does reference a Site walkover that included the direct inspection of ground conditions across the Site

1.0 The Site and Proposed Development

1.1 The Site

Location and size: The Site comprises a parcel of land approximately 0.01 ha in size that is located adjacent to No. 10 Bull Green Road, Longwood, Huddersfield (Figure 1).

Access: At the point of issue, pedestrian access to the Site was available from the Bull Green Road to the south.

Topography: The topography of the Site generally falls from north to south with the Site located on the upper reaches of a broad plateau of outcropping Rough Rock (sandstone) as illustrated on Figure 1.

Ground levels within Bull Green Road are indicated to be around 158 mAOD locally to the Site with levels across the north-eastern, upper portion of the Site resting around 3 m higher (161 mAOD).

Exiting structures: At the point of issue, the Site is understood to be occupied by a double garage of concrete panel construction (likely Grimston or similar) likely with an asbestos cement roof.

1.2 The Proposed Development

Development proposals: include for the construction of a single dwelling with associated hardstanding (driveways) and soft landscaping (private gardens to rear on the upper level of the Site and small area to the lower-level) as illustrated on the appended development plan within this Report.

ⓘ ***Development works and risk:*** *An appreciation of the construction processes is essential for development-related risk assessments given the groundworks stand to meaningfully alter the level of risk, e.g. potentially harmful soils being removed or moved by earthworks, or new slopes being formed.*

To enable this development, the following groundworks are anticipated to be required:

> Preparation: Demolition of the existing garage structure and removal of all materials include the sub-structure (foundation).

> Earthworks: The proposed development levels will result in a net cut (removal) of excavated materials from Site due to the proposed dwelling being located within the existing embankment.

> Utility Excavations: Excavation of drainage and other utility alignments.

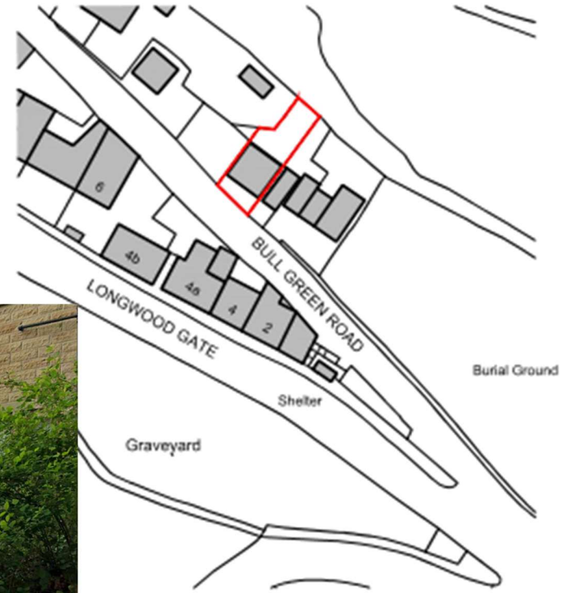
> Foundations: Construction of new sub-structure (foundation and floor slab) followed by construction of the structure.

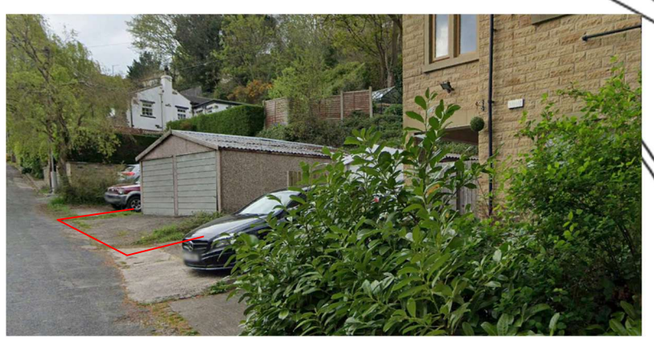
> Surfacing: Formation of hardstanding and retention of existing soft landscaping (private garden) to the upper level of the Site.

ⓘ ***Human health risk profile:*** *The proposed development would see a former private garage plot developed for a residential end use.*

The sensitivity of the development therefore increases slightly noting that the soils across former garage plots can have become degraded; commonly through informal oil changes on vehicles and construction materials, i.e. asbestos containing material. However, the proposed development works will result in the formation soils across the lower level of the Site (where the garage is located) being lowered (to suit development levels) and then encapsulated with the house construction or a new hardstanding driveway.

Figure 1: Site Location
> *Extract from Google Earth ™.*
> *Approximate Site boundary identified by red line.*
> Upper edge of the Rough Rock plateau illustrated with ground levels tapering away from this edge.
> *INSERT RIGHT: Location plan extract*
> *INSERT BELOW: Streetview illustration of Site with existing garage structure illustrated*





2.0 Site Setting

2.1 History

The Site has been subject to two distinguishable phases of use since the 1850s (the date of the earliest available ordnance survey mapping):

> The first phase (mid 1800s to c. 1960s): Terraced housing.

Potentially harmful or polluting material: Through this phase of use there is generally considered to be a low potential for harmful or polluting material to have been introduced into the shallow soils on Site.

The extensive use of coal fires historically means that coal ash and clinker can commonly be found around residential properties (discarded when the fire(s) needed clearing out) the location and extent of which cannot be reliably anticipated.

There is no evidence of nearby properties from this era including basements / cellars, e.g. those further up Bull Green Road or along Longwood Gate.

Potentially degradable or vapour generating material: through this phase of use it is unlikely that degradable material will have been introduced into the Site's shallow soils.

Evidence of mining activities: No evidence of coal or non-coal mining features, e.g. old shafts or soughs, is recorded on the Site over this period.

Potential unexploded ordnance: There is no evidence of the Site having been used for military purposes during the first or second world wars however, Huddersfield was targeted during the Second World War but subjected to an overall low intensity of bombing (ref. company archive based on National Archive data). During this period the Site was occupied by the same building over this period and no evidence of bomb-related damage on the Site or locally, e.g. ruins, on post-war mapping records or local archives[1]. Taken together, it is considered unlikely that unexploded ordnance remains beneath the Site.

> The second phase (c. 1960s to present day): Double garage unit with concrete panel construction and likely asbestos containing material (ACM) within the roof.

Potentially harmful or polluting material: through this phase of use there is the potential for harmful or polluting material to have been introduced into the shallow soils on Site. Sources of potentially harmful material can include; oil/fuel products introduced into the shallow soils during vehicle maintenance or, asbestos containing material (ACM) discarded onto the ground during construction/demolition.

Potentially degradable or vapour generating material: through this phase of use there is an overall low potential that degradable material would have been introduced into the Site's shallow soils with only rare timber expected within residual construction/demolition materials.

Whilst the is the potential for vapour generating material to have been introduced into the shallow soils, i.e. fuel, it is considered likely that volumes would have been small if indeed any spillages did occur. If and where small volumes were introduced into the soils through spillages, they are expected to have volatilised readily however, residual areas may be present.

Evidence of mining activities: No evidence of coal or non-coal mining features, e.g. old shafts or soughs, is recorded on the Site over this period.

The history of the surrounding area (within 100 m of the Site) is characterised by residential properties (terraced housing) with no evidence of industrial land uses noting former quarries are present east, north and west of the Site.

2.2 Geology

Recorded geology: The Site appears to be underlain by outcropping bedrock of Rossendale Formation (mudstone and siltstone). The boundary of the Rough Rock (sandstone) is indicated to lie on, or immediately north of the Site and given the relatively lower elevation of the Site to the overlying Rough Rock outcrop (cliff edges uphill of the Site) it is more likely the Site is underlain by the Rossendale Formation

Made Ground associated with the former terraces and or construction of the existing garage may be present on Site. These deposits are anticipated to be shallow with the former terraces likely of a similar construction to those properties higher up Bull Green Road (where no evidence of basements is present, e.g. air bricks, coal holes).

Further commentary on the ground conditions is presented within Section 3.0

Exploratory holes: No borehole records are available relating to the Site itself or locally within the same geological unit.

Structural geology: The structural geology of the Site and immediate surrounding area is relatively simple with bedrock locally is dipping at shallow angles (2 to 3 degrees) towards the east which is the overall trend across the east Huddersfield district. This trend is also exhibited within the outcropping rock faces east of the Site.

Coal and non-coal mining: No coal or non-coal mine workings are recorded beneath the Site at depths that could present a risk of surface instability.

Geological mapping confidence: The exposed reduced level excavation as discussed within Section 3.0 offers very good confidence in the geological succession beneath the Site.

2.4 Hydrogeology and Hydrology

The Site's groundwater regime (hydrogeology) is characterised by:

> Its location at the mid elevations and lower reaches of the Colne from Wessenden Brook to River Holme water body that is a heavily modified catchment, characterised by; varied but commonly steep gradients and extensive outcropping bedrock deposits (Millstone Grit Group and Pennine Lower Coal Measures).

> The bedrock deposits beneath the Site are likely argillaceous rocks (mudrocks) within which groundwater is expected to be present and flowing (bedrock aquifer) at generally very low to low rates controlled by their inherently low permeability, with fissure flow likely dominating. Permeability rates or between 10^{-5} and 10^{-9} m/s are predicted again, with faster rates within any fissures in the rock.

> The absence of Source Protection Zones.

The Site surface water regime (hydrology) is characterised by:

> Very low risk from river, reservoir and surface water flooding across the Site.

> The absence of known / recorded watercourses within 100 m of the Site.

[1] *West Riding ARP Bomb map, 14th/15th March 1941 - Google My Maps*

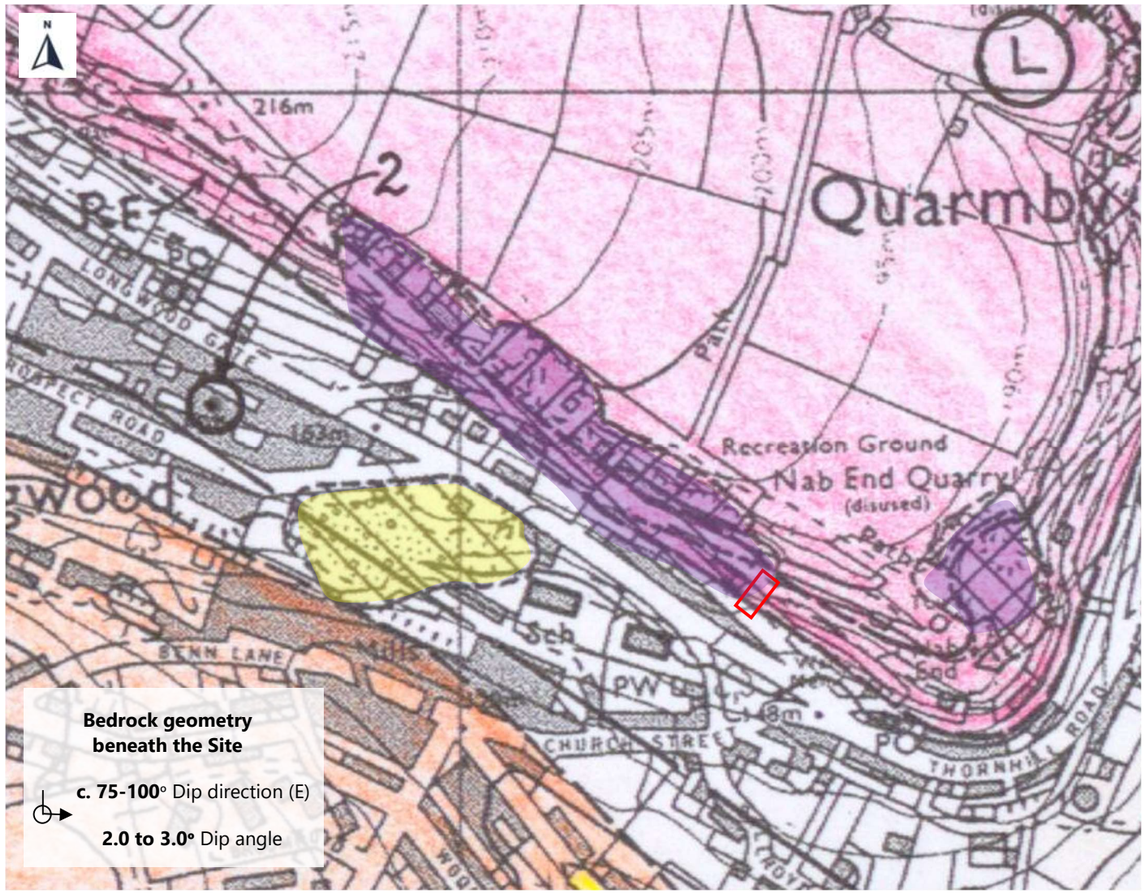


Figure 2: Geological Mapping

> *Extract from BGS 'Solid and Drift Edition' (1:10,000)*
> *Approximate Site boundary highlighted by red line.*
> *Area of 'artificial ground' highlighted yellow.*
> *Area of former quarried land highlighted purple – considered likely to be a very conservative buffer*
> *Dip direction and angle taken from various readings locally to the Site and from inspection of the exposed rock face on Nab End outcrop.*
> *North-west to south-east aligned hatching = 'artificial ground'*
> *Reproduced under Open Government License (v3.0).*

2.5 Other

Industrial / commercial land uses: are not recorded adjacent to the Site (within 100 m) historically or at present.

Landfills (historic and active). One landfill is recorded within 250 m of the Site[2,3], the distance across which viable pathways for gas migration are more likely.

This landfill is historic (closed) and recorded 140 m west m of the Site - 'Sunnybank Mills' with an address of Benn Street, Longwood, Huddersfield and ref. EAHLD04171. Further details relating to the landfill are listed below:

> The dates of operation are between June 1988 and June 1990.

> Inert and commercial waste is recorded having been deposited on Site.

> Perusal of the historical mapping records for the landfill site indicate that the extent of the landfill correlates with the extent of the former mill site that, together with; i) the nature of the waste deposited, ii) the dates of planning applications submitted for the mill's conversion (1986 to 1989; noting a 1995 planning application was submitted suggesting the mill remained in place however, online photographs suggest demolition took place in the 1980s[4]) the dates of licensing (2 year period) indicate the landfill likely relates to the demolition of the mill.

  The British Geological Survey mapping does not record the presence of 'artificial, worked or Made Ground' deposits across the landfill site but does record the presence of 'artificial ground' to the north of the former mill (Figure 2). This artificial ground likely relates to former surfacing tipping of surplus quarry arisings from the various quarries locally, in any case, this material is surface deposited.

> 'Inert' and 'commercia' waste landfill sites don't typically have a high gassing potential with the nature of material within this landfill likely relating to demolition arisings that, whilst they may contain timber and other degradable materials, e.g. cloth, the overall proportions are expected to be low and/or discrete within a higher proportion of material with little to no ground gas generation potential (construction materials, e.g. brick or concrete).

The former quarries around the Rough Rock escarpment (similar levels to the Site) were disused in the 1890s and therefore, even if degradable / gas generating material was deposited within them, it will have a very low gas generation potential given the passage of time.

Radon is emitted from naturally sources within a range of geologies. The United Kingdom Health Security Agency (UKHSA) data[5] indicates between 3 to 5 % of dwellings are expected to be above the Action Level (200 Bq m^{-3}).

[2] *Historic Landfill Sites - data.gov.uk*
[3] *Permitted Waste Sites - Authorised Landfill Site Boundaries - data.gov.uk*
[4] *The demolition of Sunnybank Mills, Longwood - geograph.org.uk - 1046823 - Category:Demolished buildings in West Yorkshire - Wikimedia Commons*
[5] *UKradon - UK maps of radon*

3.0 Ground Conditions – Anticipated

Anticipated ground conditions: Based on the Site setting the presence of three materials are anticipated across the Site:

Across the upper portion of the Site where the proposed garden area is located:

1) Topsoil; over,

3) Weathered bedrock (grading to intact rock) at 'shallow' depths (likely within 0.50 m of the surface).

   The weathered bedrock may be recovered as a 'soil-like' material that, depending on the nature of the rock will likely either comprise; granular material, e.g. silty sandy gravel (Rough Rock; sandstone) or, cohesive material, e.g. sandy silt/clay (Rossendale Formation; siltstone or mudstone)

Across the lower portion of the Site where the existing garage and proposed dwelling is located:

2) Made Ground deposits including the existing garage's concrete slab, sub-base deposits, historic fill associated with the former terraced properties, e.g. ; over,

3) Weathered bedrock (grading to intact tock) at 'shallow' depths beneath the Made Ground

There is evidence indicating the following ground-related hazards may influence the proposed development.

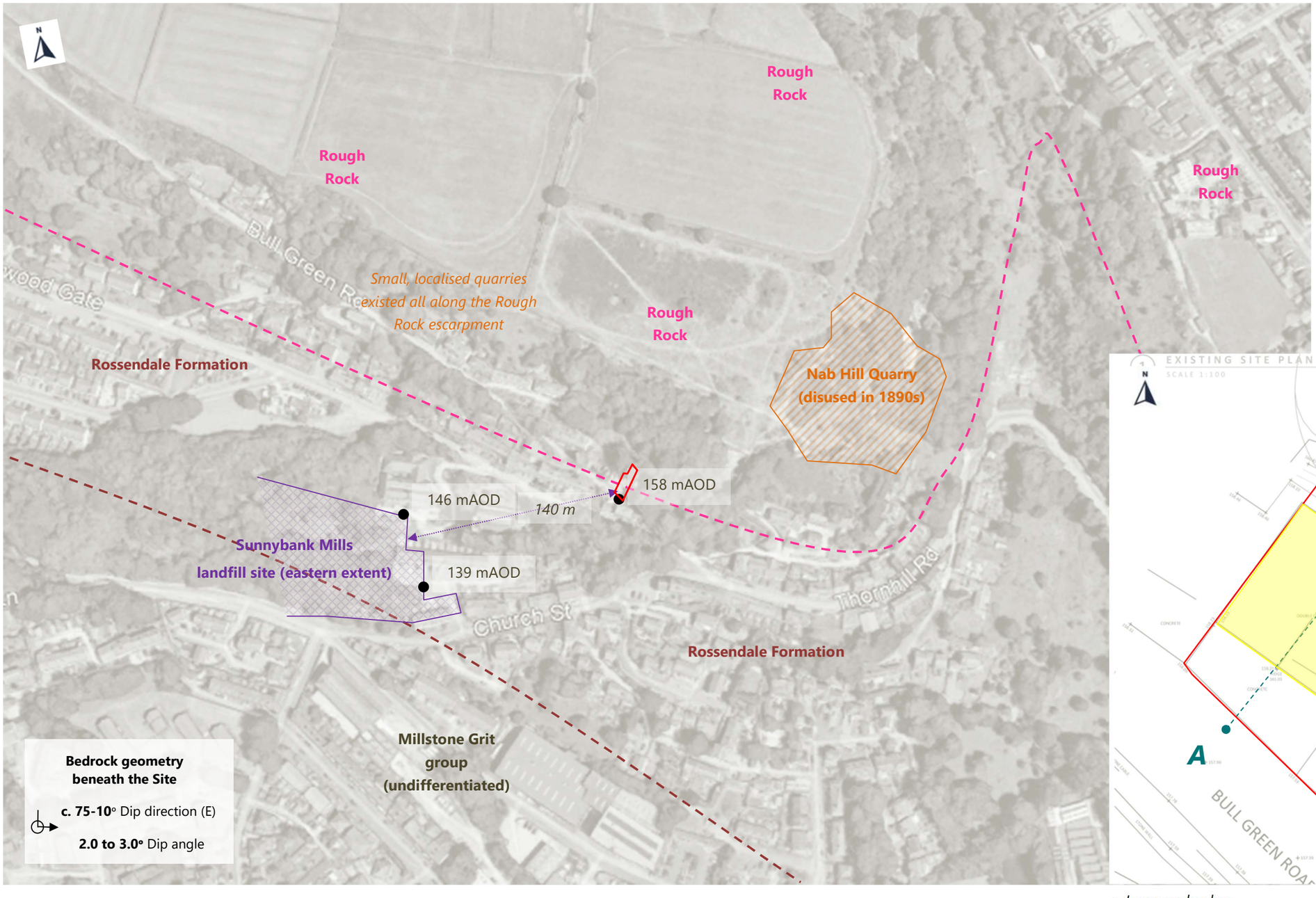
Risk assessments and, where necessary, risk management recommendations are presented as part of the commentary within Section 5.0.

- ⚠ Potentially harmful and polluting material *[possible asbestos containing material discarded to ground as part of the existing garage's construction and possible coal ash discarded to ground during the historical use of the Site as a residential dwelling*];
- ⚠ Sub-structures *[possible relic foundations and drainage features associated with former terraced dwelling]*
- ⚠ Ground gas (landfill gas) *[landfill within 250 m of the Site*];
- ⚠ Slope stability *[slope greater than 1(v):3(h) present to rear of existing garage*]; and,
- ⚠ Radon gas *[3 to 5 % of properties above the action level*].

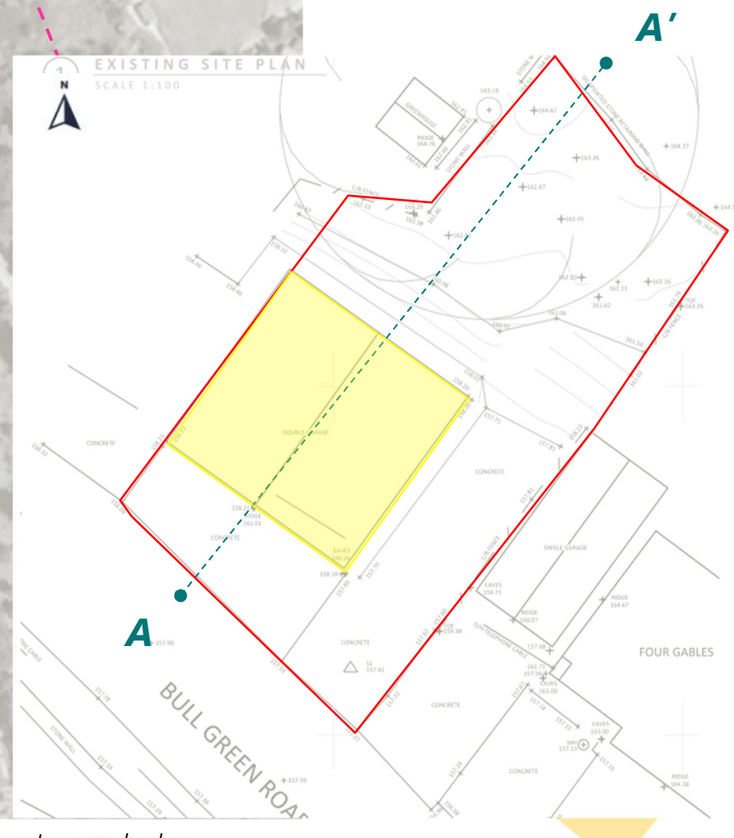
Other ground-related hazards are present, i.e. utility alignments, the investigation and assessment of which is beyond the scope of this Report.

Similarly, other ground-related hazards may be present however no evidence has been identified as part of the Site Setting review (Section 2.0).

5.0 **Ground Model –** Plan

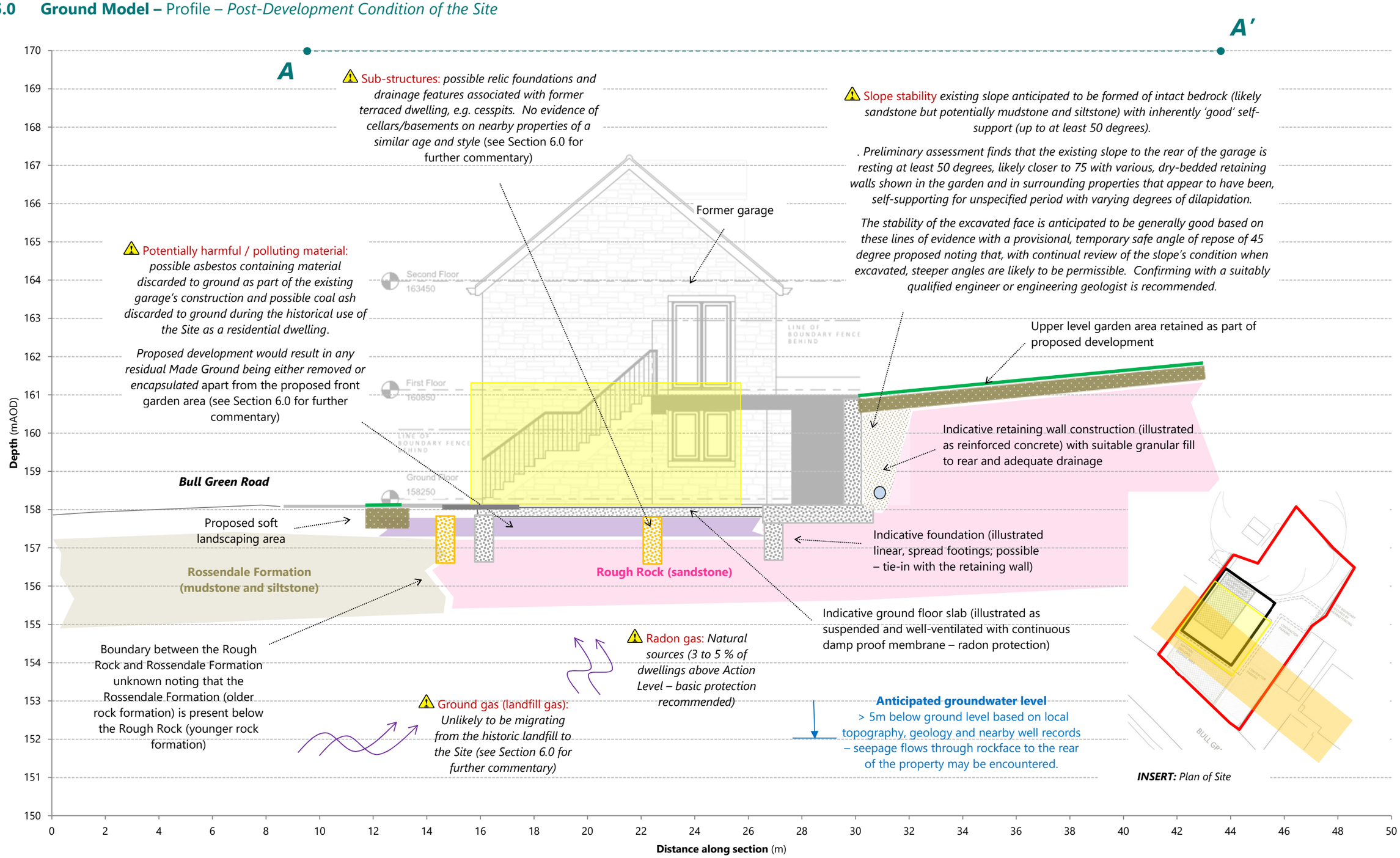


> *Small scale plan*
> *Illustrative only, do not scale from drawing*



> *Large scale plan*
> *Former terraces highlighted orange – indicative only; garage = yellow*
> *Approximate planning boundary illustrated by red line*
> *Illustrative only, do not scale from drawing*

5.0 **Ground Model –** Profile – *Post-Development Condition of the Site*



> *Illustrative only, do not scale from drawing*

6.0 **Ground Engineering** – Design Considerations & Risk Management

The following sub-sections offer advice on ground-related matters for the engineering works required as part of the development with the likely groundworks activities required as part of the development outlined in Section 1.2.

Design considerations: The main design considerations include, but are not limited to;

> A similar finished floor level for the proposed dwelling as the existing garage;

> The requirement for a net 'cut' of materials from the Site to form the retaining wall to the rear of the property and to achieve sufficient depth for the ground floor construction; and,

> A proposed garden area at the upper portion of the Site.

Ground-related hazards: Throughout the section, alongside more general commentary, advice relating to specific ground-related hazards is presented that includes advice on how to reduce the risk to lower, more acceptable levels.

In this scenario, the following ground-related hazards are identified:

⚠ Potentially harmful and polluting material *[possible asbestos containing material discarded to ground as part of the existing garage's construction and possible coal ash discarded to ground during the historical use of the Site as a residential dwelling*]

⚠ Sub-structures *[possible relic foundations and drainage features associated with former terraced dwelling]*

⚠ Ground gas (landfill gas) *[landfill within 250 m of the Site*]

⚠ Slope stability *[slope greater than 1(v):3(h) present to rear of existing garage*]

⚠ Radon gas *[3 to 5 % of properties above the action level*]

Other hazards, e.g. flood risk, may exist that cross-over with, and influence, ground-related hazards but are not directly addressed within the scope of this reporting, e.g. flood mitigation measures.

Unexpected material: It is also noted that whilst this Ground Investigation Report seeks to remove as much uncertainty as possible from the ground, there always remains the potential for unexpected material or conditions to manifest. General advice on such encounters is provided within an annexed Guidance Note.

6.1 General Groundworks

In this scenario, the following ground-related hazards are identified that could potentially influence groundworks:

⚠ Slope stability

⚠ Sub-structures

⚠ Ground gas (landfill gas)

⚠ Potentially harmful and polluting material

Excavations are anticipated to encounter:

1) Shallow Made Ground deposits possible including relic sub-structures, e.g. foundations and drainage, associated with former terraced property; and,

2) Weathered bedrock deposits, likely at shallow depths, grading into intact bedrock, likely within 1 m of the natural ground surface.

Across the upper, northern portion of the Site,

3) Topsoil deposits associated with the existing garden area (to be retained as part of the proposed development).

ⓘ ***Access into excavations:*** *Based on the high background threat excavation collapses pose both to worker's health and safety but also to groundworks activities if not managed appropriately, the risk of presented by excavation stability is highlighted as a general risk. This is a Site-wide risk.*

Excavations that appear stable can be subject to rapid loss of stability that can result in crush injuries or death.

Personnel access into any excavations should only be undertaken with adequate support and appropriate risk assessment. Further guidance is available[6].

> *Groundwater control* - In general, pumps are unlikely to be required to remove groundwater from excavations given their shallow depth and anticipated depth to groundwater however seepage flows out of the embankment face may be encountered that require management. Further guidance is available[7].

⚠ Slope stability – the existing slope to the rear of the garage is anticipated to be formed of intact bedrock (likely Rough Rock sandstone but potentially Rossendale Formation mudstone and siltstone) with inherently 'good' self-support (up to at least 50 degrees).

Preliminary assessment finds that the existing slope to the rear of the garage is resting at least 50 degrees, likely closer to 75 degrees in places with various, dry-bedded retaining walls shown in the garden and in surrounding properties that appear to have been, self-supporting for unspecified period with varying degrees of dilapidation.

The stability of the excavated face is anticipated to be generally good based on these lines of evidence with a provisional, temporary safe angle of repose of 45 degree proposed noting that, with continual review of the slope's condition when excavated, steeper angles are likely to be permissible. Confirming with a suitably qualified engineer or engineering geologist is recommended.

⚠ Sub-structures – the existing garage is anticipated to be formed on a flat slab (pseudo raft) foundation that will be removed as part of the enabling works. Beneath this, relic sub-structures associated with the former terraced property may be present. This could include relic foundations or relic drainage features, e.g. former cess pits.

The general approach to managing the risk from these features is to excavate the sub-structure to its full depth and, where necessary, replace with a suitable granular fill, compacted in suitable layers to achieve whatever performance criteria the design requires, e.g. general filling or fill that will be load bearing.

Retention of these features in the ground can only be considered if and where they will not be loaded or they don't pose a risk of instability to the surface, e.g. residual voids.

Similarly, where relic foundation walls remain below areas of proposed hardstanding, it is recommended that they are broken down to a depth of at least 600 mm below ground level to limit the potential for them to remain as 'hard spots' within the formation.

Attention should be given to the potential influence of this work on adjacent land and structures, e.g. where relic walls extend across land ownership boundaries, and having in place a continual review of excavation stability.

[6] *CIRIA Report 97 - Trenching Practice - Second Edition (1992)*
[7] *CIRIA Report No C515 Groundwater Control (2001)*

⚠ Ground gas – One source of ground gas (non-radon) is identified within influencing distance of the Site: i) the historic landfill Site located 140 m from the Site at its closest point. Former quarries around the Rough Rock escarpment (similar levels to the Site) The likelihood of landfill gases to migrate from the landfill onto Site is considered low (as discussed further within Section 6.2) and the potential for concentrations of ground gas to accumulate to harmful levels is considered unlikely,

The former quarries were disused in the 1890s and therefore, even if degradable / gas generating material was deposited within them, it will have a very low gas generation potential given the passage of time. The material within the quarries is expected to be dominated by residual sandstone not deemed of sufficient quality to extract from the quarry. Any gases generated are also more likely to de-gas to the atmosphere directly above the quarries with the fill material unlikely to have been capped.

The risk presented to Site operatives by ground gas is assessed to be acceptably low and risk mitigation is not recommended.

⚠ Potentially harmful / polluting material – the presence of potentially harmful or polluting material within the ground cannot be ruled out but, even before any construction works take place, is anticipated to comprise low volumes of discrete material (and therefore reduced exposure).

The planned reduced level excavation across the lower portion of the Site (to suit development levels) is expected to remove most of this material (the Made Ground) however, if and where residual volumes are present, they will ultimately be encapsulated by the 'hard' cover provided by both the proposed dwelling and the external hardstanding areas (breaking the 'pathway' in the potential contaminant linkage). Further commentary is provided within Section 6.4.

The overall nature of any residual Made Ground is expected to present an overall low risk of harm to Site operatives from short-duration exposure, i.e. ash content within reworked natural soils.

ⓘ ***Asbestos containing material (ACM):*** *This Report carries through the precautionary assumption that the existing garage roof is formed of ACM and from this, that fragments of ACM may have been introduced into the shallow soils around the garage from broken/cut panels. This is common around former garage units with ACM roofs. To confirm the presence or absence of ACM, it is recommended that an asbestos survey is completed and, if confirmed, that the roofing material is removed from Site by a suitably licensed and experienced contractor.*

A possible exception to this is asbestos that, if present, stands to present an increased risk given inhalation is the main pathway. It should be borne in mind that, through its widespread use historically, asbestos containing soils (ACS) are common within urban areas, with an increased likelihood of their presence on this Site owing to the presence of the garage with a roof formed of suspected asbestos containing material (ACM).

The planned reduced level excavation across the lower portion of the Site (to suit development levels) is expected to remove most of this material (the Made Ground) however, if and where residual volumes are present, fragments and potentially loose fibres of ACM may be present.

To reduce the risk to acceptably low levels the following actions are recommended:

- Whilst the likelihood of ACS being present is considered low, given the background threat posed by ACS in urban areas, it is recommended that all Made Ground soil is treated as potentially containing asbestos fibres. Following this precautionary assumption, the Control of Asbestos Regulations (2012) stipulates that a plan of work should be place for this work to ensure risks remain as low as is reasonably practicable.

  It is therefore recommended that a strategy is developed by the main contractor to manage the risk presented by asbestos fibre release during the groundworks activities. As a minimum, it is recommended that:

  1. *Training:* all operatives have asbestos awareness training to allow any suspected ACM to be more readily identified.

  2. *Control of dust:* the Site should be treated as a dust-free zone with full-suppression of dust throughout the construction programme. Misting and other controls may be needed.

  These measures will also reduce the potential risk posed to neighbouring properties.

- More generally, the provision of task-specific personal protective equipment is recommended, e.g. use of gloves when handling soil, with attention given to the potential presence of sharps within the residual Made Ground deposits, e.g. glass fragments.

Earthworks (cut and fill) are required as part of the proposed development in the form of a reduced level excavation (cut) across the lower portion of the Site that is expected to no shallower than 500 mm depth (to suit finished floor levels and ground floor slab construction).

Excavation into the existing embankment / slope to the rear of the existing garage is also planned.

Material suitability for re-use (geotechnical and environmental) is not expected to be required as part of the proposed development with all materials removed from Site.

Waste classification of excavation arisings for any material surplus to requirements (requiring disposal) will need to be agreed with the groundworks contractor in line with current guidance[8].

The waste classification of soils is something that should be approached in a step-wise manner first confirming whether or not a soil is Hazardous or Non-Hazardous followed by Waste Acceptance Criteria testing only when and where off-Site disposal is confirmed as the fate for the material.

In any event, groundworks contractors have direct access to landfill operators whose acceptance criteria can vary from month to month. On this basis, it is recommended that any waste classification is confirmed in advance by the groundworks contractor.

Materials recovered from the ground as part of the reduced level excavation are likely to be Made Ground but may grade into natural, weathered bedrock within 500 mm of the surface. If requiring disposal off Site, the Made Ground is anticipated to be classed as EWC 17 05 04 (soil and stones; mirror non-hazardous) however, as noted above, this should be confirmed with the waste broker/carrier in advance.

Again, a possible exception, or increase, to this classification is the potential presence of fragments of asbestos containing material (ACM) from the garage's construction whereby any material containing >0.1% vol/vol of asbestos would be classed as EWC 17 05 03 (soil and stones; hazardous). If and where present, reductions in asbestos content can be achieved through hand picking however, it is essential that this legal status of this work is confirmed in advance, e.g. is it notifiable work or not. This will only be known once the full extent of the reduced level excavation is exposed that directs a responsive approach to risk management.

[8] *Waste classification technical guidance - GOV.UK*

6.2 Structural Engineering

In this scenario, the following ground-related hazards are identified that could potentially influence the structural engineering design:

⚠ Slope stability

⚠ Sub-structures

⚠ Potentially harmful and polluting material

⚠ Ground gas (landfill gas)

⚠ Radon gas

Proposed foundations: Foundation options are open but will be guided by:

> The likely presence of high strength granular bedrock (likely Rough Rock sandstone) at shallow depths across the footprint of the proposed structure; and,

> The requirement for retaining walls to be incorporated as part of the proposed structure (likely incorporated as part of the foundation/floor slab construction).

Taken together, the use of spread footings is considered likely to be the most favourable option.

As an indicative solution, for centrally loaded linear strips 0.60 m wide that are formed at a minimum depth of 0.50 m below ground level (*frost-heave*) within weathered bedrock deposits, a presumed bearing capacity of 100 kN/m^2 could be adopted as part of the foundation design.

Attention should be given to ensuring the formation soils/rock are consistent in nature.

Proposed retaining wall: Wall options are open but will be guided by the nature of the retained material (active earth pressure) and less so the bearing capacity, that is anticipated to be 'high' when formed within weathered or intact bedrock deposits.

In general, the use of a reinforced concrete retaining wall is likely to be favourable however, this should be confirmed with the Engineer.

⚠ Slope stability: Once installed, the suitably designed retaining wall will serve to mitigate the risk of slope stability by offering permanent support to the slope.

Floor slab: Floor slab options are open but will be guided by:

> The anticipated presence of 'good' strength bedrock (sandstone, siltstone or mudstone) at shallow depths across the footprint of the proposed structure; and,

> The requirement for retaining walls to be incorporated as part of the proposed structures (likely incorporated as part of the foundation/floor slab construction), that may result in a split construction, e.g. partially suspended to the front half, partially ground bearing to the rear half of the property.

⚠ Sub-structures – the potential presence of relic sub-structures associated with the former terraced property as discussed within Section 6.1.

⚠ Potentially harmful / polluting material – the likelihood of potentially harmful or polluting material remaining present beneath the proposed ground floor slab is low given the proposed educed level excavation.

The Site's historical use as private garages is noted as a potential source of fuel range hydrocarbons that could generate vapours. In general, private garages are expected to have a low pollution potential in this regard with any historic spillages likely to be of low volume.

If and where any evidence of odorous or stained soils is observed during the reduced level excavation this would be considered unexpected and the advice of the Author of this Report sought with regards to a responsive strategy being developed to manage any risk associated with this material. If and where encountered, it is likely that excavation and removal of the oil/fuel impacted soils would be recommended to remove the potential risk this material would pose as a vapour generating material (potential for ingress into internal spaces and health effects).

⚠ Ground gas (landfill): One source of ground gas (non-radon) is identified within influencing distance of the Site: i) the historic landfill Site located 140 m from the Site at its closest point.

The likelihood of landfill gases to migrate from the landfill onto Site are considered low for the reasons detailed below, and therefore the potential for concentrations of ground gas to accumulate to harmful levels is also considered low,

> *The nature of the material deposited within the landfill:* Based on the dates of the landfill's operation coinciding with the demolition of the former mill buildings and the historical practice of using landfill designations as a means to deposit material on the Site of origin, the material within the landfill is expected to comprise uncapped, demolition arisings with a very low ground gas generation potential[9].

> *The distance to the landfill makes viable pathways less likely:* At its closes point, the landfill is located 140 m from the Site at elevations that are at least 10 m lower. Whilst bedrock is dipping eastwards, potentially towards the Site, any gases generated within the landfill are expected to be released direct to atmosphere locally to the fill (the most viable route). Similarly, there are no recorded mine workings or faults recorded connecting the landfill to the Site that might otherwise result in advective pathways for gas migration.

Degassing is more likely to occur via: a) utility alignments within Longwood Gate or the cul-de-sacs to the south with excavations for drainage and other utilities acting are more preferable pathways for gas emissions; and, b) natural fissures within the Rossendale Formation deposits that the landfill is recorded within. Combined, these features would result in a very tortuous and less likely pathway for gas migration from the landfill to the Site.

The last know landfill gas incident occurred in the early 1980s where historic mine workings beneath a landfill acted as open pathway by which landfill gas could migrate to beneath a property. This is not replicated here.

The risk presented to end users of the Site by ground gas is assessed to be acceptably low and risk mitigation is not recommended.

It is noted that, the provision of what is likely to be reinforced concrete retaining walls to the northern elevation of the property coupled with basic radon protection measures will themselves offer inherent protection to ground gas ingress (all types).

⚠ Radon: the Site is located within an area where between 3 to 5 % of dwellings have radon above the Action Level. At this level, basic radon protection would be recommended.

[9] BS 8576:2013 Guidance on investigations for ground gas. Permanent gases and Volatile Organic Compounds (VOCs).

The provision of a continuously sealed and protected damp proof membrane (2000 gauge) across the full footprint of new ground floor areas would reduce the risk presented by radon to acceptably low levels. This would represent 'basic protection' in line with BRE 211.

The 'toe' of the retaining wall (reinforced concrete) will also act an effective barrier to the ingress of all ground gases into the property.

Taken together, the use of a ground bearing floor slab is considered likely to be the most favourable option together with a continuously sealed and protected damp proof membrane (2000 gauge) across the full footprint of the ground floor area.

6.3 Civil Engineering

In this scenario, the following ground-related hazards are identified that could potentially influence the civil engineering design:

⚠ Potentially harmful and polluting material

⚠ Sub-structures

Hard-standing sub-grades will be subject to final design levels being agreed however, based on the revealed ground conditions and likely formation levels, the sub-grade may comprise residual Made Ground deposits or weathered bedrock deposits.

Where residual Made Ground deposits are present they are expected to offer 'poor' support with a preliminary CBR of no greater than 1.0 % suggested at this stage, with the potential presence of hard and soft spots flagged

Excavation and removal of this material is recommended beneath areas of hardstanding and replacement using a suitable granular fill, e.g. Type 1, that is regulated/engineered into place and placed onto the underlying natural, bedrock deposits

⚠ Sub-structures – the potential presence of relic sub-structures associated with the former terraced property as discussed within Section 6.1.

If and where relic sub-structures walls remain below areas of proposed hardstanding, it is recommended that they are broken down to a depth of at least 600 mm below ground level to limit the potential for them to remain as 'hard spots' within the formation.

Drainage of the existing Site is expected to be controlled by drainage to ground at highly variable rates (10^{-3} to 10^{-8} m/s) into the weathered bedrock deposits the rates of which will be controlled by the nature of the bedrock and the degree of fissuring (fissure flow will dominate in all rock types here).

The shallow bedrock is not recommended as a point of discharge given the potential for seepage flows to emerge on the slope south of the Site (south of Bull Green Road).

The use of shallow infiltration-based systems, e.g. permeable paving, could be considered however, it is recommended that the formation soils are inspected and potentially tested (infiltration testing) before this is considered.

Water supply pipes will likely all be laid at depths of around 0.70 m below the ground surface that, at this depth, may be laid within residual Made Ground deposits present across the southern portion of the Site.

⚠ Potentially harmful and polluting material: In lieu of chemical testing of the Made Ground it is recommended that, where water supply pipes are laid in the ground, that barrier pipe (PE/AL/PE) is specified as a precautionary measure. Alternatively, standard PE pipework could be employed if and where installed within a, suitable first generation quarried stone fill.

6.4 Landscaping

In this scenario, the following ground-related hazards are identified that could potentially influence the landscaping design:

⚠ Potentially harmful and polluting material

Soft landscaping is expected to remain unaltered through the development works with the upper-level garden area retained as part of the development for which no further work is recommended. A small area of soft landscaping is proposed to the front of the property as illustrated on Figure 3 for which risk management is recommended

Figure 3: Landscaping plan extract
> *Extract from appended drawing*

⚠ Potentially harmful and polluting material: the formation soils below the lower-level garden area may include residual Made Ground deposits that, in lieu of chemical testing, are assumed to be chemically unsuitable for retention within garden areas (potential for end users to be exposed to this material).

It is also noted that this material is likely to be physically unsuitable with sharps, e.g. brick and glass fragments likely, that itself would render the material unsuitable as a landscaping fill.

Given the size of this garden area, it is recommended that at least 450 mm of suitable soil forming material is imported to serve as a clean capping over any residual Made Ground deposits. This thickness aligns with current guidance[10] and the level of risk present on Site.

At this depth, the potential for residual asbestos containing material (ACM) to be present from the garage's construction is considered unlikely and therefore provision of a demarcation layer or similar 'barrier' is not recommended in this scenario.

If and where the formation soils are proven to be natural weathered bedrock, the design and specification of the soft landscaping can be led by the Architect / Landscape Architect, e.g. minimum 150 mm thick topsoil if grassed.

Area of hardstanding will serve as a physical barrier to any residual Made Ground and therefore, beyond checks on the provision of hardstanding, no risk management is recommended.

Attention should be given to the fact that imported soil forming materials will be required that, should be sourced from a reputable supplier and tested 'at source' to confirm they are suitability for use.

The physical and chemical quality of any soil forming material imported to Site should be confirmed as being suitable for use against both; the relevant British Standards, e.g. BS3882:2015 for topsoil and BS8601:2013 for subsoil, and Local Planning Authority (LPA) guidance[11].

Reference should be made to Appendix 1A of the LPA guidance for the specific frequencies and suites of testing that are required for imported soils depending on their origin. The frequency and suite of testing varies depending on the nature of the source, e.g. Greenfield or manufactured, and, until the source is confirmed, specific details of the testing not stipulated within this Report but confirmed within the follow-on Validation Report. Again, given the size of this garden area, it is likely that no more than three samples will be required to confirm the material's suitability (all sources).

If and where any exceedances of the Generic Assessment Criteria do occur, the consultant or engineer responsible for the validation of the remedial works should be responsible for assessing the suitability of the material, in agreement with the Local Planning Authority.

The specification/recommendation of a 'clean capping' layer will be treated as a 'remedial action' by the local planning authority for which a dedicated 'Remediation Strategy' may be required. Based on the low level of threat and scale of the development, the advice contained herein may be deemed sufficient assurance that the soft landscaping will be 'suitable for use', the overall aim of any contaminated land planning condition.

The following lines of evidence should be sought to demonstrate this work has been completed:

- ***For the clean capping thickness*:** Either;
  - Reduced level survey alongside finished level survey illustrating how the Made Ground deposits have been removed or,
  - Hand excavated trial pits illustrating (through photographic evidence) how, the required thickness of clean capping has been provided over the Made Ground deposits.

  Guidance on the requirement for photographic evidence can be found in Local Planning Authority guidance[11].
- ***For the clean capping quality:***
  - The soils (materials) used within clean capping quality shall be deemed 'suitable for use' when tested in line with the requirements of the Local Planning Authority and against the relevant screening criteria, a copy of which is appended for reference.
- ***For other forms of barrier, e.g. paving*:**
  - Photographic evidence of the physical barrier and commentary from a suitably qualified person as to the adequacy of the barrier to achieve the objective of the risk mitigation.

[10] *Cover Systems for Land Regeneration - Thickness of cover systems for Contaminated Land BRE/AGS/NHBC: 2004 (under review)*
[11] *Verification requirements for cover systems (leeds.gov.uk)*

7.0 Conclusions and Recommendations

7.1 Conclusions

In conclusion, the Ground Investigation Report (desk-based) finds that;

> Further assessment is not recommended however, the action of demolishing the existing garage and removal of its sub-structure will represent an opportunity for some limited ground investigation fieldworks to be completed to support the proposed design works and remove any uncertainty around:

i) The potential presence of relic sub-structures; or, related to this,

ii) The depth to a suitable formation material for new foundations.

Other, more specific ground investigation fieldwork, e.g. chemical testing of soils, is not specifically recommended at this stage with precautionary risk management recommended instead. Chemical testing may wish to be considered as part of this work to confirm waste classifications of excavation arisings however, this requirement should be confirmed with the groundworker.

> Risk mitigation is recommended to reduce the level of risk presented by various hazards to acceptably low levels details of which are presented throughout Section 6.0 of this Report alongside the ground engineering advice.

7.2 Recommendations

Recommended follow-on work includes:

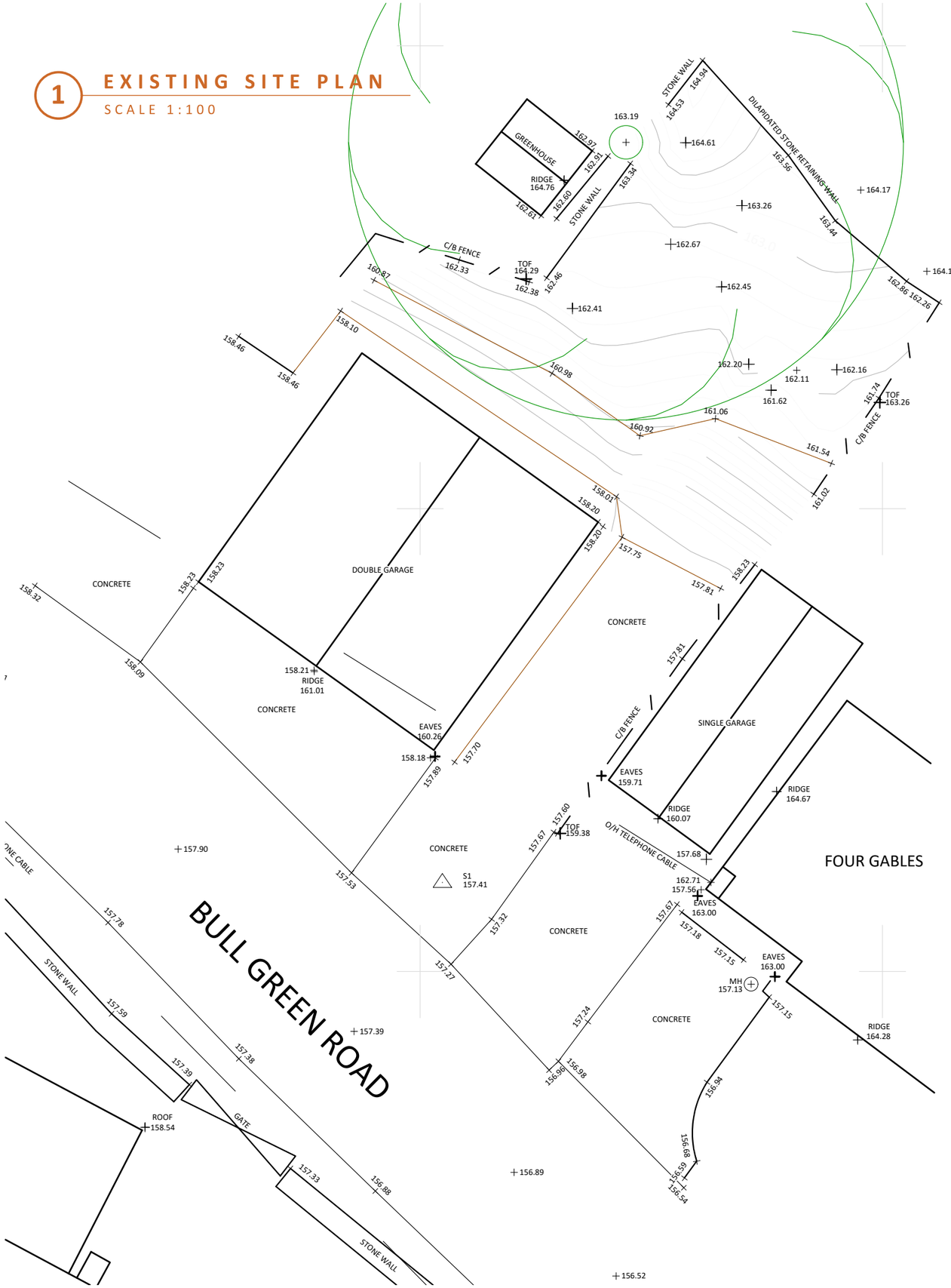
1. Review of this Ground Investigation Report and the advice contained herein.
2. Submission of the Ground Investigation Report to the project design team and other key stakeholders, i.e. the local planning authority or building control.
3. Follow-on reporting will be required to confirm the soil forming material imported to the front garden is both; suitably thick and, of suitable quality. This is considered likely to be addressed in a short-form letter report.

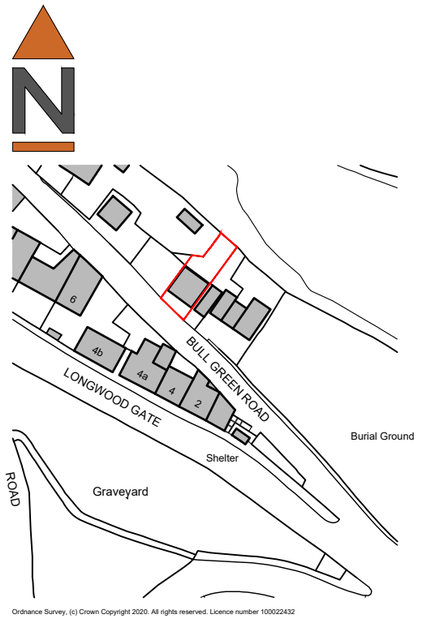
   As noted within Section 6.4, the specification/recommendation of a 'clean capping' layer will be treated as a 'remedial action' by the local planning authority for which a dedicated 'Remediation Strategy' may be required. Based on the low level of threat and scale of the development, the advice contained herein may be deemed sufficient assurance that the soft landscaping will be 'suitable for use', the overall aim of any contaminated land planning condition.

ⓘ ***Photographic diary of the groundworks:*** *Irrespective of any specific requirement set out herein, it is recommended that a photographic record of the groundworks is maintained to document the physical condition and nature of the ground conditions across the Site. This will serve as a valuable record for the project as well as any future planned works on the Site.*

1 EXISTING SITE PLAN

SCALE 1:100





2 SITE LOCATION PLAN

SCALE 1:1250

Revisions

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Client
Rose Taylor

Project
Bull Green Road House
Longwood, Huddersfield
HD3 4XW

Drawing title
Existing SIte Block and Location Plans

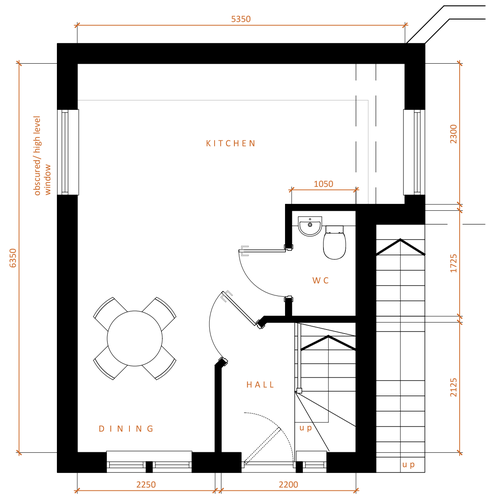
ISSUED FOR INFORMATION

Scale @ A3	Drawn by
As shown	CG
Date	App'd
25/06/22	-
Drawing no	Rev
22.1171/(EX)01	-

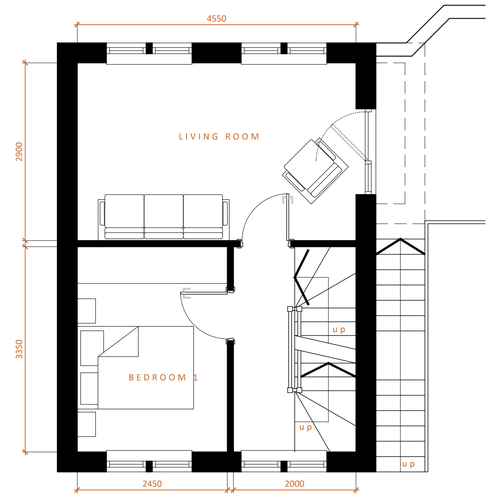
KEY

- LANDSCAPED GARDENS/ GRASSED AREAS
- PAVING
- TARMACADAM DRIVEWAY
- TREE ROOT PROTECTION ZONE
- EXTERNAL WALLS
- 1.8m HIGH CLOSE BOARDED TIMBER FENCE

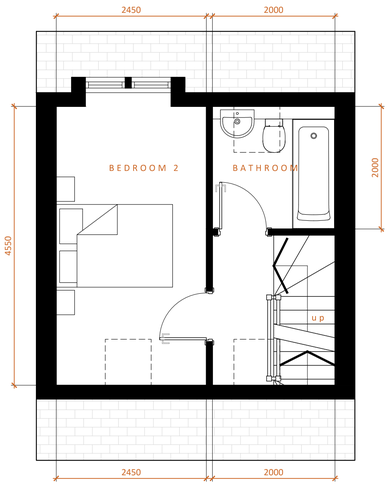
1 PROPOSED SITE BLOCK PLAN
SCALE 1:100



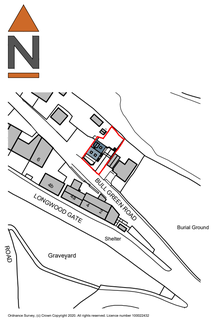
2 PROPOSED GROUND FLOOR PLAN
SCALE 1:50



3 PROPOSED FIRST FLOOR PLAN
SCALE 1:50



4 PROPOSED SECOND FLOOR PLAN
SCALE 1:50



5 SITE LOCATION PLAN
SCALE 1:1250

Rev B -21/02/24- 3.2X11m driveway indicated as highways comments, patio at first floor extended above drive, house redesigned to accommodate driveway changes.

Rev A -22/01/24- Dormer to SW elevation replaced with roof window

Revisions

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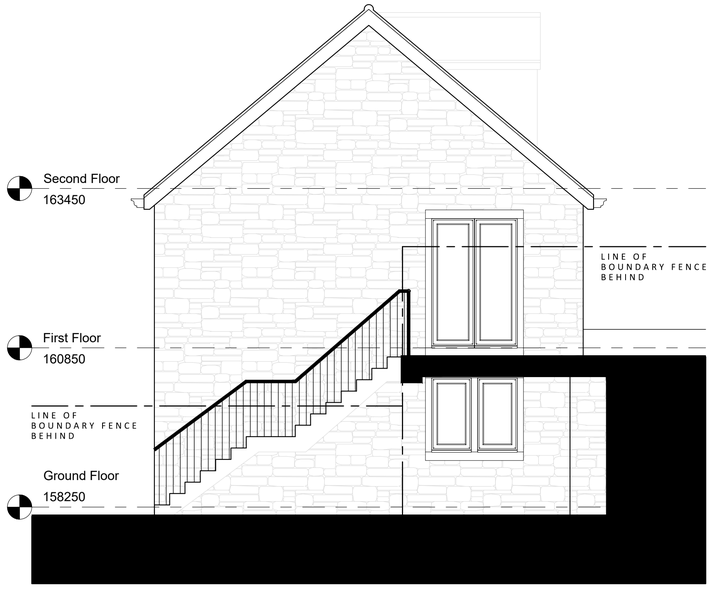
Drawing title
Plans
As Proposed

PLANNING APPLICATION

Scale @ A1	Drawn by
As Shown	CG
Date	App'd
November '23	-
Drawing no	Rev
22-1171/(AL)10	B

1 PROPOSED SOUTH-WEST ELEVATION
SCALE 1:50



2 PROPOSED SOUTH-EAST ELEVATION
SCALE 1:50

PROPOSED MATERIALS SCHEDULE

WALLS	COURSED REPRODUCTION YORKSTONE WITH ARTSTONE DETAILING
ROOF	CONCRETE INTERLOCKING ROOF SLATE WITH MATCHING RIDGE TILE &ROOF VERGES
DOORS/ WINDOWS	UPVC DOUBLE GLAZED WINDOW & DOOR UNITS
ROOFLIGHTS	PROPRIETARY ALUMINIUM DOUBLE GLAZED ROOFLIGHTS.

3 PROPOSED NORTH-EAST ELEVATION
SCALE 1:50

4 PROPOSED NORTH-WEST ELEVATION
SCALE 1:50

Rev B -21/02/24- 3.2X11m driveway indicated as highways comments, patio at first floor extended above drive, house redesigned to accommodate driveway changes.

Rev A -22/01/24- Dormer to SW elevation replaced with roof window

Revisions

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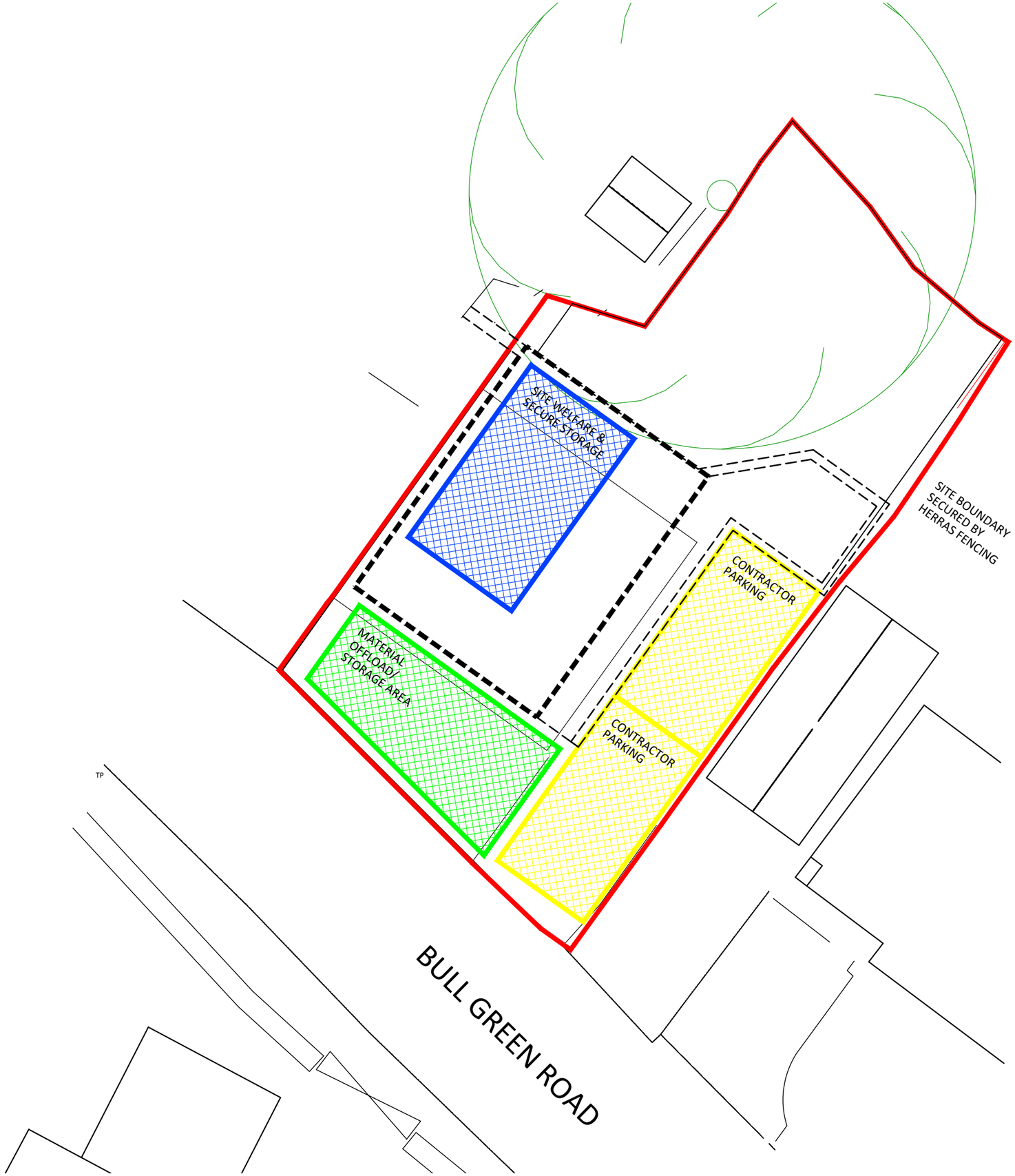
Drawing title
Elevations
As Proposed

PLANNING APPLICATION

Scale @ A1	Drawn by
1:50	CG
Date	**App'd**
November '23	-
Drawing no	**Rev**
22-1171/(AL)11	B



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Bull Green Road House
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HD3 4XW

Drawing title
Proposed Construction Phase
Site Plan

PLANNING APPLICATION

Scale @ A3	Drawn by
As shown	CG
Date	App'd
Nov '23	-
Drawing no	Rev
22.1171/(AL)12	-

Material Suitability
Chemical Screening

SOIL AND STRUCTURES

Notes on Generic Assessment Criteria
1. Assumes sandy loam soil (default soil type)
2. Assumes 6% SOM
3. Assumes small terraced house
4. S4UL = Suitable 4 Use Levels (LQM/CIEH) - minimal risk
5. C4SL = Category 4 Screening Levels (DEFRA) - acceptably low risk
6. Bold GACs derived from SGV report input parameters in CLEA v1.071

Material Description	**Topsoil (on site)**	**Topsoil (on site)**
Lab Sample Number	2918149	2918150
Sample Reference	TP101	TP103
Sample Number	None Supplied	None Supplied
Depth (m)	0.10-0.30	0.10-0.20
Date Sampled	18/12/2023	18/12/2023
Time Taken	None Supplied	None Supplied

Analytical Parameter (Soil Analysis)	**Units**	**Detection**	**Accredit?**	**Generic Assessment Criteria**		***Exceeds by more than x2***	***Exceeds by less than x2***
Stone Content	%	0.1	NONE	Not applicable		< 0.1	< 0.1
Moisture Content	%	N/A	NONE	Not applicable		17	20
Total mass of sample received	kg	0.001	NONE	Not applicable		0.5	0.5
Asbestos in Soil				Type		-	-
	Type	N/A	ISO 17025	Detected or not?		Not-detected	Not-detected
				Analyst		JBH	JBH
General Inorganics							
pH - Automated	pH Units	N/A	MCERTS	Review when <5 or >9		6.8	6.1
Water Soluble Sulphate as SO_4 16hr extraction (2:1)	mg/kg	2.5	MCERTS	Not applicable		17	15
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	g/l	0.00125	MCERTS	Not applicable		0.0085	0.0075
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	mg/l	1.25	MCERTS	Not applicable		8.5	7.5
Organic Matter	%	0.1	MCERTS	GSV variable		6.4	6.4
Speciated PAHs				**S4UL**	**C4SL**		
Naphthalene	mg/kg	0.05	MCERTS	>	Surrogate Marker	< 0.05	0.25
Acenaphthylene	mg/kg	0.05	MCERTS	>	Surrogate Marker	< 0.05	0.15
Acenaphthene	mg/kg	0.05	MCERTS	>	Surrogate Marker	< 0.05	0.24
Fluorene	mg/kg	0.05	MCERTS	>	Surrogate Marker	0.06	0.28
Phenanthrene	mg/kg	0.05	MCERTS	>	Surrogate Marker	0.58	2.8
Anthracene	mg/kg	0.05	MCERTS	>	Surrogate Marker	0.12	0.64
Fluoranthene	mg/kg	0.05	MCERTS	>	Surrogate Marker	0.97	3.8
Pyrene	mg/kg	0.05	MCERTS	>	Surrogate Marker	0.91	3.5
Benzo(a)anthracene	mg/kg	0.05	MCERTS	>	Surrogate Marker	0.52	2
Benzo(k)fluoranthene	mg/kg	0.05	ISO 17025	>	Surrogate Marker	0.62	2
Chrysene	mg/kg	0.05	ISO 17025	>	Surrogate Marker	0.65	2.2
Benzo(b)fluoranthene	mg/kg	0.05	MCERTS	>	Surrogate Marker	0.3	0.92
Benzo(a)pyrene	mg/kg	0.05	MCERTS	>	5	0.54	1.8
Indeno(1,2,3-cd)pyrene	mg/kg	0.05	MCERTS	>	Surrogate Marker	0.26	0.87
Dibenz(a,h)anthracene	mg/kg	0.05	MCERTS	>	Surrogate Marker	0.1	0.29
Benzo(ghi)perylene	mg/kg	0.05	MCERTS	>	Surrogate Marker	0.28	0.91
Coronene	mg/kg	0.05	NONE		-		
Total PAH							
Speciated Total EPA-16 PAHs	mg/kg	0.8	MCERTS	Not available		5.91	22.6
Phenols				**S4UL**	**C4SL**		
Total - Monohydric	mg/kg	1	MCERTS	420	<		
Heavy Metals / Metalloids				**S4UL**	**C4SL**		
Arsenic (aqua regia extractable)	mg/kg	1	MCERTS	>	37	18	20
Boron (water soluble)	mg/kg	0.2	MCERTS	290	<	2	0.7
Cadmium (aqua regia extractable)	mg/kg	0.2	MCERTS	>	22	< 0.2	< 0.2
Chromium (hexavalent)	mg/kg	1.2	MCERTS	21	<	< 1.2	< 1.2
Chromium (aqua regia extractable)	mg/kg	1	MCERTS	910	<	27	28
Copper (aqua regia extractable)	mg/kg	1	MCERTS	2400	<	41	43
Lead (aqua regia extractable)	mg/kg	1	MCERTS	>	200	76	85
Mercury (aqua regia extractable)	mg/kg	0.3	MCERTS	1	<	< 0.3	< 0.3
Nickel (aqua regia extractable)	mg/kg	1	MCERTS	130	<	33	26
Selenium (aqua regia extractable)	mg/kg	1	MCERTS	350	<	1.4	1.3
Zinc (aqua regia extractable)	mg/kg	1	MCERTS	3700	<	120	120

Annex

Background Threat and Risk

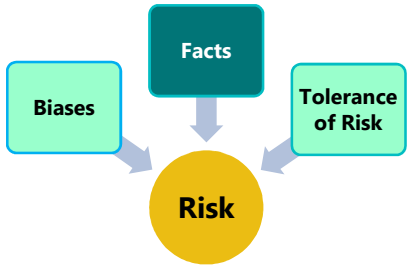
SOIL AND STRUCTURES

This annex offers further reading and background information relating to the referencing of 'background threat' within the risk assessment process.

The ratings presented herein **do not** reflect site-specific risk.

Introduction

Risk is an inherent part of all decisions and everyone has an appreciation of risk. How risk is assessed by both individuals and organisations is guided by three main influences; facts, biases and tolerance of risk.



Acknowledgement of this interplay is important given that, as well as informing the assessment; it also informs the response to risk – the practical outcome of the theoretical process. To support greater ownership of the assessment and any recommended actions, risk assessments should therefore aim to be; clear, proportionate and transparent (evidence-based).

Risk Assessment Influences

Biases: There are many types of biases that affect decisions or judgements including: i) *commercial bias*; does a given risk rating confer commercial opportunities or benefits on the person undertaking the assessment?; or, ii) *confirmation bias*; has the assessor not encountered any problems in similar scenarios and therefore generalised or under-assessed the risk rating.

Facts: The most important and ideally, guiding factor for the assessment of risk. Facts need to be evidenced and assessed by a competent person[1].

Tolerance of Risk[2]: Is informed by both societal and individual factors. Societal factors may include: is the hazard acceptable at all, e.g. locating nuclear power stations within urban areas; or, balancing scientific and technological advances with possible burdens to society and the economy. An example of this for land contamination is the reduction of 'excess lifetime cancer risk (ELCR)' as part of generic assessment criteria for soil testing (society accepting more risk). Individual factors may include: how a given risk affects them, their family and their values; or, accepting a higher risk for a greater reward.

Background Threat

Referencing 'background threat' as part of the Risk Assessment is intended to offer further detail on the hazards as well as an indication of the relative threats they pose. This aims to support; clarity, transparency and proportionality and help the reader better contextualise the risk and thus take greater ownership of it and any recommended action. Proportionality is central to effective risk management. Being over protective erodes the value of the process and adds unnecessary cost; being under protective exposes people and places to real risk.

Within the following tables, details on plausible routes or 'exposure pathways' by which a hazard may result in harm or other outcomes are detailed together with commentary on the assigned 'background threat' levels. The rating of 'background threat' is traffic-lighted between; high, moderate and low, with the nuances of the rating drawn more fully out within the commentary provided.

[1] http://www.legislation.gov.uk/uksi/2015/51/contents
[2] http://www.hse.gov.uk/risk/theory/r2p2.pdf

	Background threat	Exposure pathway	Rationale for assigned level of threat (Incident data, public perception and general commentary on harm and other impacts)
Geological Risks			
Collapsible soils[3] *Deposits that can collapse when saturated or loaded. Generally isolated to South-East England*	**High**	**Harm:** burial and crushing. **Other impacts:** time-delays and damage to plant, structures and sub-structures.	Incident data for harm and other impacts is not readily available however, collapsible soils are widely distributed within the UK and the rapidly developing nature of the hazard means that the threat does carry immediacy. Public perception of the threat 'collapsible soils' pose is likely varied given its technical nature. **Harm:** With links to excavation collapses which account for a high proportion of year-on-year fatal and non-fatal injuries within the construction sector[4], the threat of harm is considered **high**. **Other impacts:** With potentially large time and cost implications (on a site-by-site basis) for responding reactively to the adverse affects of collapsible soils the threat of other impacts is also considered **high**.
Compressible soils[5] *Deposits that are very soft or degradable.*	**Moderate**	**Harm:** none that are directly linked or obviously plausible. **Other impacts:** time-delays and damage to structures and sub-structures.	Incident data for harm and other impacts is not readily available. The slowly developing nature of the hazard means that the threat does not carry immediacy. However, with compressible soil's links to subsidence, one of the most damaging geo-hazards in the UK[6] that is on the rise largely due to the influence of clay soils[7] and, with their extensive distribution across the UK, other impacts are significant. Public perception of the threat 'compressible soils' pose is likely varied given its technical nature. **Harm:** The slowly developing nature of the hazard means the threat of harm is considered **low**. **Other impacts:** With potentially moderate time and cost implications (on a site-by-site basis) for responding reactively to the adverse affects of compressible soils the threat of other impacts is considered **moderate**.

[3] https://www.bgs.ac.uk/products/geosure/collapsiblePHI.html
[4] http://www.hse.gov.uk/statistics/tables/index.htm#riddor
[5] https://www.bgs.ac.uk/products/geosure/compressiblePHI.html
[6] https://www.bgs.ac.uk/research/engineeringGeology/shallowGeohazardsAndRisks/shrinking_and_swelling_clays.html
[7] https://www.crawco.com/assets/uploads/docs/Crawford-Subsidence-The-Silent-Surge-vFinal.pdf

	Background threat	Exposure pathway	Rationale for assigned level of threat (Incident data, public perception and general commentary on harm and other impacts)
Geological Risks, continued			
Ground dissolution[8] *Soluble rocks.*	**Moderate**	**Harm:** falls into open or partially open dissolution features. **Other impacts:** time-delays and damage to plant, structures and sub-structures.	Incident data for harm and other impacts is not readily available. The rapidly developing nature of the hazard (sinkholes) means that the threat does carry immediacy. Ground dissolution is a geology/region specific hazard and therefore threat levels vary across the UK. The frequency with which incidents take place is likely to be relatively constant with possible increases due to extreme weather events and probable increases due to urban sprawl into ground dissolution prone areas, making incidents more likely. Public perception of the threat 'sinkholes' pose is likely to be relatively high. **Harm:** The rapidly developing nature of the hazard but lack of evidence of fatalities or injuries attributed to sinkholes means the threat of harm is considered **moderate**. **Other impacts:** With potentially moderate time and cost implications (on a site-by-site basis) for responding reactively to the adverse affects of ground dissolution albeit likely on a small scale (sinkholes are likely to be localised) the threat of other impacts is considered **moderate**.
Running sand[9] *Loosely packed sand that can become fluid or 'run' when wet and support is withdrawn, e.g. when excavated.*	**High**	**Harm:** burial and crushing. **Other impacts:** time-delays and damage to plant.	Incident data for harm and other impacts is not readily available however, fine-grained / saturated sands are widely distributed within the UK and the very rapidly developing nature of the hazard means that the threat does carry immediacy. Public perception of the threat 'running sand' poses is likely varied given its technical nature. **Harm:** With links to excavation collapses which account for a high proportion of year-on-year fatal and non-fatal injuries within the construction sector[10], the threat of harm is considered **high**. **Other impacts:** Time and cost implications (on a site-by-site basis) for responding reactively to the adverse affects of running sands is varied but very dependent on their extent. The threat can be **high,** e.g. reactively changing foundation solution and adverse excavation conditions.

[8] https://www.bgs.ac.uk/products/geosure/solublePHI.html
[9] https://www.bgs.ac.uk/products/geosure/running_sandPHI.html
[10] http://www.hse.gov.uk/statistics/tables/index.htm#riddor

	Background threat	Exposure pathway	Rationale for assigned level of threat (Incident data, public perception and general commentary on harm and other impacts)
Geological Risks, continued			
Sensitive clays[11] *Fine grained (clay) soils that can shrink and swell when wetted or dried respectively.*	**Moderate**	**Harm:** none that are directly linked or obviously plausible. **Other impacts:** damage to structures and sub-structures.	Incident data for harm and other impacts is not readily available. The slowly developing nature of the hazard means that the threat does not carry immediacy. However, with sensitive clays direct links to subsidence, one of the most damaging geo-hazards in the UK[12] that is on the rise and, with their extensive distribution across the UK, other impacts are significant. Public perception of the threat 'subsidence' poses is likely to be relatively high. **Harm:** The slowly developing nature of the hazard means the threat of harm is considered **low**. **Other impacts:** With potentially moderate time and cost implications for responding reactively to the adverse affects of sensitive clays the threat of other impacts is considered **moderate**.
Slope instability[13] *Falls, topples, slides or flows of soils or rocks generally due to gravity but controlled by various other factors, e.g. drainage.*	**High**	**Harm:** falls from height, burial and crushing. **Other impacts:** time delays and damage to plant, structures and sub-structures.	Aggregated incident data for harm and other impacts is not readily available however there are relatively frequent case-studies of landslips taking place[14][15] with some nationally significant incidents[16] resulting in significant changes to assessment and design. The slow to very rapidly developing nature of the hazard means that the threat does carry immediacy. Slope instability can occur anywhere throughout the UK. Public perception of the threat 'landslides' pose is likely to be relatively high. **Harm:** The potentially very rapidly developing nature of the hazard means the threat of harm is considered **high**. **Other impacts:** With potentially high time and cost implications for responding reactively to the adverse affects of slope instability the threat of other impacts is considered **high**.

[11] https://www.bgs.ac.uk/products/geosure/shrink_SwellPHI.html
[12] https://www.bgs.ac.uk/research/engineeringGeology/shallowGeohazardsAndRisks/shrinking_and_swelling_clays.html
[13] https://www.bgs.ac.uk/products/geosure/landslidesPHI.html
[14] https://www.bgs.ac.uk/research/engineeringGeology/shallowGeohazardsAndRisks/landslides/home.html
[15] https://www.bgs.ac.uk/landslides/casestudies.html
[16] https://www.bgs.ac.uk/research/engineeringGeology/shallowGeohazardsAndRisks/landslides/aberfan.html

	Background threat	Exposure pathway	Rationale for assigned level of threat (Incident data, public perception and general commentary on harm and other impacts)
Geological Risks, continued			
Natural ground gas[17] *Methane and carbon dioxide primarily (though can include other gases) given off as part of natural bio-geo-chemical processes.*	**Moderate**	**Harm:** ingress and accumulation of asphyxiant, toxic or explosive gases into occupied spaces. **Other impacts:** damage to structures and sub-structures through explosion.	Aggregated incident data for harm and other impacts is not readily available however nationally significant incidents have taken place[18] with the threat carrying an immediacy. However, the frequency with which this hazard manifests is considered to be low. Public perception of the threat 'natural ground gases' pose is likely varied given its technical nature. **Harm:** The rapidly developing nature of the hazard means the threat of harm is considered high however the low frequency of incidents reduces this to **moderate**. **Other impacts:** With potentially high cost implications for responding reactively to the adverse affects of natural ground gas the threat of other impacts is considered high however the low frequency of incidents reduces this to **moderate**.
Radon[19] *Naturally occurring radioactive gas that is emitted from soils and rocks to varying degrees (depending on their composition) .*	**High**	**Harm:** ingress and accumulation of radioactive air and dust into occupied spaces. **Other impacts:** none that are directly linked or obviously plausible.	Incident data for harm is readily available[20] with radon being a significant contributory factor to lung cancer deaths across affected areas of the UK and with a risk of death that is the same order of magnitude as all deaths within the construction sector[21]. The slowly developing nature of the hazard means that the threat does not carry immediacy however the radioactive nature of the hazard does. Radon can occur anywhere throughout the UK but affects certain geological areas more so than others. Public perception of the threat 'radon' pose is likely low despite the high background threat. **Harm:** The slowly developing but significantly hazardous nature of the hazard means the threat of harm is considered **high**. **Other impacts:** The cost of mitigation is low if the risk is unacceptable and addressed proactively whereas responding reactively will incur moderate costs (retrospective fitting of protection). Overall however, the threat of other impacts is considered **low**.

[17] https://www.bgs.ac.uk/products/geohazards/methane.html
[18] http://www.hse.gov.uk/comah/sragtech/caseabbeystead84.htm
[19] http://www.ukradon.org.uk/
[20] https://www.ukradon.org/information/risks
[21] http://www.hse.gov.uk/risk/theory/r2p2.pdf

	Background threat	Exposure pathway	Rationale for assigned level of threat (Incident data, public perception and general commentary on harm and other impacts)
Geological Risks, continued			
Aggressive geology[22] *Primarily concerned with acidic conditions arising from sulphate compounds in the ground with the potential to degrade buried concrete. Can include other conditions, e.g. saline or solvents.*	**Low**	**Harm:** none that are directly linked or obviously plausible. **Other impacts:** damage to structures and sub-structures.	Incident data for harm and other impacts is not readily available. The slowly developing nature of the hazard means that the threat does not carry immediacy. However, when aggressive geologies are present, damage to buried concrete can be severe[21]. Aggressive geology is typically, though not always, linked to sulphide bearing geologies that results in the hazard being geology/region specific and therefore threat levels vary across the UK. Public perception of the threat 'aggressive geology' pose is likely low given its technical nature. **Harm:** The slowly developing nature of the hazard means the threat of harm is considered **low**. **Other impacts:** With potentially high cost implications for responding reactively to the adverse affects of aggressive geology the threat of other impacts is considered high however, on a site-by-site basis, the low frequency of incidents and ease of management reduces this to **low**.
Hydrogeological and hydrogeological risks			
All flood risk carries high background threats. It is recommended that the advice of a suitably qualified competent person is sought for more information.			

[22] https://www.bgs.ac.uk/research/environmentalModelling/GeoProperties/SulphatesSulphides.html

	Background threat	Exposure pathway	Rationale for assigned level of threat (Incident data, public perception and general commentary on harm and other impacts)
Historical Risks			
Contamination (on-site and off-site) *N.B. within the sub-surface environment there is invariably interplay between soil (contamination) and water (pollution) systems with these two risks commonly interacting with one another.*	**Moderate**	**Harm:** dermal contact with, or ingestion and inhalation of dust or vapours of, harmful material by either workers during construction or end users of the site (various depending on development). **Other impacts:** time-delays, damage to structures, sub-structures and ecology.	Aggregated incident data for harm and other effects is not readily available although the Environment Agency's enforcement register does offer an indication[23]. Case law also exists that directly relates contaminated land (airborne dust) to harm[24] as well as other impacts[25][26]. Harm is time-dependent; acute (short term) or chronic (long term). Acute risks for workers are generally informed by well-developed science of exposure limits for short and long term conditions[27]. Acute risks for end users are less well understood but an area of ongoing research[28]. Chronic risks are better understood and supported by established research including that undertaken by central government[29]. Public perception of the threat 'contamination' poses is likely varied given its technical nature. Contamination can occur in any location however former industrial land or waste depositories naturally carry a higher threat with increased volumes of potentially harmful material. Naturally geologies can also contain harmful material however these generally contribute to 'normal background concentrations' that local populations are exposed to. **Harm (acute risk):** For acute risk, the rapidly development nature of the hazard means the threat of harm is high however, the low frequency of incidents reduces this to **moderate**. **Harm (chronic risk):** For chronic risk an assessment of 'threat' is difficult not least as the threat can vary highly within a site itself. In general however, the slowly developing nature of the hazard means the threat of harm is lower than acute risk but not low. Whilst the frequency of chronic risk incidents resulting in harm is low in the UK, the potential for harm raises this to **moderate**. **Other impacts:** With potentially high cost implications for responding reactively to the adverse affects of contamination the threat of other impacts is considered **moderate**.

[23] https://environment.data.gov.uk/public-register/view/search-enforcement-action e.g. Groundwater Regulations, Environmental Protection Act 1990, Environment Act 1995
[24] http://www.environmentlaw.org.uk/rte.asp?id=266
[25] https://www.freeths.co.uk/2017/01/13/case-law-update-contaminated-land-liabilities/
[26] http://www.environmentlaw.org.uk/rte.asp?id=228
[27] http://www.hse.gov.uk/coshh/basics/exposurelimits.htm
[28] https://sobra.org.uk/about-us/sub-groups/
[29] http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=18341

	Background threat	Exposure pathway	Rationale for assigned level of threat (Incident data, public perception and general commentary on harm and other impacts)
Historical Risks, continued			
Pollution (waters) *N.B. within the sub-surface environment there is invariably interplay between soil (contamination) and water (pollution) systems with these two risks commonly interacting with one another.*	**High**	**Harm:** pollution of sensitive water bodies, e.g. Controlled Waters[30] with potential for harm to water users. **Other impacts:** damage to ecology.	Aggregated incident data for harm and other effects is readily available that directly relates pollution to harm[31] with other impacts also reported[32] however discerning where this harm arises from historic, unused sources such as those more commonly encountered on land development is difficult. Harm varies according to the nature of the incident, e.g. a recent spillage of a large volume of potential pollutants versus an ongoing seepage of an unknown volume of potential pollutants. For land development, it is commonly seepages that are encountered. These seepages can be from either; a single point-source, e.g. an old storage tank, or diffuse source, e.g. a large area of soils leaching pollutants, e.g. a landfill. Public perception of the threat 'pollution' poses is likely to be relatively high. **Harm:** The slowly developing nature of the hazard but potentially large impacts means the threat of harm is considered moderate however, the relatively high frequency with which these incidents take place result in the threat being considered **high**. **Other impacts:** With potentially high cost implications for responding reactively to the adverse affects of pollution the threat of other impacts is considered **high**.

[30] https://www.legislation.gov.uk/ukpga/1991/57/section/104
[31] https://environment.data.gov.uk/public-register/view/search-enforcement-action e.g. Groundwater Regulations, Environmental Protection Act 1990, Environment Act 1995
[32] https://www.bbc.co.uk/news/uk-england-devon-49242485

	Background threat	Exposure pathway	Rationale for assigned level of threat (Incident data, public perception and general commentary on harm and other impacts)
Historical Risks, continued			
Mining risks are varied and can carry high background threats. It is recommended that the Coal Mining Risk Assessment, if required for the site, is consulted.			
Landfill gas	**Moderate**	**Harm:** ingress and accumulation of asphyxiant, toxic or explosive gases into occupied spaces. **Other impacts:** damage to structures and sub-structures through explosion.	Aggregated incident data for harm and other impacts is not readily available however nationally significant incidents have taken place[33][34][35] with the threat carrying immediacy. However, the frequency with which this hazard manifests is considered low. Public perception of the threat 'landfill gas' poses is likely varied given its technical nature. **Harm:** The rapidly developing nature of the hazard means the threat of harm is considered high however the low frequency of incidents reduces this to **moderate**. **Other impacts:** With potentially high cost implications for responding reactively to the adverse affects of landfill gases the threat of other impacts may be considered high however the low frequency of incidents reduces this to **moderate**.
Sub-surface structures *i.e. tunnels, basements and cellars and not mine shafts or underground mine workings*	**Moderate**	**Harm:** falls from height, burial and crushing. **Other impacts:** time delays and damage to plant.	Incident data for harm and other impacts is not readily available. The rapidly developing nature of the hazard (surface collapses) means that the threat does carry immediacy. The frequency with which incidents take place is likely to be relatively constant. Public perception of the threat 'old basements' pose is likely to be relatively high and linked to 'sinkholes'. **Harm:** With links to excavation collapses which account for a high proportion of year-on-year fatal and non-fatal injuries within the construction sector[36], the threat of harm may be considered high however, the ease of management reduces this to **moderate**. **Other impacts:** With potentially moderate time and cost implications (on a site-by-site basis) for responding reactively to the adverse affects of sub-surface structures the threat of other impacts is also considered **moderate**.

[33] http://users.ox.ac.uk/~ayoung/LF/cwm039b.pdf
[34] CIRIA document ref. "Assessing risks posed by hazardous ground gases to buildings (revised)" (C665) – Loscoe case study
[35] https://inews-co-uk.cdn.ampproject.org/c/s/inews.co.uk/news/uk/council-houses-torn-down-burning-coal-seam-carbon-monoxide-derbyshire-826029?amp
[36] http://www.hse.gov.uk/statistics/tables/index.htm#riddor

	Background threat	Exposure pathway	Rationale for assigned level of threat (Incident data, public perception and general commentary on harm and other impacts)
Historical Risks, continued			
Unexploded ordnance	**Moderate**	**Harm:** explosion damage (direct or indirect; on site and off site). **Other impacts:** time delays and damage to plant, structures and sub-structures.	Aggregated incident data for harm and other impacts is not readily available however incidents are well reported in national and regional news as well as on enthusiast websites[37] with the threat carrying immediacy. No deaths are directly attributed to unexploded ordnance since 1949. The frequency with which this hazard manifests varies across land used for military purposes and land used for military purposes but possibly bombed, with the former being likely and the latter a low likelihood. Public perception of the threat 'unexploded ordnance' poses is likely to be relatively high due compared to a lower background threat. **Harm:** The rapidly development nature of the hazard means the threat of harm is high however, the low frequency of incidents on land not used for military purposes reduces this to **moderate**. **Other impacts:** With potentially high cost implications for responding reactively to the adverse affects of aggressive geology the threat of other impacts is considered high however, on a site-by-site basis, the low frequency of incidents reduces this to **moderate**.
Archaeological interests can carry high background threats. It is recommended that the advice of a suitably qualified competent person is sought for more information.			
Utilities can carry high background threats. It is recommended that the advice of a suitably qualified competent person is sought for more information.			
Ecological Risks			
Ecological risk can carry high background threats. It is recommended that the advice of a suitably qualified competent person is sought for more information.			

[37] http://bombfuzecollectorsnet.com/page14.htm