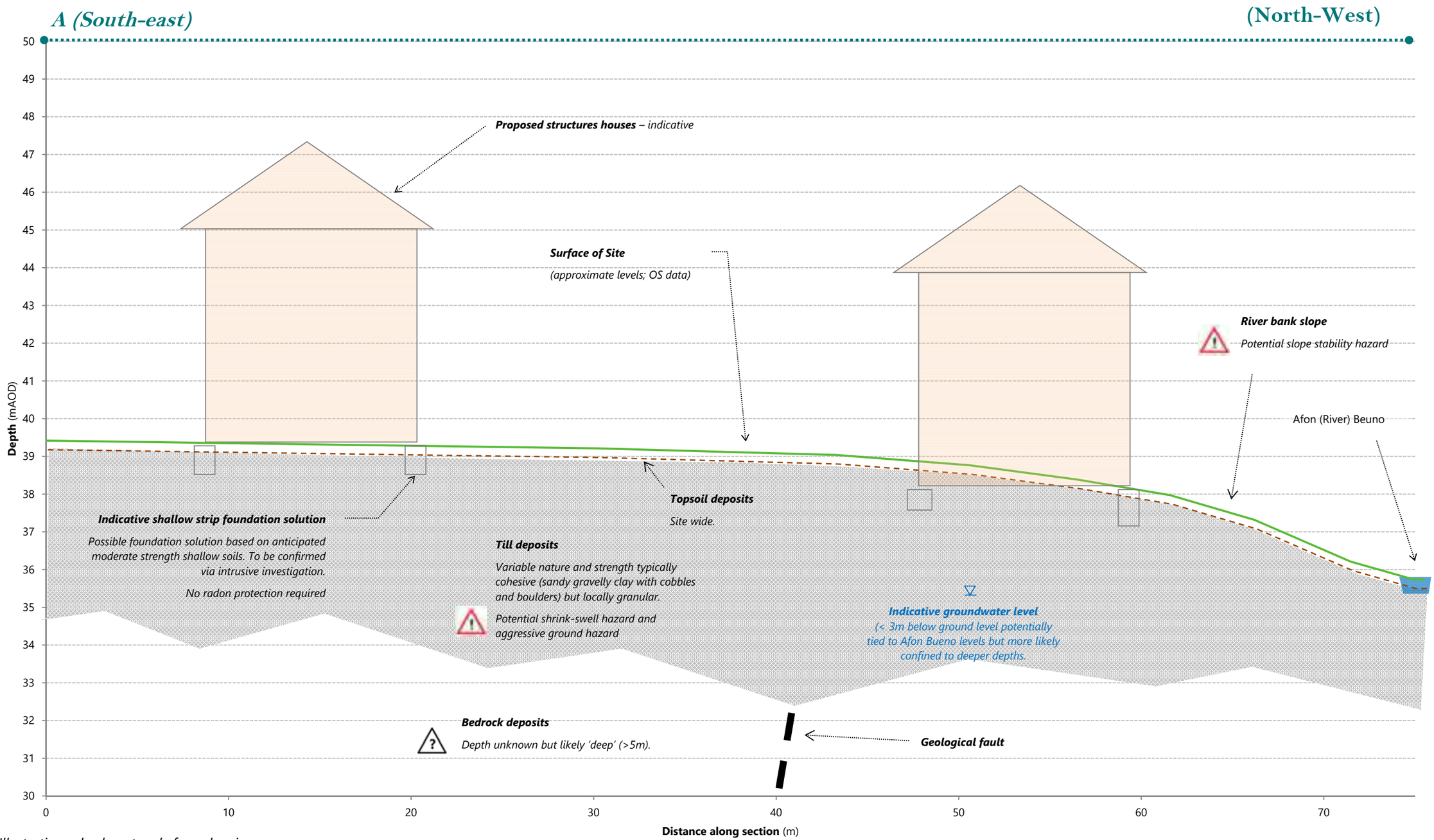
4.0 **Preliminary Ground Model** – Profile (shallow)



> *Illustrative only, do not scale from drawing*

> *Key questions highlighted with question marks (?) and select hazards highlighted with exclamation marks (!)*

5.0 Engineering Considerations

The following sub-sections offer advice on ground-related matters for the engineering works required as part of planned development works.

This advice is based on available opensource data that, whilst offering a reasonable level of confidence in the anticipated ground conditions, should be used to inform the scoping of the recommended intrusive investigation and not relied upon to inform design decisions.

The development design is outlined Section 1.2 together with the likely groundworks activities required as part of the development.

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

> Low imposed loads of the proposed structures;

> The variable but likely moderate strength of the shallow Till deposits that may support a shallow spread foundation solution; and,

> Sloping ground towards the river (Afon Beuno) that may need localised cut or stepped foundations.

5.1 General Groundworks

Excavation progress is likely to be at typical rates through the shallow soils employing a medium sized excavator, e.g. 3CX or larger.

Excavation stability is unlikely to warrant short-term temporary support if the Till deposits are consistently 'firm to stiff'. Localised granular pockets may be present that could give rise to instability. Access to any excavations by personnel should be prohibited unless suitable temporary support is provided and other risks assessed by a suitably qualified person, e.g. ground gases. Further guidance is available[10].

Excavation conditions will be affected by inclement weather (increased instability and softening of clays) with open excavations potentially holding water due to predicted low rates of drainage within the Till deposits. Groundwater is not expected to be encountered within 3.00 m of the Site surface and, 'perched' groundwater may exist within the shallow granular lenses in the Till that could be encountered in excavations. Further guidance is available[11].

Excavation stability (slopes) is likely to be a consideration for both temporary and permanent works along the western and northern edges of the Site where the banks of the Afon Beuno are present.

Material suitability for re-use (geotechnical and environmental) is discussed below and in Section 7.0.

> *Topsoil deposits* are likely to be suitable for use for landscaping fill (Class 4) with confirmation testing of its chemical suitability potentially required by the local planning authority.

> *The Till deposits* present on Site are considered likely to be variably-graded and generally cohesive. A next 'cut' (removal) of material is likely with the Till potentially suitable for as a general fill (Class 1 or 2)

> For material re-use as an engineering or load-bearing fill the Engineer's approval will be required, e.g. selection of a suitable compaction regime.

> For all scenarios, developing a strategy for management of materials/soils in advance of the works is advised to minimise handling and maintain soil conditioning.

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[12].

Natural soils requiring disposal off Site will likely class as EWC 20 02 02 (soil and stones).

Mineral resources include recovered Topsoil that may have a value within local markets.

5.2 Structural Engineering

Foundations are likely open to all options however, the recorded presence of Till suggests that a traditional strip foundation may be viable across all plots.

Attention should be given to:

> The proximity of any foundation excavations or groundworks to the adjacent river;

> The presence of slopes along the northern and western edges of the Site that may need Engineered design depending on the angles / levels proposed; and

> The potential influence of existing or planned vegetation.

The recorded presence of a geological fault running across the Site is not considered to presence a constraint or hazard to the development unless a shallow bedrock profile is present on Site. This seems unlikely in this setting but cannot be ruled out. If and where shallow bedrock is present then provision of rafted foundations to any plots spanning the fault zone is recommended with slip-planes provided to the underside (sand layers).

Floor slab options are likely open (ground bearing or suspended) but will be guided by; the selection of foundation solution; any flood risk mitigation necessary; and, the influence of vegetation.

Proof rolling of the formation and treatment of any soft spots (or hard spots, e.g. boulders) through either excavation and replacement with suitable granular fill is a general advisory but less likely to be required across the Site.

6.3 Civil Engineering

Earthworks (cut and fill) may required as part of the proposed development along the edges of the Site that borders the river.

Hard-standing sub-grades or formations will be subject to final design levels being agree however, in general, when taken down through the existing Topsoil will likely comprise a cohesive (clay) sub-grade.

It is considered unlikely that pre-treatment of the sub-grade will be necessary (inferring a CBR value of >2.5 %).

Proof rolling of the formation and treatment of any soft spots (or hard spots, e.g. boulders) through either excavation and replacement with suitable granular fill is a general advisory but less likely to be required across the Site.

Drainage of the existing Site is expected to be defined by a low permeability soils (Till) that likely have 'poor' drainage characteristics (f ~ 10^{-6} to 10^{-9}) and a groundwater table that is likely deeper than 3 m below ground level.

These factors may combine to limit the potential for drainage to ground to be included for as part the proposed drainage strategy. Shallow infiltration systems, e.g. permeable paving, may be viable.

[10] *CIRIA Report 97 - Trenching Practice - Second Edition (1992)*
[11] *CIRIA Report No C515 Groundwater Control (2001)*
[12] *Waste classification technical guidance - GOV.UK*

The presence Afon Beuno along the northern and western edges of the Site is an obvious discharge point (as shown on Figure 1) with any shallowly percolating and infiltrating surface water expected to be readily transported to this watercourse.

Water supply pipes on Site will likely be laid within natural Till deposits.

Soft landscaping comprising public open space and private gardens is proposed as part of the development.

Based on the existing grass cover of the Site, sufficient Topsoil is expected to be recovered from Site that is likely to be suitable for use within the development based on the history of the Site.

Confirmation of the Topsoil's suitability for use is commonly requested by the local planning authority.

It is recommended that at least 150 mm of Topsoil[13] is placed in all soft landscaping areas and attention given to not over work or compact the soil to maintain its condition.

[13] *BS3882:2015 - Specification for Topsoil and requirements for use.*

6.0 **Ground Related Risk Management** – Hazard Screening and Preliminary Risk Assessment

Hazard Screening	Indicators?	Action	Commentary
Geological Hazards			
Collapsible soils	No	Responsive	No evidence of Blown Sand revealed on Site (ref. Section 4.0 and 5.0).
Compressible soils	No	Responsive	No evidence of compressible soils (organic soils or low strength soils) revealed on Site (ref. Section 4.0 and 5.0).
Ground dissolution	No	Responsive	No evidence of rocks liable to dissolution revealed on Site (ref. Section 4.0 and 5.0).
Running sand	No	Responsive	No evidence of fine sand and saturated silt soils revealed on Site (ref. Section 4.0 and 5.0).
Sensitive clays	**Yes**	**Assess risk**	Evidence of soils susceptible to shrink-swell revealed on Site (Till) (ref. Section 4.0 and 5.0).
Slope instability	**Yes**	**Assess risk**	Existing slopes on Site (around 1{v}:5{h}) with new slopes possibly formed as part of the proposed development (ref. Section 1.0).
Natural ground gas	No	Responsive	No evidence of gas generating soils on Site (ref. Section 4.0 and 5.0).
Radon	No	Responsive	Radon can be present across the UK. In this setting less between 1 and 3 % of properties are predicted be recorded above the action level (ref. Section 2.0).
Aggressive geology	**Yes**	**Assess risk**	Evidence of potentially aggressive soils revealed on Site – Till can contain pyrite or gypsum (ref. Section 4.0 and 5.0).
Hydrogeological & Hydrological Hazards			
River and sea flooding	**Yes**	Seek advice	High to low risk locally along edge of Afon Beuno (ref. Section 2.0).
Surface water flooding	No	Seek advice	Very low risk (ref. Section 2.0).
Groundwater flooding	No	Seek advice	Groundwater is not expected to rise above ground level or come within 3 m of the surface during prolonged rainfall and flooding events (ref. Section 2.0).
Watercourses	**Yes**	Seek advice	Open watercourse running along the northern and north-western boundary of the Site (ref. Section 2.0).
Historical Hazards			
Contamination (on-site)	No	Responsive	Former use of Site that is unlikely to have resulted in potentially harmful material entering the shallow soils on Site. (ref. Section 2.0).
Contamination (off-site)	No	Responsive	No evidence of potentially contaminative land uses adjacent to the Site that could have plausibly impacted soil quality on Site. (ref. Section 2.0).
Pollution (waters)	No	Responsive	Former use of Site that is unlikely to have resulted in potentially polluted material entering the shallow soils on Site. (ref. Section 2.0).
Landfill gas	No	Responsive	No landfill recorded within 250 m of the Site (ref. Section 2.0).
Mining (incl. mine gas)	No	Responsive	No evidence of probable or recorded shallow mining activities below the Site (ref. Section 2.0).
Sub-surface structures	No	Responsive	No clear evidence of sub-structures, e.g. cellars or basements, on Site (ref. Section 2.0)..
Unexploded ordnance	No	Responsive	No evidence of military land uses recorded on Site or evidence of bomb damage on Site or immediately adjacent to Site on post-war mapping (ref. Section 2.0).
Archaeological interests	No	Seek advice	No evidence of archaeological features recorded on historical mapping for the Site.
Utilities (above or below)	**Yes**	Seek advice	Evidence of above ground utilities on the Site.
Ecological Hazards			
Sensitive land uses	No	Seek advice	Site not designated as statutory protected area, e.g. SSSI.
Invasive species	Possibly	Seek advice	No evidence of non-native invasive species on Site (streetview and aerial photography) but where necessary, to be confirmed.
Protected species	Possibly	Seek advice	Potential habitats present on Site and where necessary, to be confirmed.

Preliminary Risk Assessment	Risk	Outline detail of recommended action *N.B. responsibility rests with the Contractor for the implementation of any responsive action*

N.B. The levels of risk detailed below may change subject to any further assessment that is recommended.

Geological Hazards		
Collapsible soils	Low	Collapsible soils (blown sand) are very unlikely to be present in this geological setting - no further action recommended.
Compressible soils	Low	Responsive action: Compressible soils are unlikely to be present in this geological setting – notify Engineer if and where any organic or very low strength soils are encountered.
Ground dissolution	Low	Rocks prone to dissolution are very unlikely to be present in this geological setting - no further action recommended.
Running sand	Low	Responsive action: Running sand soils are unlikely to be present in this geological setting – notify Engineer if and where any fine sand or saturated sand soils are encountered.
Sensitive clays	**Low**	**Site wide risk:** Further assessment: intrusive investigation to confirm ground conditions and classify clay soils.
Slope instability	**Low**	**Localised risk:** Further assessment: intrusive investigation to confirm ground conditions locally to Afon (River) Beuno.
Natural ground gas	Low	Responsive action: Gas generating soils are unlikely to be present in this geological setting – notify Engineer if and where any organic soils are encountered or bubbling groundwater.
Radon	Low	No radon protection measures recommended.
Aggressive geology	**Low**	**Site wide risk:** Further assessment: intrusive investigation to confirm ground conditions and classify sulphate content and pH of formation soils.
Historical Hazards		
Contamination (on-site)	Low	Responsive action: Potentially harmful soils are unlikely to be present in this setting – notify Engineer if and where any evidence of potentially harmful material is encountered in the soils e.g. stained, discoloured or odorous soils.
Contamination (off-site)	Low	Responsive: Notify Engineer if any evidence of potentially harmful or polluting material is observed near the boundaries of the Site, e.g. stained, discoloured or odorous soils.
Pollution (waters)	Low	Responsive: Notify Engineer if any evidence of potentially polluting material is observed in the soils on the Site, e.g. stained, discoloured or odorous soils or water.
Landfill gas	Low	Responsive: Notify Engineer if any evidence of potentially degradable material is encountered in the ground or evidence of bubbling groundwater is encountered.
Mining (incl. mine gas)	Low	Responsive: Notify Engineer if any evidence of circular or square brick lined structures or voids are revealed in the ground.
Sub-surface structures	Low	Responsive: Notify Engineer if any evidence of relic walls or voids are revealed in the ground.
Unexploded ordnance	Low	Responsive: Notify Engineer if any evidence of rounded metal or glass objections are revealed in the ground.

7.0 Conclusion and Recommendations

Based on available information and the scope of this Report the Site ground conditions are considered to be; reasonably well-characterised with; intrusive investigation recommended to support further assessment of risk and support the design.

In conclusion, the Engineering Desk Study finds that;

> The risk rating for the ground is 'low'.

  Further assessment is recommended to: confirm the ground conditions across the Site; confirm the foundation arrangements for the existing structures; and, confirm the geotechnical characteristics of the soils / rocks.

> The anticipated moderate strength of the shallow soils may support the adoption of traditional, strip foundations.

Recommended follow-on work includes:

1. Review of the risk register herein;
2. Submission of the Engineering Desk Study to the project design team and, where necessary, the local planning authority.
3. Further assessment is recommended at this stage the in the form of an intrusive ground investigation the outline scope of works for which includes:
   - Machine excavated trial pits to enable; mass logging of soils and, bulk and disturbed sample recovery; and,
   - Geotechnical testing of the soils across the Site (classification and where necessary, strength).

   If and where any evidence of potentially harmful or polluting material is encountered, appropriate screening of this material should be undertaken with sampling and testing conducted in line with current guidance[14].
4. Production of a Ground Investigation Report to enable the preliminary risk assessment presented herein to be revised and to confirm engineering design requirements.

[14] [14] *BS 10175 (2011 + 2017) Investigation of potentially contaminated sites. Code of practice.*

VISUAL SCALE 1:500 @ A3

REV	DESCRIPTION	DATE	BY

PROJECT
SITE AT BONTNEWYDD
for KINGSCROWN
PROPERTIES

DRAWING TITLE
SITE LAYOUT FEASIBILITY
SKETCH

SCALE	DATE	DRAWN	CHECKED
1 : 500 @A3	07/04/22	GT	SV

DRAWING STATUS: PRELIMINARY

JOB No	DRAWING No	REVISION
C1104	02	

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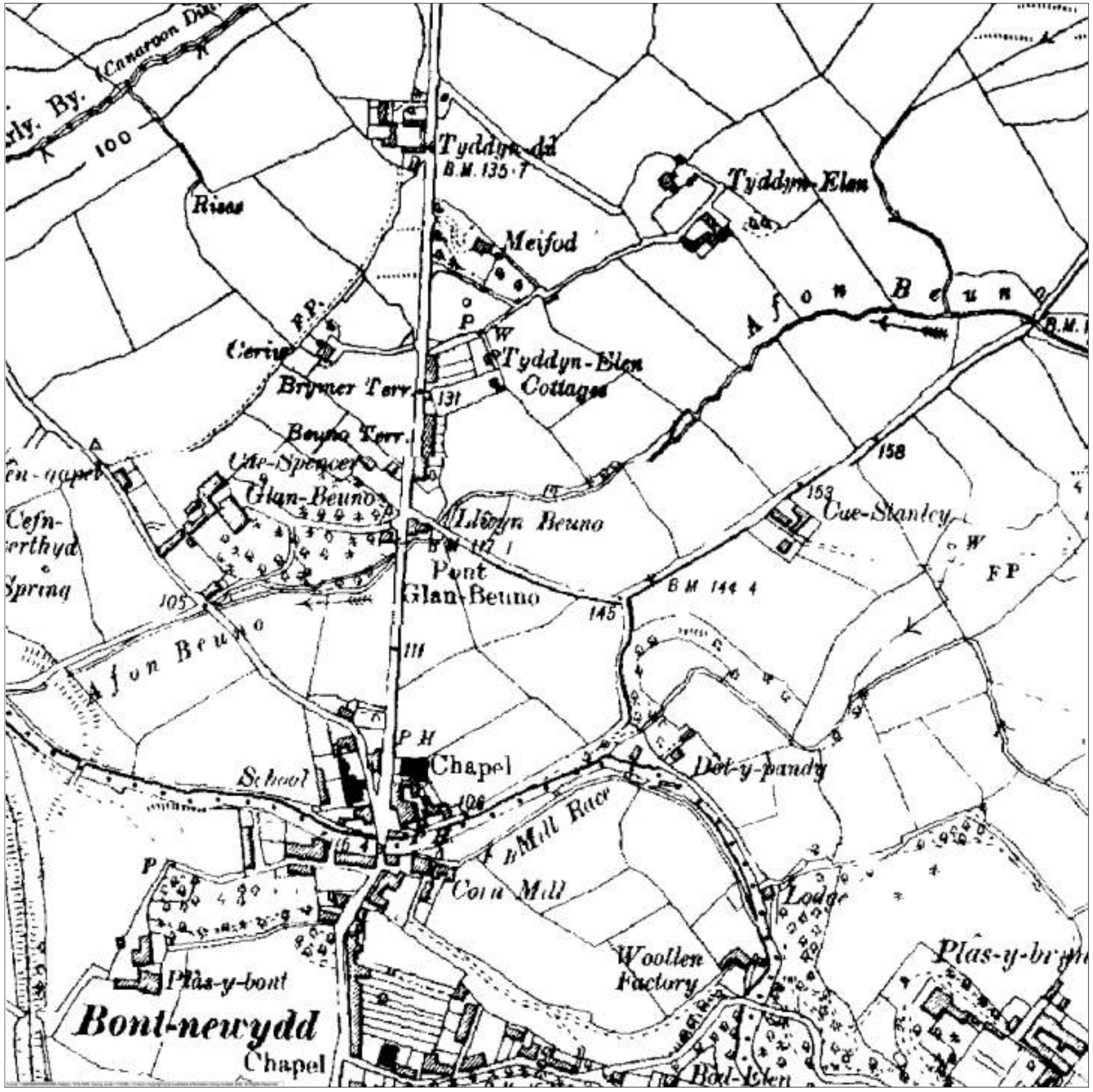
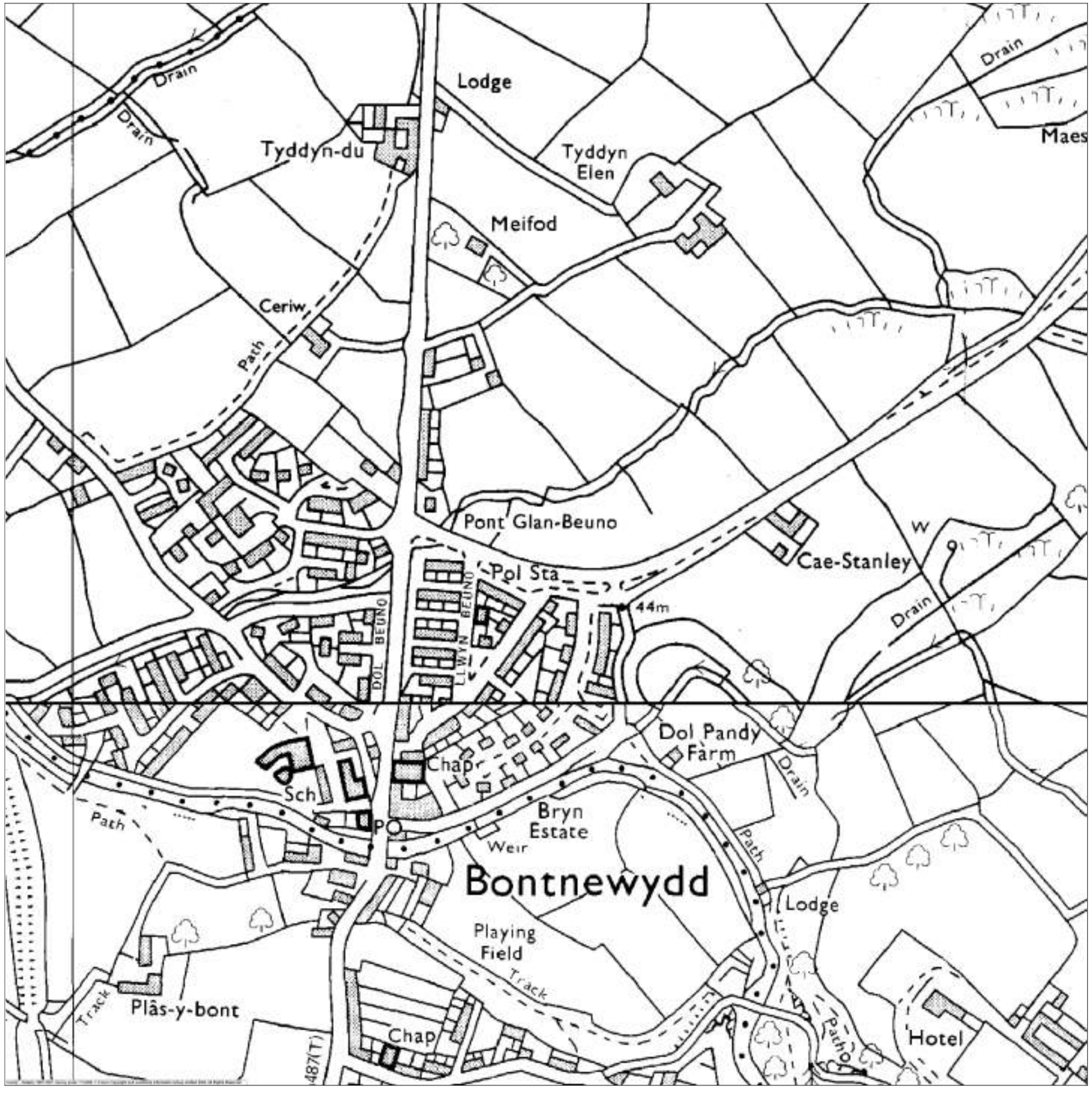




Landmark
INFORMATION GROUP

Landmark Historical Map
County:
Published Date(s): 1981-1991
Originally plotted at: 1:10,000

Annex

Context and Scope of the Desk Study

SOIL AND STRUCTURES

Context

The purpose of site investigation is to reduce uncertainty in the ground.

For all site investigations the legal imperative for reducing uncertainty is primarily governed by health and safety law; identifying hazards and, where present, limiting their potential for harm. In addition, the reduction of uncertainty also applies to: various environmental laws (relating to the prevention of pollution and harm); as well as, the commercial risk of potential abnormal groundwork costs.

Current UK planning policy, the National Planning Policy Framework (NPPF)[1], makes reference to the need to ensure that '*a site is suitable for its proposed use taking into account of ground conditions and any risks arising from land instability and contamination*' (Paragraph 178). The NPPF also makes reference to the need to adopt Mineral Safeguarding Areas (Paragraph 204).

In practice, this policy is implemented through planning conditions. Where applied, these conditions compel the developer to demonstrate the site is 'suitable for its proposed use' with respect to contamination and, in former mining areas, with respect to stability. Within Mineral Safeguarding Areas, planning conditions may also compel the developer to evaluate the viability of prior-extraction of a mineral before a development 'sterilises' the ground.

Warranty providers may also impose conditions on the development.

The assessment of other ground-related hazards, e.g. slope stability or collapsible soils, is typically not conditioned (unless a specific hazard locally) but rather an inherent part of the engineering design.

Scope

The first stage of 'site investigation' is invariably a desk-based exercise, the Desk Study. As the first stage, the scope of the Desk Study is naturally broad, and includes both: i) an assessment of ground-related risk; as well as, ii) preliminary advice relating to ground engineering.

The assessment of risk is guided by a series of international standards including ISO 31000:2018[2] 'Risk Management – Guidelines'. The Desk Study is developed with reference to this guidance and other additional UK and sector-specific guidance that includes; the Construction (Design and Management) Regulations (2015)[3] and, the Environment Agency's 'Land Contamination Risk Management (LCRM)[4].

The preliminary advice relating to ground engineering covers three engineering disciplines; structural, civil and mechanical. Their inclusion is designed to offer practical advice and, alongside a description of the development design, offer a fuller picture of the likely changes that the site's ground will undergo. This feeds into the risk assessment with groundwork changing a site's risk profile.

The value of a Desk Study is in the early identification and assessment of uncertainty in the ground. A well-undertaken Desk Study is the most cost-effective way to reduce uncertainty. The Desk Study also identifies potential opportunities in the ground such as: the potential for material recovery as part of the works, e.g. topsoil, subsoil or building stone or, the viability of ground source heat pumps.

[1] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810197/NPPF_Feb_2019_revised.pdf

[2] https://www.iso.org/iso-31000-risk-management.html

[3] http://www.hse.gov.uk/construction/cdm/2015/index.htm

[4] https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm

Annex

Context and Scope of the Desk Study

SOIL AND STRUCTURES

Whilst factual advice is offered with respect to the following areas the following exclusions apply to the Desk Study:

> The flood risk setting of the Site, this Report does not constitute a flood risk assessment and the advice of a suitably qualified civil engineer or flood risk assessor should be sought to confirm the risk rating and requirement, if any, for mitigation.

> The condition of the existing structure and associated infrastructure, e.g. utilities, to inform risk assessments, this Report does not constitute a building or structural survey. The advice of a RICS qualified surveyor or suitably qualified structural engineer should be sought if and where a survey or change in loading, e.g. new fixed plant, is required.

> The possible presence of non-native invasive species and protected species, this Report does not constitute an ecological survey. The advice of a suitably qualified ecologist should be sought if and where a survey is required.

> The possible presence of archaeological features, this report does not constitute an archaeological survey. The advice of a suitably qualified archaeologist should be sought if and where a survey is required.

Risk is rated with respect to the routine detailed within *CIRIA C552 – Contaminated Land Risk Assessment; a guide to good practice (2001)*.

The following tables are adapted from CIRIA C552 and serve as the routine by which risk is assessed within the Report and the corresponding definitions of the different classifications.

Risk is assessed with respect to the condition of the Site at the point of issue that can therefore be subject to change over time.

		Consequence			
		Severe	**Medium**	**Mild**	**Minor**
Likelihood	**High Likelihood**	Very High Risk	High Risk	Moderate Risk	Moderate / Low Risk
	Likely	High Risk	Moderate Risk	Moderate / Low Risk	Low Risk
	Low Likelihood	Moderate Risk	Moderate / Low Risk	Low Risk	Very Low Risk
	Unlikely	Moderate / Low Risk	Low Risk	Very Low Risk	Very Low Risk

Very High	• There is a high probability that severe harm could arise to a designated receptor from an identified hazard, OR, there is evidence that severe harm to a designated receptor is currently happening. • This risk, if realised, is likely to result in a substantial liability. • Urgent investigation (if not already undertaken) and risk mitigation is likely to be required.
High	• Harm is likely to arise to a designated receptor from an identified hazard. • Realisation of the risk is likely to present a substantial liability. • Urgent investigation (if not already undertaken) is required and risk mitigation may be necessary in the short term and is likely to be required over the longer term.
Moderate	• It is possible that harm could arise to a designated receptor from an identified hazard. However, it is relatively unlikely that such harm would be severe, of if any harm were to occur, it is more likely that the harm would be relatively mild. • Investigation (if not already undertaken) is normally required to clarify the risk and to determine the potential liability. Some and risk mitigation may be necessary in the longer term.
Low	It is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised, would be mild at worst.
Very Low	There is a low probability that harm could arise to a receptor. In the event of such harm being realised it is not likely to be severe.

Annex

Background Threat and Risk

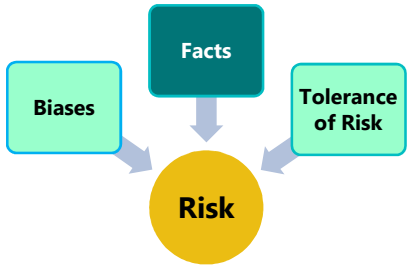
SOIL AND STRUCTURES

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