Ground Investigation Report (intrusive)

Lansdowne Road, Chadderton

SOIL AND STRUCTURES

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Report Status

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Appointment

Soil and Structures Ltd were instructed by Stonehouse & Co Ltd on behalf of Pipework Ltd (the Client) in April 2023 to prepare a desk-based Ground Investigation Report (*this Report*) to support the re-development of an existing commercial site located off Lansdowne Road, Chadderton (the Site).

Development proposals include replacement of the existing modular units (office) with a two-storey office and works building and extension of an existing steel frame structure.

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

Scope and Context

The Ground Investigation Report (desk-based) offers preliminary design and risk management advice with respect to the ground conditions and the proposed development of the Site.

In being a desk-based report, the advice is generally offered on a preliminary basis noting that for some design situations or hazards, specific advice can be offered at this stage, e.g. the requirement for radon protection.

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

i) Potential ground-related hazards that may affect the development that is governed by health and safety law (various acts and regulations); and,

ii) 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 Report is expected to support the initial engineering design and be submitted to the local planning authority in support of the discharge of relevant planning conditions.

Fieldwork

This Report include references to intrusive investigation fieldwork completed by the Client.

Background to this Report

This Report is preceded by ground-related reporting. This includes a Coal Mining Risk Assessment prepared by Soil and Structures Ltd ref. 20305-R-001-V01 dated 03 May 2023.

This Report carries through the conclusions and recommendations made within the Coal Mining Risk Assessment.

References

This Report has been written with reference to various sources of information. These are either appended or included as footnotes at the base of each respective page.

1.0 The Site and Proposed Development

1.1 The Site

Location and size: The Site comprises a parcel of land approximately 0.35 Ha in area located at the junction of Lansdowne Road and Arkwright Street, Chadderton (Figure 1).

Access: Vehicular access to the Site via an access road off Arkwright Street on the eastern border of the Site.

Topography: The Site has a generally sloping topography with a slight fall in levels to the west from a high point of around 140 mAOD to around 137 mAOD on the eastern border of the Site.

Existing structures: At the point of issue, modular units are preset within the north-western corner of the Site (*that are due to be replaced with a permanent structure*) and a permanent steel-framed structure is present on the northern edge of the Site (*that is due to be extended*). Other open storage containers and temporary equipment stores (shipping containers) are also present across the Site.

Surface cover: Outside of the building footprints the surface cover of the Site is a mix of what appears to be concrete hard standing and hardcore surfacing.

Utilities: Current satellite imagery (2021) does not indicate the presence of overhead utilities across the Site with buried utilities expected to cross the Site.

1.2 The Proposed Development

Development proposals: Include for the replacement of the existing modular units (office) with a two storey office and works building and extension of an existing steel frame structure.

ⓘ ***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. unstable slopes being removed by earthworks, or unsuitable material being exposed as part of the works.*

To enable this development, the following groundworks are likely to be required, N.B. listing is outline only.

> Enabling works: Removal of modular units and surface strip or breakout (hard).

> Earthworks: No earthworks are expected to be required.

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

> Foundations: Excavation and formation of new foundations for the office and works building and the steel frame structure.

> Surfacing: New hardstanding formation.

ⓘ ***Risk profile of the proposed development for human health:*** *The proposed development would see an existing commercial property redeveloped for the same commercial end-use albeit with permanent structures. The planned development of permanent structure does result in an increased potential for various ground-related hazards to impact development of the Site (discussed in this report) including, but not limited to, potential fill deposits beneath the structure (former basements) and increased sensitivity to any ground gases (all types). The risk to human health from potentially harmful material in the soils is expected to remain the same. Whilst this does not confirm the risk is acceptably low, it does suggest this will be the case.*

Figure 1: Site Location Plan
> *Extract from appended 'Location Plan'.*
> *Proposed development footprints (approximate) highlighted in orange.*
> *Site boundary identified by red line*

2.0 Site Setting

2.1 History

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

> **The first phase** (Figure 2, 3 and 4): occurred from around the mid to late 1800s and at least to the 1950s but likely much later when the Site was occupied by a road, small properties (probable small commercial) and a possible industrial unit and embankment that appears to be part of the larger Hartford Iron Works complex.

A 'tank' is recorded in north-east corner of the Site towards the latter part of this phase of use.

Evidence of potentially harmful material and *evidence of potentially gas generating material:* Through this phase of use it is possible that potentially harmful or degradable material was introduced into the Site's soils such as coal ash from house fires and less well defined materials arising from either the iron works building (peripheral building to main works) or the 'tank'.

Evidence of mining activities: No evidence of coal mining features, e.g. old shafts or soughs, is recorded on the Site over this period. Various local features are present, e.g. 'Stockfield Colliery' to the south-west (~750 m), Hunt Clough Colliery to the north-west (~1500 m) and various 'brick works' that were commonly associated with either local collieries (like Stockfield) or their own private coal mines within their land boundaries.

Evidence of unexploded ordnance: Military land use: There is no evidence of the Site having been put to military uses on historical mapping or on internet searches. *History of bombing:* local features, e.g. works buildings, would have been strategic targets during the Second World War (First World War bombing did occur in northern towns but generally coastal regions) however, none are recorded locally to the Site with bombing density expected to have been low to moderate in this area. Furthermore, there is no evidence of bomb damage on the Site, e.g. ruins or missing buildings, on the Ordnance Survey mapping following the Second World War or on internet searches[1].

> **The second phase** (Figure 1): occurred between the 2010s and the present day when the Site was developed for its current use (works yard, modular offices and open structures).

Evidence of potentially harmful material and *evidence of potentially gas generating material:* Through this phase of use it is possible that potentially harmful or polluting material was introduced into the Site's soils such as localised oil or fuel spillages. Overall, these are expected to be of limited volume and localised.

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

The history of the surrounding area is characterised by heavy industry associated with metal works, mills and brick works as well as coal (Lancashire coalfield region) and the expanding residential districts of Chadderton and Oldham.

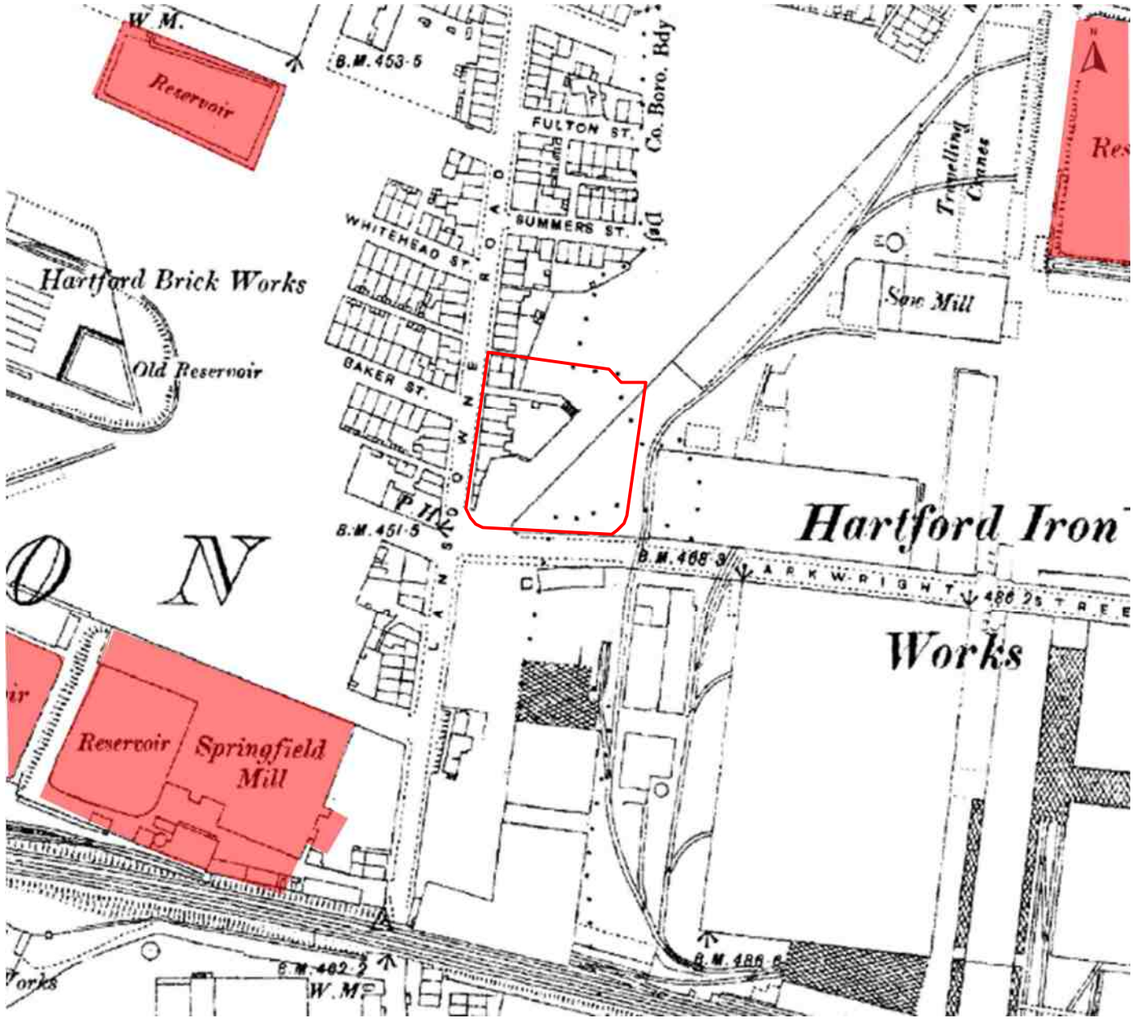


Figure 2: First phase of historical use

> *Extract from 1893 historical mapping (appended).*
> *Red line = approximate Site boundary*
> *Red shading = reservoirs and other features that are ultimately developed as landfills*

[1] *Dedicated to remembering those that died during the Greater Manchester blitz. (greatermanchesterblitzvictims.co.uk)* *Interactive map of Manchester blitz bomb sites shows where civilians were killed in 1940 Christmas attacks - Manchester Evening News*

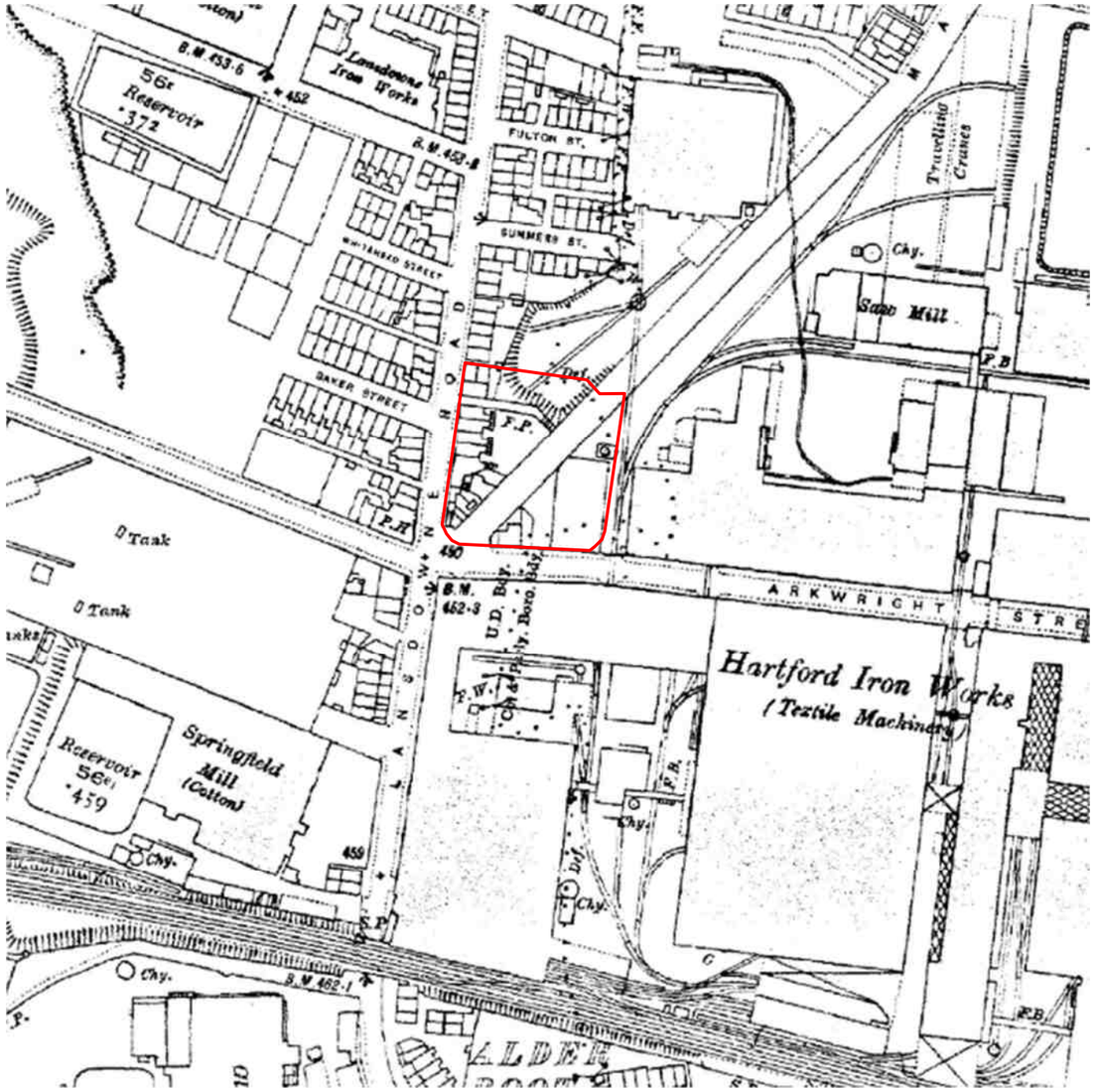


Figure 3: First phase of historical use

> *Extract from 1932 historical mapping (appended).*
> *Red line = approximate Site boundary*

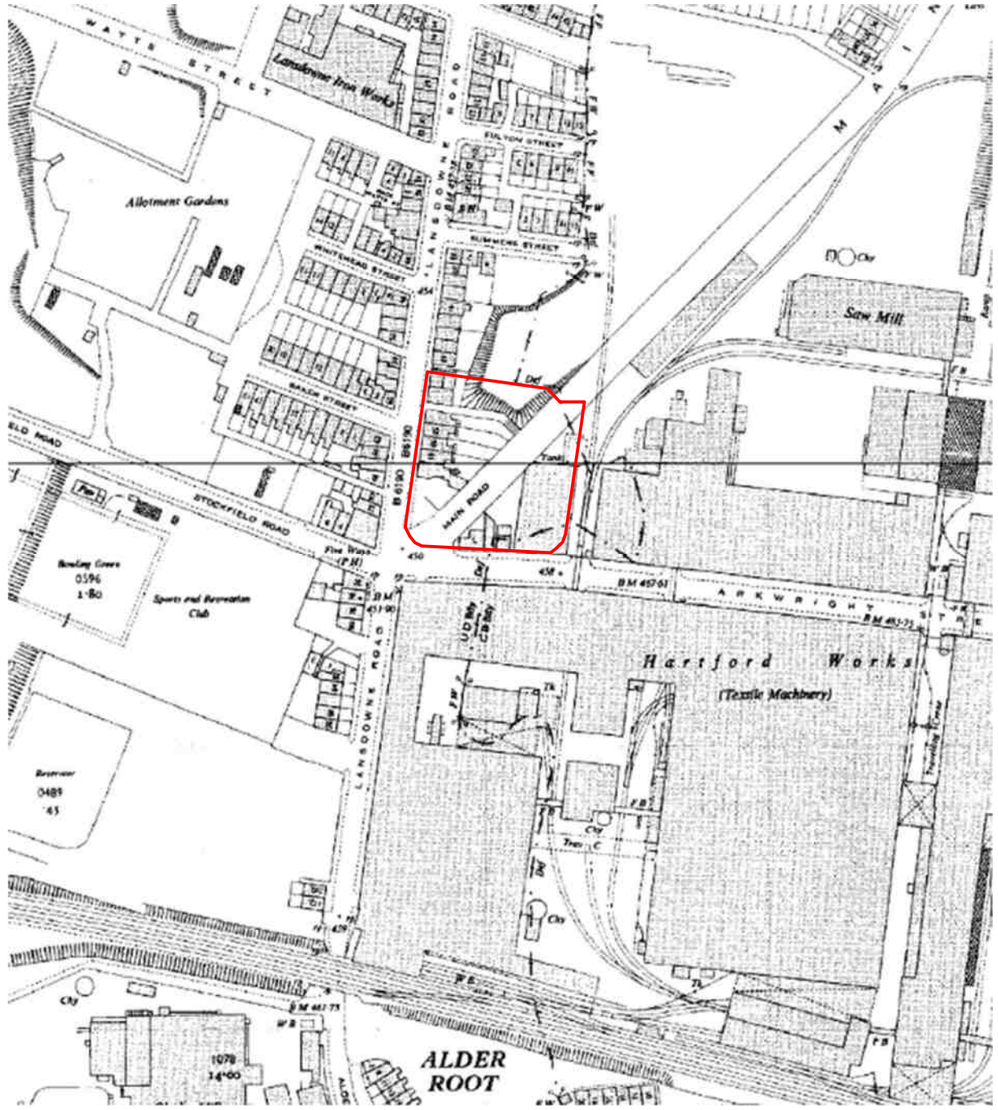


Figure 4: First phase of historical use

> *Extract from 1955 historical mapping (appended).*
> *Red line = approximate Site boundary*

2.2 Geology

Recorded geology: The Site is recorded being underlain by:

> Till deposits overlying

> Bedrock of the Pennine Lower Coal Measures that are characterised by *sandstone very fine to fine grained, interbedded with mudstone and siltstone; sub-ordinate seatearth, ironstone, marine bands and coal*[2].

The Till deposits are locally recorded to depths of between 9.14 m (*350 m east*), at least 20 m (*190 m north*) and 23.72 m (*460 m south-west-west*) in local boreholes.

Made Ground deposits were also anticipated to be present across the Site due to the Site's historical uses with the potential for basement-depth fill deposits (~3.0 m) confirmed through the Client's trial pits completed along Lansdowne Road where former terraced properties (residential or commercial) were recorded.

Structural geology: The structural geology of the Site and immediate surrounding area is complex with extensive faulting and evidence of folding locally. Coal Authority mining records[3] indicates that bedrock (in the 'deep' Arley coal mineworkings) beneath the Site dips at a moderate angle (9.8 to 12.5 degrees) in a south-westerly direction. The British Geological Survey mapping (Figure 2) records a similar angle and direction (10 degrees; south-westerly).

Exploratory holes: No on Site borehole records are available however, various boreholes advanced locally to the Site[4] may be instructive to this assessment. The boreholes are all listed as 'confidential' and, at the point of issue, have not been released for review.

Geological mapping confidence: The geological mapping and mining records offer generally good confidence in the geological succession beneath the Site. The 'triangulation' of Till depths between boreholes at distances of around 190 to 460 m from the Site is a generalisation that directs a more conservative estimation of Till depths (that is a primary control on risk from shallow mine workings).

Coal and non-coal mining: Commentary on the coal and non-coal mining setting of the Site is set out within Soil and Structures' Coal Mining Risk Assessment.

Mineral resources: None of the materials recorded or anticipated beneath the Site are expected to be viable for prior extraction pre-development with the coal reserves beneath the Site too deep to be economically viable for opencast extraction.

Figure 2: Geological Mapping

> *Extract from BGS 'Solid Edition' – location of Site highlighted by red circle.*
> *Reproduced under Open Government License (v3.0).*

[2] *https://www.bgs.ac.uk/Lexicon/*
[3] *Coal Mining Risk Assessment prepared by Geoinvestigate Ltd dated May 2022 ref. G22173*
[4] *GeoIndex - British Geological Survey (bgs.ac.uk)*

2.3 Recorded Hydrogeology & Hydrology

A water catchment is divided into two main elements; groundwater (hydrogeology) and surface water (hydrology). The groundwater regime is primarily governed by the geology and the surface water regime by the topography and surface cover. For any given site, these regimes are likely to influence each other and be influenced by off-site factors, e.g. groundwater levels being 'recharged' higher up a catchment.

The Site's drainage regime is influenced by:

i) Its location in the higher elevations of the Wince Brook water catchment[5] that drains to the west;

ii) The Site's 'hard' cover (concrete) and generalised westward falls in topography, resulting in a tendency for surface water to drain to the existing piped network associated with the Site and run-off towards the west.

iii) The anticipated ground conditions are expected to exhibit highly variable rates of infiltration in any residual Made Ground that may be a store for 'perched' water and low rates of infiltration within the Till deposits with 'f' provisionally estimated to be between 10^{-6} to 10^{-10} m/s;

iv) The Site being classified at very low risk with respect to river and reservoir flooding with surface water flooding (low risk) mapped affecting the central and north-eastern portions of the Site – likely flows from the higher elevations to the north-east)[6].

v) The Site being located on a Secondary (undifferentiated) Aquifer (superficial) and Secondary A (bedrock) Aquifer but outside of local Source Protection Zones (SPZs)[7]; and,

vi) The historic borehole 200 m north of the Site (same geology, different elevation) recording a no groundwater within 20 m of the surface but noting the presence of gravel bands within the Till.

Drainage to ground should not be considered given the potential for collapse / wash out of any fill deposits.

The nearest surface water feature is Wince Brook located 1050 m south-west-west of the Site at its nearest point.

2.4 Environmental Setting

The environmental setting relates to land designations either on-site or within the surrounding area that have the potential to influence or present a risk to the proposed development.

Landfills (historic and active) are recorded within 250 m of the Site[8,9], the distance across which viable pathways for gas migration are more likely. There are seven historic landfills within 250 m of the Site and no active landfills recorded. The landfills are almost all associated with former mill ponds / reservoirs associated with the mills and works buildings that formerly occupied the surrounding area and, with two exceptions, have since been built over. There is no information relating to the licensing of each of the landfills, e.g. acceptance criteria, input dates. In the Author's experience of investigating and reclaiming similar features in the Greater Manchester area and other formerly industrialised towns and cities, the reservoirs could be filled with a wide range of materials but are commonly end tipped with demolition arisings (particularly where not developed over) and industrial wastes such as boiler ash.

The former landfills are located within the same geological units as the Site (Made Ground and Till) and therefore located within material of similar permeability however, the landfills are located at similar elevations with two located east of the Site at higher elevations (155 m north-west and 225 m south-west of the Site at their nearest points).

In most the landfills having been formed in former reservoirs, there is a degree of containment with direct gassing to the surface (vertical) considered the most plausible pathways for gas emissions; controlled by barometric pressure changes and any perched water levels within these features that are likely shallow and changeable.

Furthermore, urban environments have highly developed and bisected sub-surfaces resulting in a patchwork pattern of potential pathways across which gases may flow and be intercepted, e.g. service corridors. For non-natural, landfill-type gases direct pathways generally have a much stronger bearing on the level of risk with case studies bearing this out[10],[11]. The patchwork pattern of pathways makes establishing plausible links difficult to reliably assess or, alternatively, supports an assessment of this Site being exposed to a background threat from this hazard. Although severe, non-natural landfill gas incidents are low frequency events.

In plainer terms, there is no evidence of direct pathways connecting the landfills and the Site and, taken together it is considered unlikely that maintained concentrations of landfill type gases will be present beneath the Site that could pose a threat to end users of the Site.

Similarly, with most of the landfills lying at a lower elevation relative to the Site, the potential for migration of any leachate below the Site (at depths that may present a risk) is considered unlikely. Those landfill at higher elevations are located within former works complexes such that flow paths for any migration of leachate will again, be tortuous and unlikely to be direct towards the Site.

The presence of infilled basements (or Made Ground >2.50 m deep) below the proposed office block serves as a potential source of ground gas. Given their appears to be limited volumes of degradable material (cloth) the gas generation potential of this material is considered very low with the 'dry' state of the material suggesting that this limited volume of degradable material has not been exposed to conditions conducive to degradation. Whilst this material could degrade in theory, in practice, the proposed construction of an office block over this area will either necessitate partial or full removal of this material (geotechnically unsuitable) or else, 'seal' the Made Ground back in the ground (limiting the potential for water infiltration and wetting).

Historic infilled land, e.g. ponds and quarries (excluding the landfill detailed above) are not evidenced on the Site or within 100 m of the Site.

Historic and current industrial sites are recorded on the Site in the form of a building associated with the periphery of Hartford Iron Works and the former 'tank' the contents of which are unknown. In general, these former uses are likely to have resulted in a generally degraded chemical quality to the shallows soils across the Site.

Statutory protected areas, e.g. SSSI are not recorded on the Site[13].

Radon is emitted from naturally sources within a range of geologies. The United Kingdom Health Security Agency (UKHSA) data[12] indicates between 5 to 10 % of dwellings are expected to be above the Action Level (200 Bq m^{-3}). This translates to an intermediate potential of the Site being affected by radon.

[5] *Wince Brook | Catchment Data Explorer | Catchment Data Explorer*
[6] *Your long term flood risk assessment - GOV.UK (check-long-term-flood-risk.service.gov.uk)*
[7] *Magic Map Application (defra.gov.uk)*
[8] *Historic Landfill Sites - data.gov.uk*
[9] *Permitted Waste Sites - Authorised Landfill Site Boundaries - data.gov.uk*
[10] *Prevalence of CO2 from disused mineral mines and the implications for residential buildings: research - gov.scot (www.gov.scot)*
[11] *Ground Gas: The Lessons from Loscoe - Future Climate Info*
[12] *UKradon - UK maps of radon*

3.0 **Fieldwork** – Intrusive Investigation

Preliminary intrusive investigation was completed by the Client to characterise the ground conditions beneath the proposed office block.

Table 1: Scope and Rationale of the Intrusive Investigation

Activity	Ref.	Rationale
3 machine excavated trial pits (unknown machine)	TP101 to TP103	To investigate shallow ground conditions across the proposed office block.

Exploratory hole locations are illustrated on the Ground Model drawings in Section 5.0 with written descriptions of the materials presented in Section 4.0 (as illustrated in the photographs and based on commentary provided by the Client).

4.0 **Ground Conditions** – Anticipated & Revealed

Anticipated ground conditions: Five main materials are anticipated beneath the Site:

(1) Concrete or bituminous hardstanding; underlain by,

(2) 'recent' Made Ground deposits likely comprising sub-base material associated with the hardstanding construction; underlain by,

(3) 'old' Made Ground deposits that are expected to be generally shallow across the Site deepening locally to former structures and likely comprised of 'brick fill'; underlain by,

(4) Till deposits predominantly comprised of clays but with gravel bands noted locally; underlain by,

(5) weathered to intact bedrock of the Pennine Lower Coal Measures likely encountered at depths of between 9 and 25 m based on local borehole records.

The Preliminary Ground Model for the Site (plan and profile) is presented in Section 4.0 and includes further commentary on the ground conditions.

Revealed ground conditions: Within the three exploratory holes completed by the Client beneath the proposed office block, three materials were encountered the nature of which was as anticipated with one variation. These included:

(1) Bituminous hardstanding; underlain by,

(3) 'old' Made Ground deposits comprised of 'brick fill' that included relic sub-structures (basement walls); underlain by,

(4) Till deposits ('clay soils' were encountered at a depth of 2.05 m below ground level in TP102; underlain by,

Limited to no evidence of 'recent' Made Ground deposits was revealed with the bound bituminous gravel appearing to have been laid directly on the 'old' Made Ground deposits.

Photograph 1: Trial pit TP101 excavation – 3 m deep, brick fill to base

Photograph 2: Trial pit TP102 excavation – 2.60 m deep, brick fill to 1.80 m depth over 0.25 m 'ash fill' over 'clay'

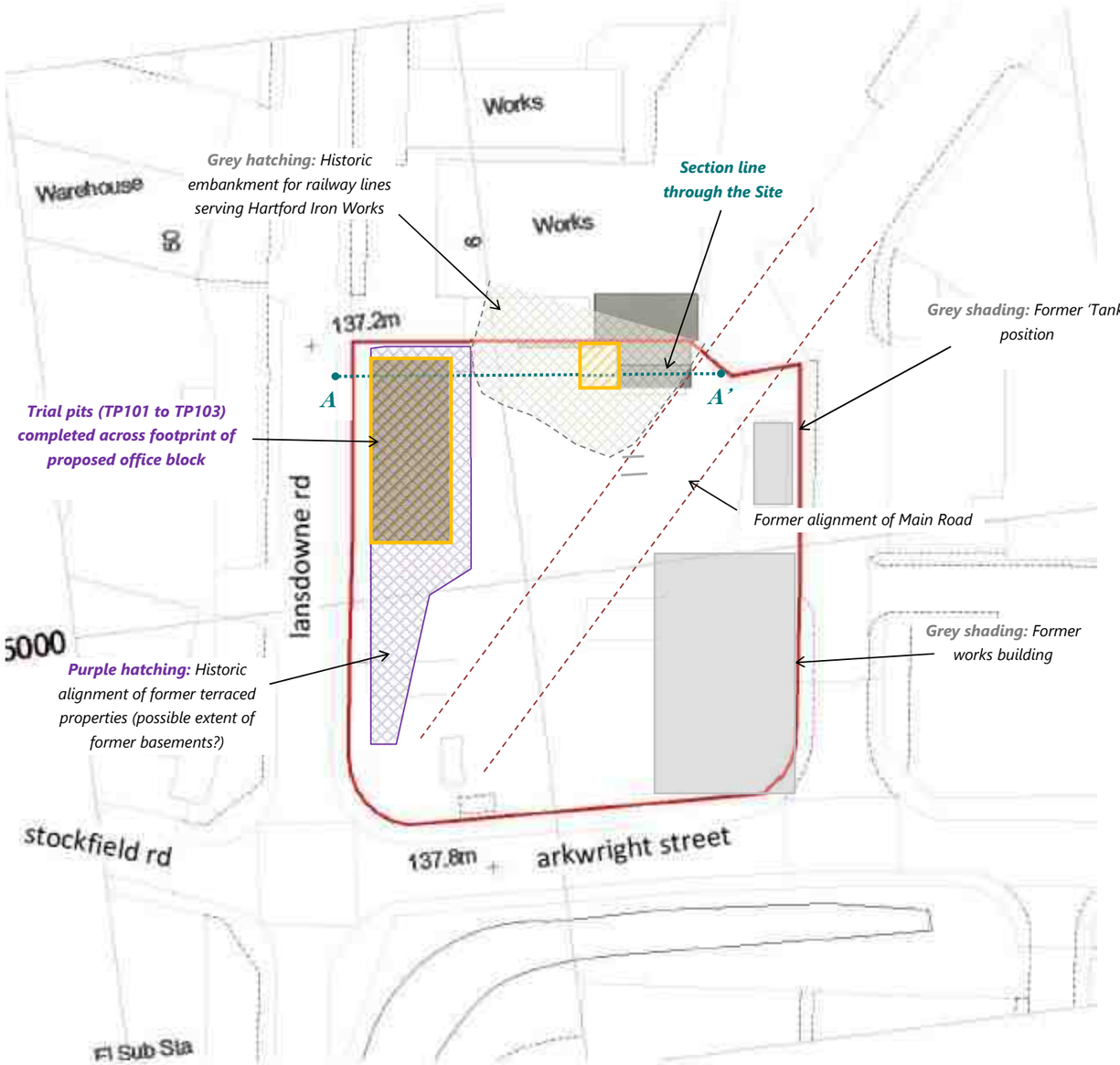
Photograph 3: Trial pit TP103 excavation – 3.00 m deep, brick fill to base with evidence of basement footings

5.0 **Ground Model –** Preliminary - Plan and Profile

Bedrock geometry beneath the Site

~212 to 228° Dip direction

9.8 to 12.5° Dip angle



Key

Section line through Site (profile on next page).

Proposed structures

Ground Conditions (revealed)

> Trial pits across the proposed office block development revealed the presence of backfilled basements within which relatively 'clean' brick fill was encountered. 'Clean' is taken to mean that very limited evidence of other materials or degradable material, e.g. timbers, were encountered.
>
> As anticipated, a pocket of 'ash fill' was noted within the base of the 'brick fill' – material that has likely been transported down through the bricks over time and accumulated at the base. Demolition historically was commonly completed through controlled burning of the structures to remove the timber and cause the building to collapse in on itself. This is plausible in this scenario.

> Groundwater was not encountered within the trial pits nor it is expected within at least 5 m of the ground surface however, perched lenses may be encountered within the Made Ground

> Potentially harmful or polluting material, no evidence of grossly impacted material, e.g. tar or stained soils, was encountered that might otherwise present a risk to operatives and end users of the Site. The ash fill deposits are common on brownfield sites and likely include elevated concentrations of arsenic, lead and polycyclic aromatic hydrocarbons that are unlikely to be above screening thresholds for the commercial end use. It is further noted that development proposals include for the reinstatement of hardstanding that would serve as a physical barrier most pollutant pathways, in all but the worst case scenarios, e.g. vapour generating soils.

Ground-related Hazards

⚠ Compressible / Collapsible Ground

The 'old' Made Ground deposits within the basements may be susceptible to collapse (inundation) or compression when loaded.

⚠ Relic sub-structures

Relic basement walls and foundations have been confirmed across the proposed office footprint.

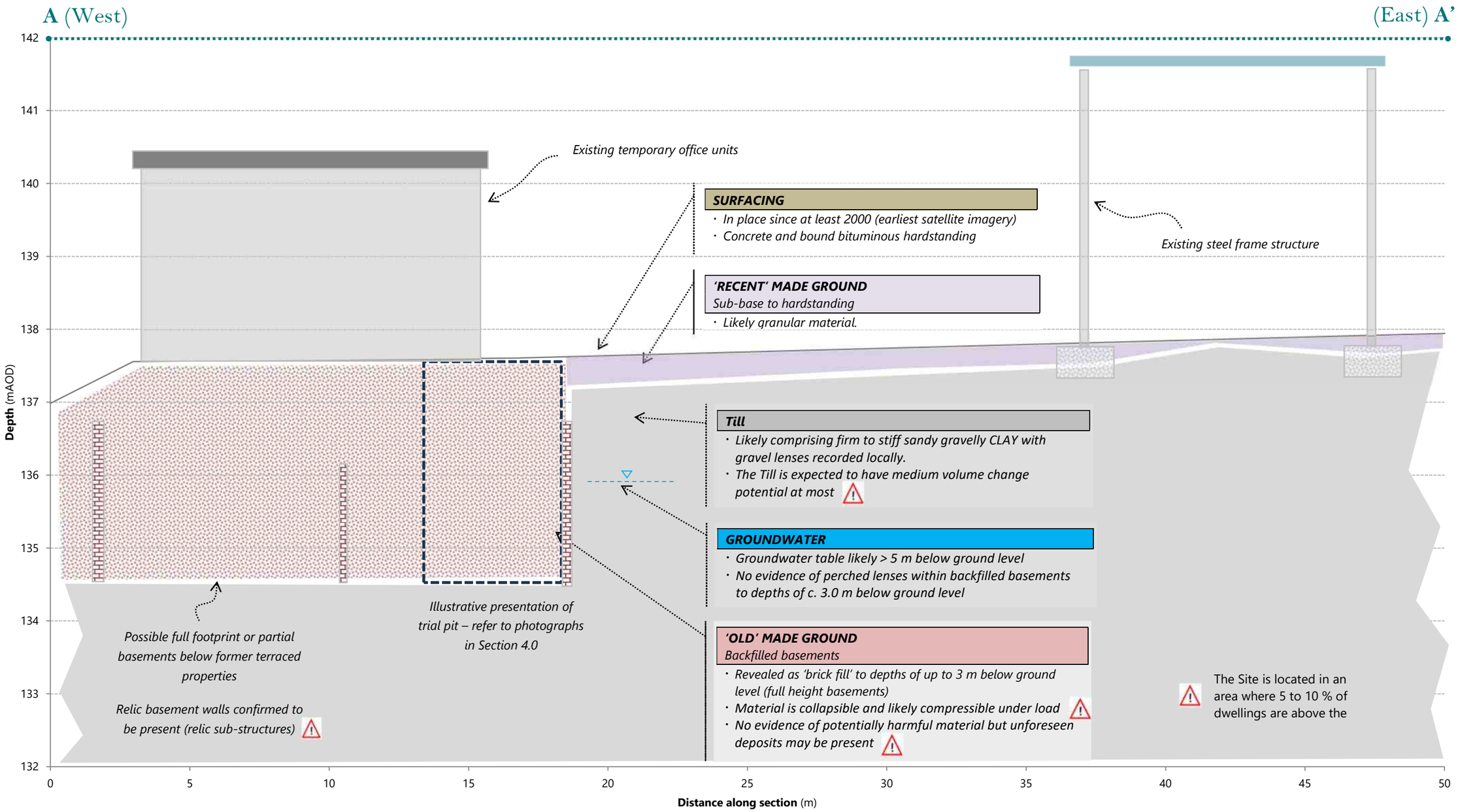
⚠ Potentially harmful or polluting material

No evidence of grossly impacted material was encountered within the trial pits.

⚠ Radon

The Site is located within an area where 5 to 10 % of dwellings are above the household Action Level for radon

5.0 **Ground Model** – Preliminary - Profile



> *Illustrative only, do not scale from drawing*

6.0 Ground Engineering – Preliminary Design and Risk Management Advice

ⓘ ***Preliminary Design and Risk Management Advice:*** *The following sub-sections offer preliminary design and risk management advice on ground engineering matters. This advice is offered with reference to likely groundworks activities required as part of the proposed development as outlined in Section 1.2.*

It should be noted that, based on the available information, additional intrusive investigation is not recommended however consideration should be given to additional trial pits to delineate the extent of the former basements and the condition of relic sub-structure walls along the boundary of the Site. Consultation with the project engineering team should be made in advance of any additional fieldworks.

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

> Low imposed load of the proposed structures;

> The confirmed presence of a backfilled basements across the proposed office footprint; and,

> The confirmed presence of relic sub-structures beneath the proposed plot.

ⓘ Ground-related hazards ⓘ: Throughout the section, commentary on various ground-related hazards is presented together with 'traffic-lighted' text for highlighting the relative levels of risk; **low**, **medium** or **high**, together with recommendations for any further assessment or ways to reduce the risk to lower, more acceptable levels.

Risk is inherently dynamic, and any assessment of risk should be updated / revised where new lines of evidence come to light.

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

> Compressible / collapsible material [*Historic hazard*];

> Shrink-swell [*Geological hazard*];

> Radon [*Geological hazard*];

> Relic sub-structures [*Historical hazard*]; and,

> Potentially harmful and polluting material present on Site [*Historical hazard*].

The simplified 'traffic-light' risk rating system is intended to capture the core principles of current guidance[13],[14] whilst supporting a more co-ordinated approach to all the inter-related elements of ground engineering.

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 ground conditions. General advice on such encounters is provided within a Guidance Note within the annex to this Report.

6.1 General Groundworks

Excavation progress is likely to be at typical rates down to depths of around 2.5 m below ground level employing a medium sized excavator, e.g. 3CX with any bucket. The confirmed presence of relic sub-structures (basement walls and possible floors) may require localised use of a breaker to speed excavations.

Excavated material will vary across the Site with three main materials anticipated to be encountered.

1. **Surfacing materials** – likely bound bituminous hardstanding across the proposed office block and concrete across the proposed steel frame extension.
2. **'Recent' Made Ground** deposits – possibly comprised of granular sub-base materials,
3. **'Old' Made Ground** deposits – confirmed as brick fill with localised 'ash fill' pockets consistent with historic demolition of the former terraces (often set on fire to collapse into themselves); and,
4. **Till deposits** – likely cohesive and present below either the infilled basements or at shallower depths across the proposed steel frame extension.

ⓘ Relic Sub-Structures ⓘ The presence of relic sub-structures (infilled basements) has been confirmed beneath the Site.

The proposed structure is planned across the alignment of these sub-structures that will 'clash' with the proposed foundations (all types).

Based on the moderate depth at which these sub-structures are present (up to 3 m depth) and the fact they stand to influence all foundation types, the risk is assessed to be **moderate**. This is a localised risk across the alignment of the former terraced structures and not anticipated across the proposed steel frame extension.

Further assessment could be undertaken to delineate the extent of these basements and their stability/condition or else a responsive design approach adopted.

The responsive design approach would involve adopting a foundation solution that can mitigate the potential risk posed by these sub-structures and the brick fill within them. Various solutions exist that include, but are not limited to: i) a reduced level excavation to remove the brick fill, replacing it with a suitable engineered fill; or, ii) large diameter beam and pier foundations formed below the former basements.

The potential for relic cess-pits or other sub-structures cannot be discounted however no evidence of these are suggested on historical mapping.

The existing hardstanding may require the use of a breaker to remove as part of proposed enabling works.

ⓘ Potentially Harmful Material ⓘ The Site has been in use as an industrial of commercial premise since the 1850s. As a result, soil quality is expected to have been degraded through the inclusion of various potential harmful (or polluting) materials such as ash, fuels and oils. The material contained within the former 'tank' cannot be confirmed but may have been potentially harmful or polluting. The former tank location is located away from areas of planned development works.

At this stage, the risk of presented by potentially harmful material is assessed as **low** based on: i) the continued commercial use of the Site that would result in all hardstanding surfaces being reinstated following completion of the works (physical barrier); and, ii) the lack of evidence of any acutely harmful or polluting material within the brick fill deposits, e.g. tar deposits. This is a Site-wide risk noting that groundworks are only planned across specific areas of the Site.

If and where potentially harmful or polluting material is revealed, e.g. tar deposits or stained soils, then a responsive assessment of the potential risk this 'source' may present is recommended. A Guidance Note for this is in the annex.

[13] *BS EN 1997-1:2004 Eurocode 7 – Geotechnical Design (all parts)*

[14] *Land contamination risk management (LCRM) - GOV.UK (www.gov.uk)*

Pollution potential: Based on the general condition of the Site, the general setting of the Site within a formerly and currently heavily industrialised area, lack of evidence of any free product within the trial pits and presence of 'thick' Till deposits overlying the bedrock aquifer, the risk to controlled waters is assessed as **low** at this stage.

Excavation stability (trenches) is indicated to be generally 'unstable' within the backfilled basements with excavations likely to warrant short-term temporary support given the presence unstable, gap-graded 'brick fill' deposits. Any excavations into the natural (clay dominated) Till deposits expected to remain stable in the short term (weeks).

In general, all open excavations may be subject to progressive collapse across due to the inherent loss of support, water softening of the base, wash out of finer particles by rainfall or nearby surface loadings.

ⓘ ***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,* ***high*** *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[15].

Groundwater control: The control of groundwater is not expected to be a major constraint to the development of the Site with most excavations expected to be relatively shallow (<1.50 m).

The Made Ground deposits stand to retain water during inclement weather and therefore pumps are likely to be required to remove groundwater from excavations. Further guidance on groundwater control is available[16].

Earthworks (cut and fill) are not likely to be required as part of the proposed development however, may be elected as a means to manage the risk in relation to the infilled basements (relic sub-structures).

Material suitability for re-use (geotechnical and environmental). Is unlikely to be a consideration apart from the brick fill within the former basements that, in its current condition (gap-graded), is considered unsuitable as a material for re-use unless pre-treated (crushing to a suitable grade). Excavation of any Made Ground deposits can be deemed a waste management activity by the Environment Agency unless an exception or materials management plan is in place.

For completeness, the Till (anticipated to be sandy gravelly CLAY) is likely to be suitable as a general fill (Class 2C).

For material re-use as an engineering or load-bearing fill the Engineer's approval will be required. Additional testing may be required to confirm grading and where necessary, a compaction regime if placed in load bearing situations, e.g. beneath ground bearing floor slabs or behind retaining walls.

For all scenarios, developing a strategy for management of materials/soils in advance of the works is advised to minimise handling, nuisance (dust, silt) 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[17].

Any natural soils are expected to be classed as EWC 20 02 02 (soil and stones) if requiring disposal off Site.

The Made Ground deposits, if requiring disposal, mainly comprise 'brick fill' that could be described as 'clean' or free from degradable material or other non-demolition related material. On this basis, the 'brick fill' is also likely to be to be classed as EWC 20 02 02 (soil and stones) if requiring disposal off Site. Selected removal of some minor constituents may be required, e.g. metal, timber and ash pockets towards the base. It is noted that, the presence of ash deposits may, if blended with the brick fill, result in more onerous classifications, e.g. EWC 17 05 04 (other soil and stones) and it is recommended that confirmation is sought from the groundworks contractor in advance of works commencing.

The bituminous surfacing may classify as EWC 17 03 02 (other bituminous mixtures) given its apparent age but again, this should be confirmed with the groundworks contractor.

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 (through solid soil testing; as presented herein) 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 and therefore, at this stage, any advice beyond that given above is unlikely to reflect the actual waste management plan for the development. On this basis, it is recommended that any waste classification (WM3[11]) is confirmed in advance by the groundworks contractor. If and where there are any questions relating to the waste classification process, these can be referred to the Author of this Report.

6.2 Structural Engineering

Proposed Foundations: The presence of a former, infilled basements have the greatest bearing on the foundation solution with the fill deposits in their current condition representing unstable ground for excavations as well as including material that would obstruct or hamper the advancement of piles (cobbles, boulders).

ⓘ **Collapsible / compressible material** ⓘ With respect to the stability of the fill deposits, the proximity of Lansdowne Road (public highway) is a key constraint and guides the adoption of either supported and/or localised excavations (or no excavations) or, the formation of shallow foundations.

Furthermore, in their current condition, the brick fill deposits are liable to collapse under the proposed loads that can manifest as delayed total or differential settlement of the structure as the fill deposits re-order themselves.

Based on the technical practicalities of managing this hazard, e.g. large excavations or temporary support of excavations, and noting the high background threat posed by potential collapses along Lansdowne Road (harm and commercial risk), the risk from this hazard is assessed as **moderate**.

Foundation options remain open to a variety of options but are likely to be guided towards the adoption of either:

i) Trench fill strips formed below the basement floor level that, based on the revealed ground conditions, can be designed based on a net allowable bearing capacity of 100 kN/m^2. As noted above, the potential for collapse within the brick fill deposits will likely guide the requirement for temporary support of excavations, with particular attention drawn to Lansdowne Road, and/or partial of full removal of the brick fill to limit the depth of excavation with the brick fill. In either, it is recommended that the advice of the groundworks contractor is sought early in the project to establish a suitable approach.

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

ⓘ **Shrink-swell** ⓘ The formation depth is anticipated to be c. 3.0 m below existing ground level that will place foundations out of the zone of influence of shrink-swell effects in the Till deposits. If and where the proposed foundations straddle the former basements then stepping up of the foundations will be required into the natural Till deposits. Either further assessment in the form of sampling and testing of the plasticity of the Till is recommended or else a precautionary approach adopted and a 'medium volume change potential' assumed that, in the Author's experience, Till rare exceeds[18]. This would direct a minimum formation depth of 0.90 m outside of the zone of influence of any planned trees and other vegetation.

Based on the ease with which this hazard is managed but noting the high background threat posed by clay related subsidence, the risk from this hazard is assessed as **low**.

ii) A raft or reinforced ring beam could be formed on re-engineered granular fill deposits either comprising compacted 6F5 or Type 1. In both cases, the compaction regime would dictate the bearing capacity for the foundations but will likely be guided towards an 'end product' specification of achieving an equivalent CBR of ~5 % (firm to stiff clay) that would need to reflect the consistency of any natural Till deposits that the foundations may straddle across.

iii) Quasi-piled foundation: The use of pre-formed concrete access cover 'rings' could be considered that would be employed to act as permanent formwork limiting the size of excavations within the former basements allowing suspended ground-beams to be formed at the higher level and support the structural loads. The foundations would essentially act as piers or short, wide diameter piles and enable a suspended wall and floor construction above, at shallow depth, limiting the overall depth and volume of excavation.

*ⓘ **Shallow coal mining hazard:** The adoption of a piled foundation solution is not recommended in this setting given that pile toes (the base) would encroach on zones of potential instability within possible unrecorded coal mine workings beneath the Site. For further detail, reference should be made to Soil and Structure's Coal Minning Risk Assessment ref. 20305-R-001-V01.*

Furthermore, based on the revealed condition of the former basements, it is likely that pre-digging of pile positions (due to clashes with relic sub-structure walls and flagstone floors) would be required that itself makes most piling techniques less favourable.

Ground improvement techniques are limited in these ground conditions however, the use of vibro-stone-replacement columns could be considered to increase the consistency and density of the brick fill deposits. It should be noted that the presence of relic walls and possible basement slabs stands to obstruct this technique in the same way as piles.

Formation of a basement beneath the proposed structure could also be considered if and where mass excavations of all the relic basements is considered.

Floor slab. The Made Ground deposits (brick fill) are unsuitable for supporting the structural slab loads either due to excessive total settlement or differential settlement (tilt). However, floor slab options are expected to be either integrated into the foundation, i.e. raft, or else suspended unless engineered fill is placed across full depth of the former basements, potentially facilitating the use of a ground bearing floor slab.

ⓘ ***Ground Gases and Vapours:*** *At this stage, there is limited evidence that ground gas generating materials are present in the basement fill (incidental rags being the only evidence).*

Off-Site sources of potential ground gas were identified and discussed within Section 2.1. The likelihood of ground gases generated from these sites being transported onto the Site is considered unlikely and the requirement for ground gas monitoring is therefore not recommended.

Given ground gas is one of the select hazards currently regulated under the planning regime, this assessment is carried forward but ground gases not identified within Section 5.0 as a specific ground-related hazard.

Based on the low background threat posed by ground gas {natural and non-natural sources; outside of underground or confined space operations where the risk is high) and very low gas generation potential of on-Site sources and/or unlikely pollutant-linkages from off-Site sources, the risk presented by ground gas is assessed as low. This is a Site-wide risk but very much specific to the proposed office block.

The risk to end users of the Site from vapour intrusion into the proposed structures is assessed as low at this stage based on the lack of evidence of vapour generating material in the basement fill, e.g. fuels or solvents.

As a general advisory, for both ground gas and vapours it is recommended that, that a responsive strategy is adopted during the works. If and where any evidence of ground gas generating material or vapours, i.e. odours, is noted then further assessment and/or risk mitigation should be considered e.g. gas and/or vapour monitoring or bespoke barriers.

It is noted that all the recommended foundation solutions will likely include either inherent ground gas protection or the opportunity for it either as a raft (structural barrier) or suspended slab (ventilated void).

ⓘ **Radon** ⓘ Provision of basic radon protection is recommended owing to the Site being located within an area where between 5 and 10 % of dwellings are above the Action Level. In general, radon is not regulated despite the background threat from radon being one of the highest ground-related hazards (with the current 'Action Level' representing 50 % of an adult's average radiation dose).

Based on the high background threat posed by radon but accounting for the ease with which it is mitigated, the risk is assessed to be **moderate**. This is a Site wide risk. It is also noted that the workplace limit is higher than the 'Action Level' for dwellings but again, the low cost of risk mitigation and high background threat, guides the inclusion of basic radon protection.

Basic radon protection measures should be provided in line with BRE 211 that includes for the provision of a continuous, well-sealed damp-proof membrane across the full footprint of any occupiable structures.

Proprietary radon barriers are available however, these can commonly be relatively 'thin' membranes with similar performance criteria to equivalent damp-proof-membranes. Soil and Structures recommend the adoption of a 2000 gauge damp-proof-membrane to limit the potential for the membrane to be damaged by follow-on trades (thicker membrane less susceptible to ripping and puncture).

Whilst not specifically recommended, if and where a suspended ground floor is specified then the provision of sub-floor ventilation (front-to-back or side-to-side but not both) would result in the radon protection being upgraded to 'full protection' (together with the membrane) that is likely to be cost-neutral as well as offering inherent protection to all ground gases.

[18] *4.2 Building near trees - NHBC Standards 2023 NHBC Standards 2023 (nhbc-standards.co.uk)*

Retaining walls are not expected to be required as part of the proposed development however it is noted that the proposed steel frame structure extension will include for an extension of the existing retaining wall that appears to also be acting as the foundation for the existing steel frame structure.

Consideration could be given to the investigation of the existing retaining wall's construction or else allowance made for continuation of the same construction detail (subject to the same and/or suitable formation soils being proven) being continued for the extension.

Buried concrete classifications should be confirmed through further assessment (chemical analysis of the soils) or else a precautionary approach adopted of DS-2 AC-2.

Groundwater is likely to be defined as 'mobile' across all depths.

6.3 Civil Engineering

Hard-standing levels are expected to be formed close to the existing ground surface with a net reduction in levels to accommodate new hardstanding build-ups (if and where new hardstanding is required)

Based on the likely formation levels, the sub-grade could include 'brick fill' (unless replaced / removed) that is not expected to offer 'good enough' support given the potential for excessive total and differential ground movement (voids will exist between the bricks).

On this basis, it is recommended that the sub-grade for new hardstanding areas comprises natural Till deposits that, are expected to achieve a preliminary CBR of 2.5 %.

Specific attention should be given to the potential for formations to vary, e.g. where hardstanding straddles the edge of former basements.

In general, proof rolling of any hardstanding formation should be completed using a >800 mm vibratory roller to locate any hard or soft spots and pre-treat the ground.

Provision of tensile reinforcement, e.g. geotextile layers or geo-grids, is not recommended at this stage, but may be considered if and where evidence of varying ground conditions is encountered, e.g. hardstanding that spans over the edge of former basements. Inclusion of tensile reinforcement can reduce the required thickness of the sub-base.

Drainage of the existing Site is expected to be controlled by drainage to the existing piped network.

Drainage into Made Ground deposits can result in collapse compression (rapid gains in density, wash out of fines and re-ordering of soil particles). Therefore, at this stage, drainage to ground is not recommended as part of the proposed drainage strategy with the existing pipe network likely rehabilitated and re-used subject to the drainage engineer's recommendations. On this basis, infiltration testing is not recommended.

Water supply pipes will likely be laid within 'shallow' Made Ground deposits the nature of which is unknown at this stage and therefore the risk presented to water supply pipes also unknown.

Given this uncertainty, and this industrial / commercial legacy of the Site, it is recommended that a precautionary approach is adopted for water supply pipes and barrier pipe specified (PE/AL/PE). If and where any free product is encountered within the ground, additional precautions are likely to be required and should be confirmed with the Author of this Report if encountered.

6.4 Landscaping

No soft landscaping is planned as part of the proposed development.

If and where any imported soil forming materials should be sourced from a reputable supplier and tested 'at source' to confirm they are suitability for use. The suitability of the imported soil forming material should be confirmed in line with the local planning authority's guidance[19] that will need to be followed irrespective of the requirement for a Remediation Strategy or not.

6.5 Mechanical Engineering

Ground source heat pumps (vertical): Open loop ground source heat pumps screen as being favourable on the Site[20]. Closed loop systems are generally viable across a broader range of geological and hydrogeological conditions.

Further testing, including a field trial would be recommended to confirm the performance of any borehole-based ground source heat pump system and the advice of a specialist consultant sought.

Attention should be given to:

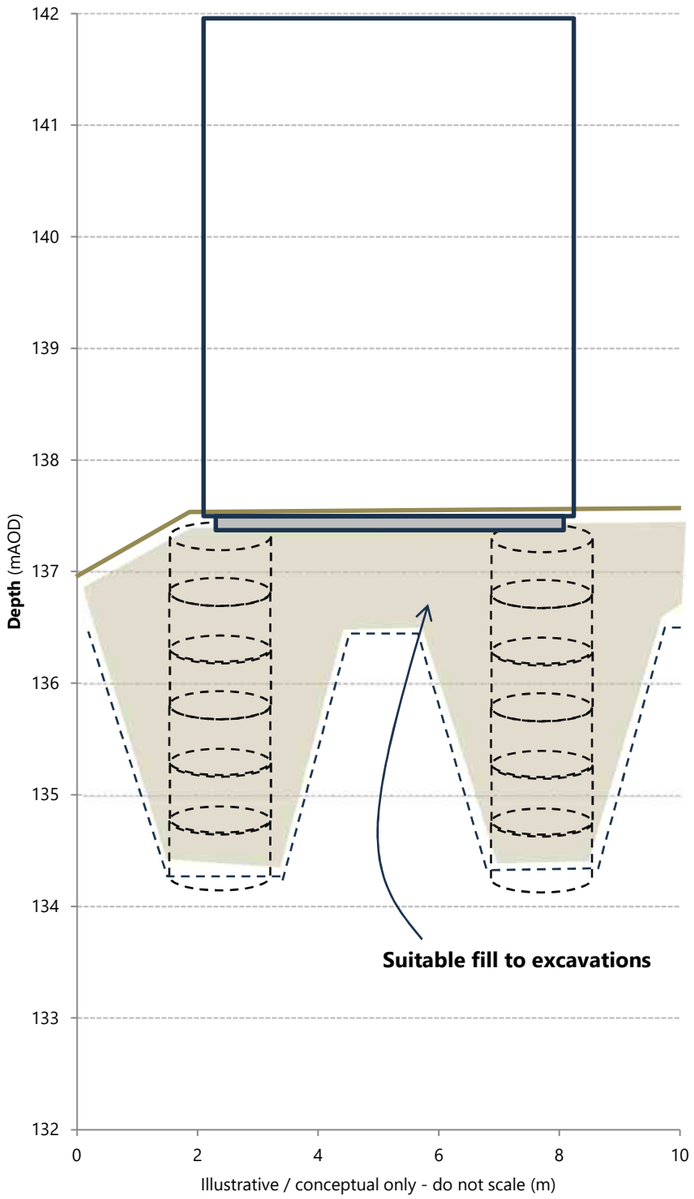
> The possible presence of unrecorded coal mine workings within the drill depths of any borehole-based ground source heat pump; and,

> The deeper bedrock deposits are expected to be is a varied sequence of rocks with sandstone, mudstone, siltstone and coal. Sandstone typically has thermal conductivity of 2.80 W m^{-1} K^{-1} and thermal diffusivity of 1.645 x 10^{-6} m^2 s^{-1} with the mudstone and siltstone bands having lower values for both characteristics[21].

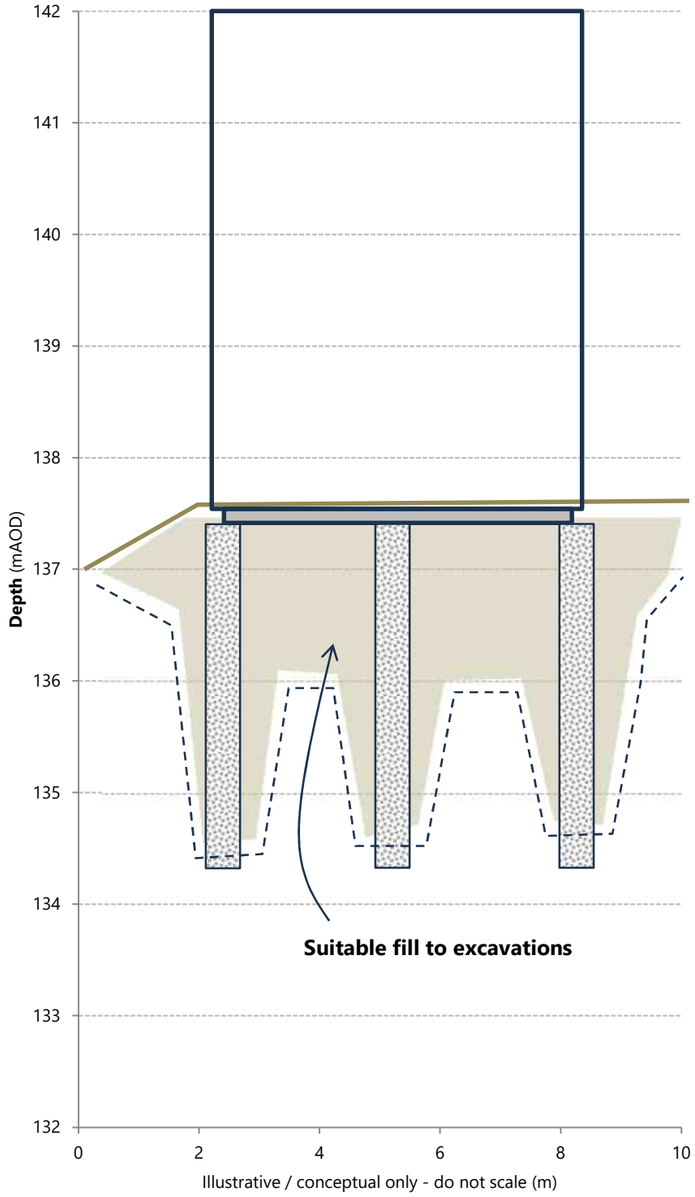
Further guidance is available[22],[23].

[19] Reports in Support of Planning Applications | Oldham Council
[20] GSHP (bgs.ac.uk)
[21] *Busby et. Al. (undated) Initial Geological Considerations before Installing Ground Source Heat Pump Systems*
[22] Geothermal energy - British Geological Survey (bgs.ac.uk)
[23] Who Are The Ground Source Heat Pump Association | GSHPA

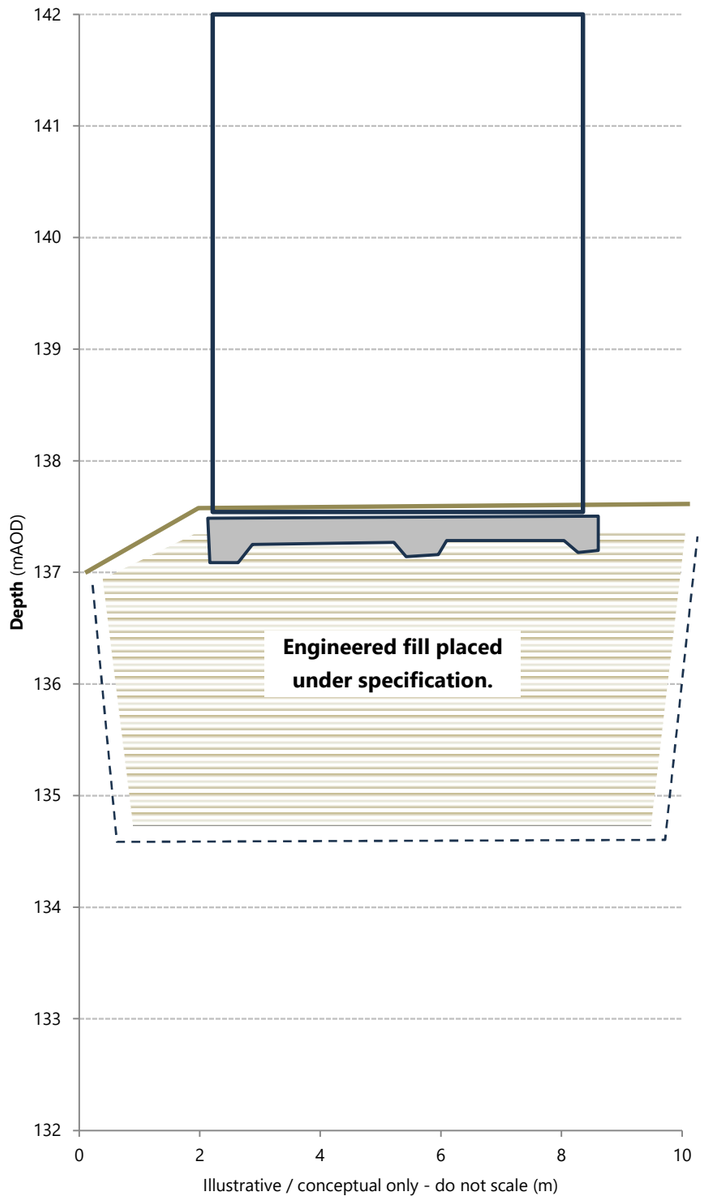
Conceptualisation of the proposed foundation solutions (adapted from the advice given in Section 6.0)



Quasi-piled foundation solution



Trench fill foundation solution



Raft foundation solution

All drawings are illustrative / conceptual only *– please reference the commentary in Section 6.0 for further detail and note that temporary works may have a guiding influence on the design.*

7.0 Conclusion and Recommendations

Based on available information and the scope of this Report the anticipated ground conditions are considered 'moderate to low risk' overall, noting the specific hazards of relic sub-structures and 'deep' Made Ground deposits that influence most elements of the proposed design as well as radon.

7.1 Conclusions

In conclusion, the Ground Investigation Report finds that:

> Further investigation is not recommended at this stage but may wish to be considered to obtain better resolution on the extent of the former basements. In addition, consideration may wish to be given to chemical testing of the fine material within the brick fill deposits to support waste classification; and,

> 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 more general ground engineering advice.

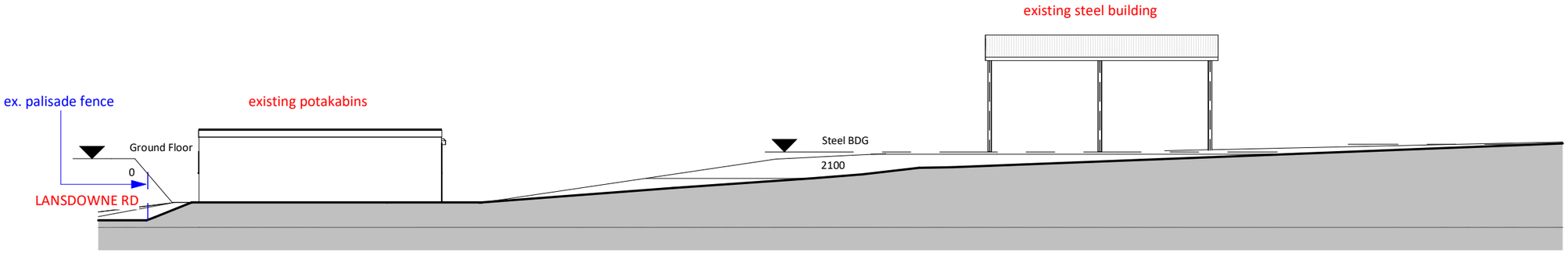
7.2 Recommendations

Recommended follow-on work includes:

1. Review of this Ground Investigation Report (intrusive) and the advice herein; and,
2. Submission of the Ground Investigation Report (intrusive) to the project design team, the local planning authority and, where necessary, other stakeholders.

Based on the findings and recommendations presented within this Report

ⓘ ***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.*



Existing Site Section

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00 Site Plan - Existing

1 : 500

00 Site Plan - LOCATION

1 : 1250

NOTES
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No.	Description	Date

PURPOSE OF ISSUE
Planning

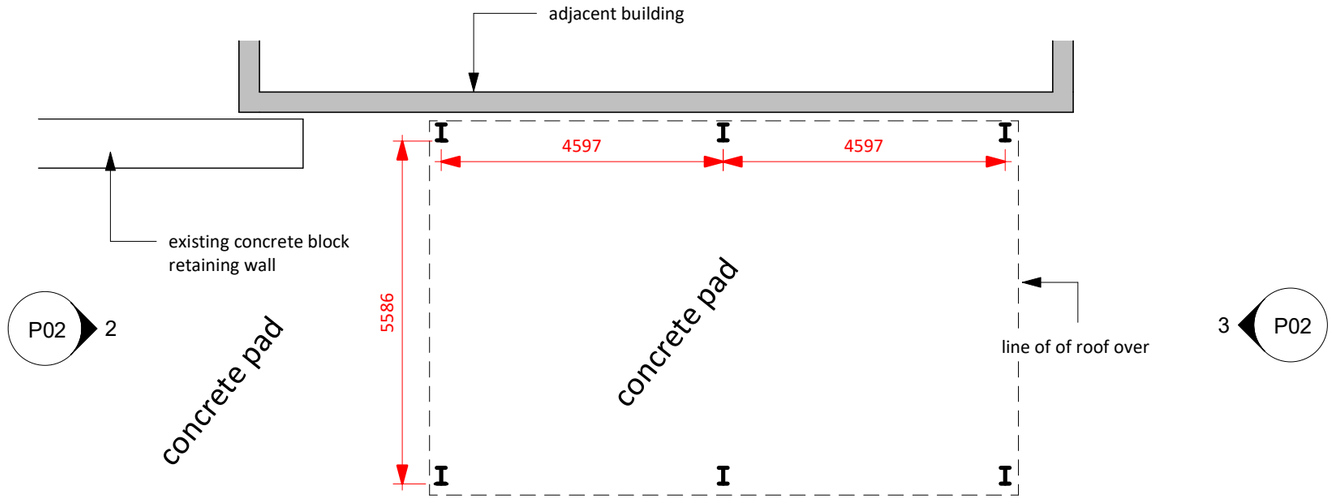
PROJECT
11 Landsdowne Road, Oldham

SHEET
Existing Site Plan & Site Section

CLIENT
Pipework Ltd

Date	Project number	Scale (@ A3)
14.03.23	J23-017	As indicated

Drawn by	DRAWING NUMBER	REV
bl	P00	



11. Steel Building Existing Plan

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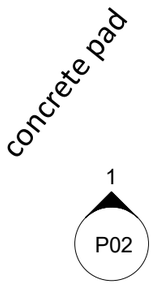

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Planning

PROJECT
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SHEET
Existing Steel Building Plan

CLIENT
Pipework Ltd

Date	Project number	Scale (@ A3)
14.03.23	J23-017	1 : 100

Drawn by	DRAWING NUMBER	REV
bl	P01	

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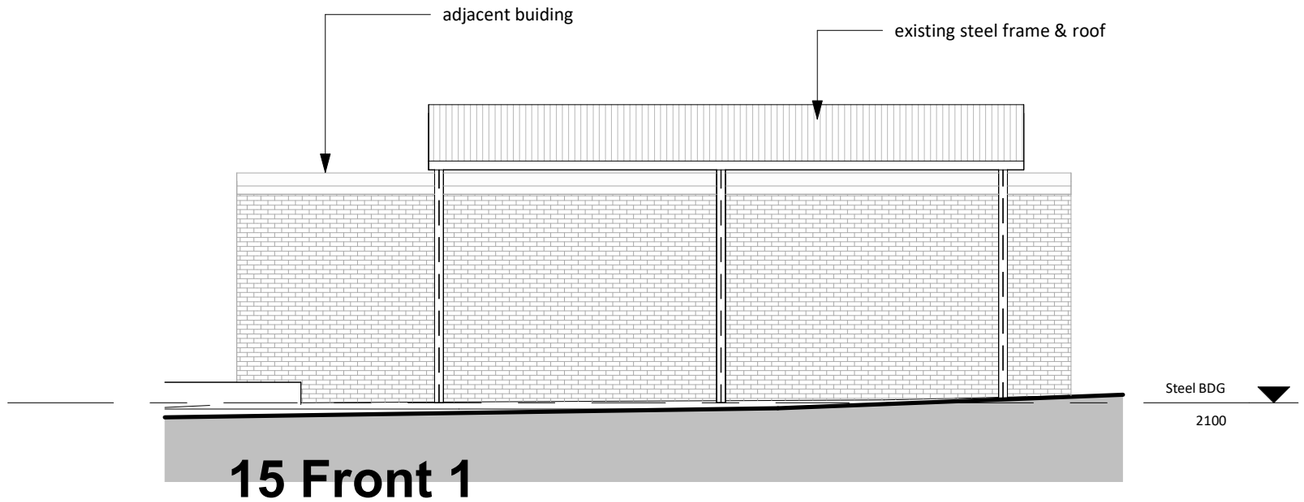

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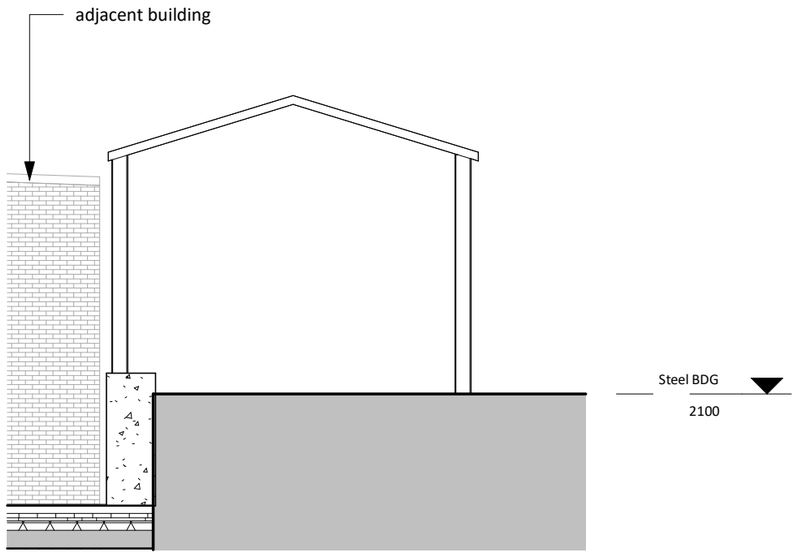

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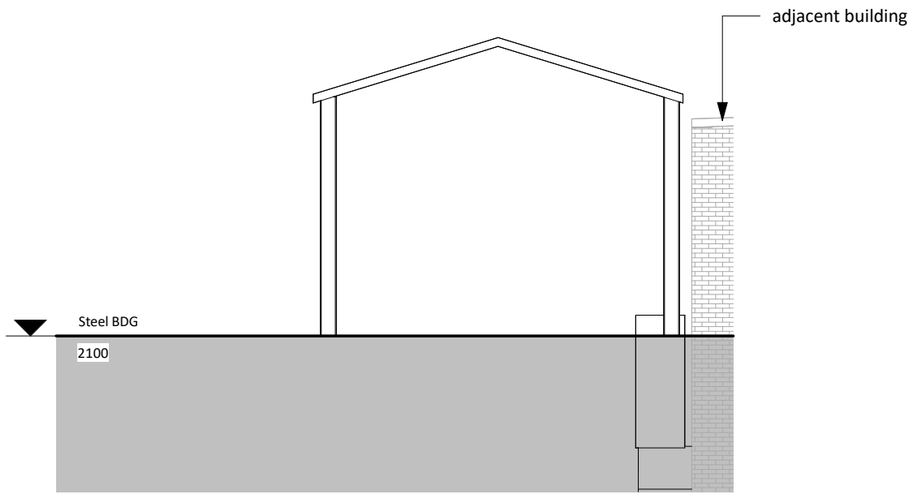

15 Side 2
1 : 100

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PURPOSE OF ISSUE
Planning

PROJECT
11 Landsdowne Road, Oldham

SHEET
Existing Steel Building Elevations

CLIENT
Pipework Ltd

Date	Project number	Scale (@ A3)
14.03.23	J23-017	1 : 100

Drawn by	DRAWING NUMBER	REV
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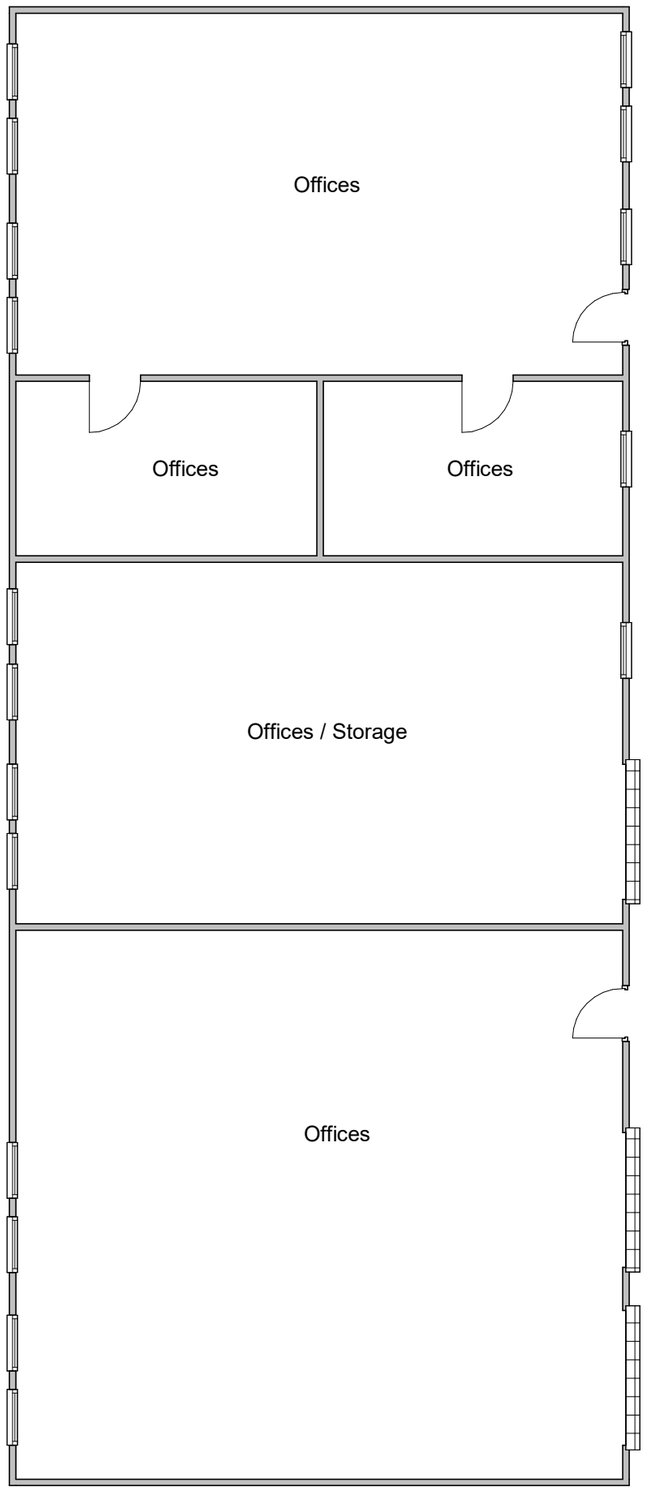

02a Portacabins Existing

1 : 100

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PURPOSE OF ISSUE
Planning

PROJECT
11 Landsdowne Road, Oldham

SHEET
Existing Potakabins

CLIENT
Pipework Ltd

Date	Project number	Scale (@ A3)
14.03.23	J23-017	1 : 100

Drawn by	DRAWING NUMBER	REV
bl	P03	

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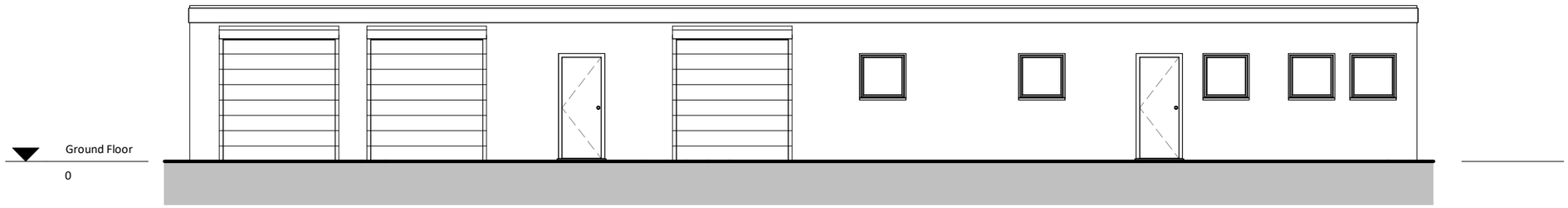

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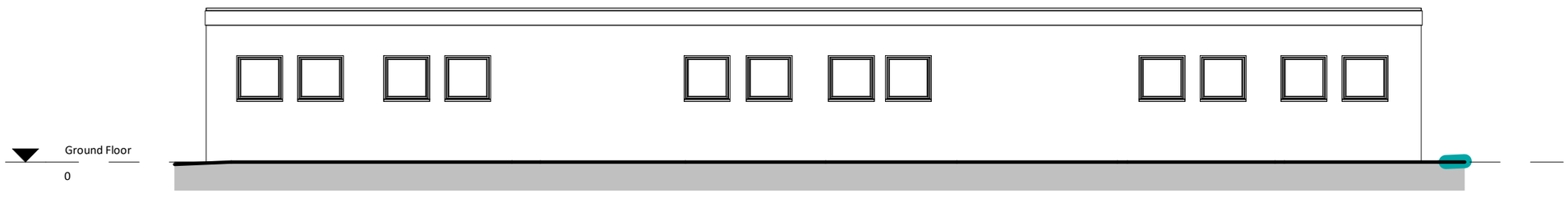

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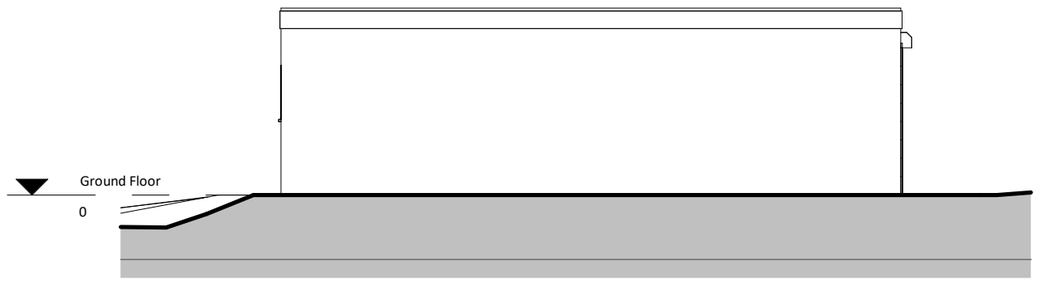

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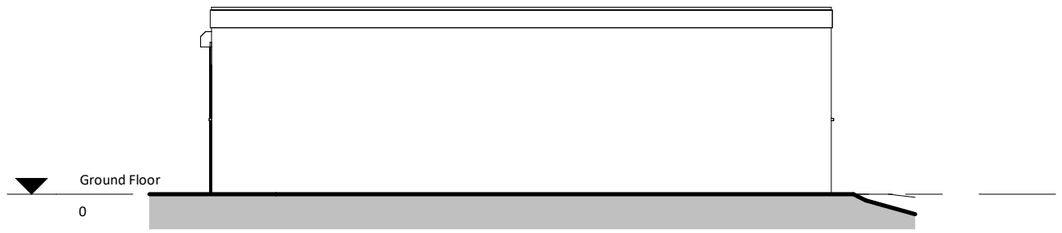

10 Side 2 (Existing)
1 : 100

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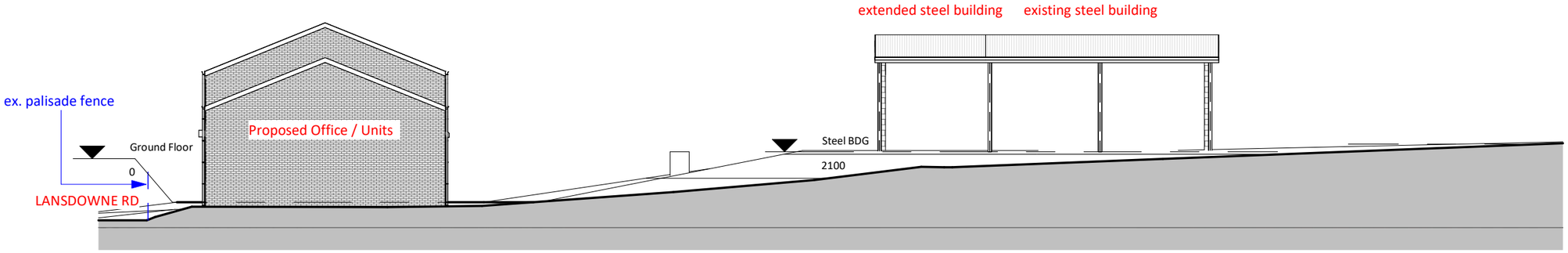
11 Landsdowne Road, Oldham

SHEET
Existing Portakabin Elevations

CLIENT
Pipework Ltd

Date	Project number	Scale (@ A3)
14.03.23	J23-017	1 : 100

Drawn by	DRAWING NUMBER	REV
Author	P04	

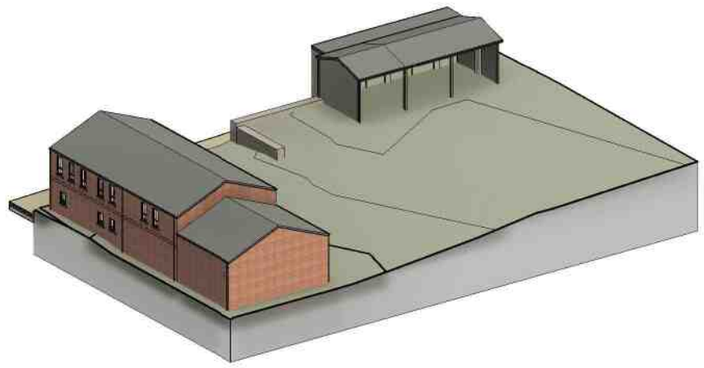


Proposed Site Section

1 : 200

00 Site Plan - Proposed

1 : 500



I3 General Isometric

NOTES
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No.	Description	Date

PURPOSE OF ISSUE
Planning

PROJECT
11 Landsdowne Road, Oldham

SHEET
Proposed Site Plan

CLIENT
Pipework Ltd

Date	Project number	Scale (@ A3)
14.03.23	J23-017	As indicated

Drawn by	DRAWING NUMBER	REV
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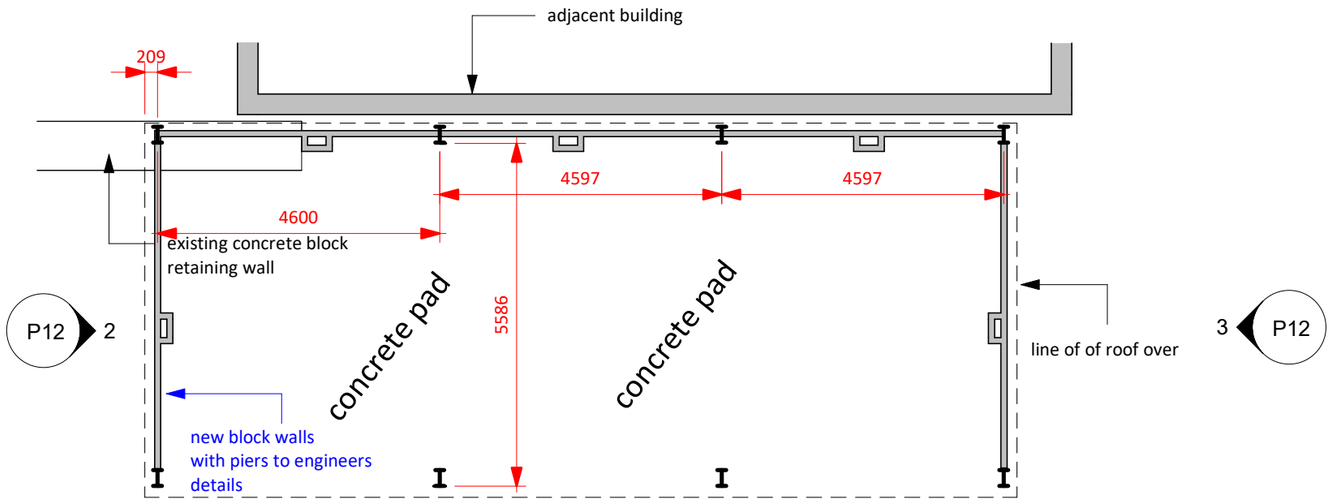
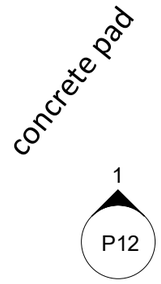


11. Steel Building Proposed Plan

1 : 100



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No.	Description	Date

PURPOSE OF ISSUE
Planning

PROJECT
11 Landsdowne Road, Oldham

SHEET
Proposed Steel Store Floor Plan

CLIENT
Pipework Ltd

Date	Project number	Scale (@ A3)
14.03.23	J23-017	1 : 100

Drawn by	DRAWING NUMBER	REV
Author	P11	

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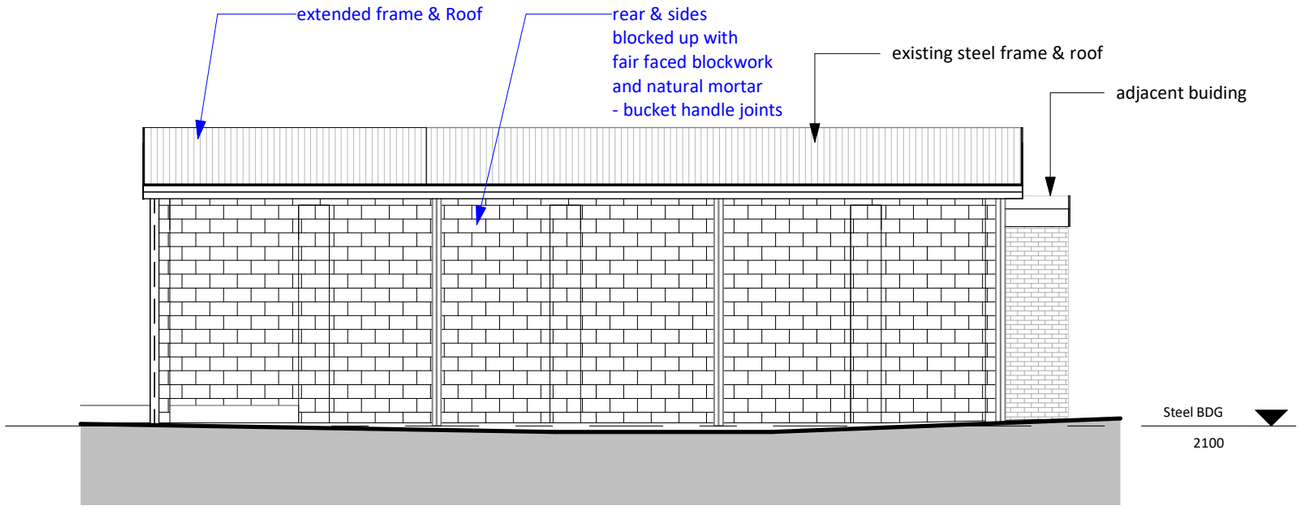

16 Front 1 Proposed
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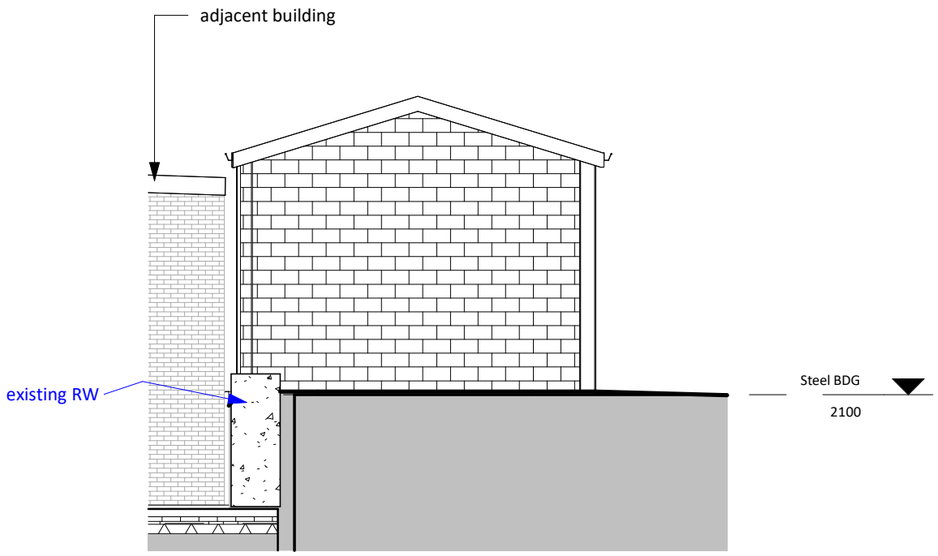

16 Side 1 Proposed
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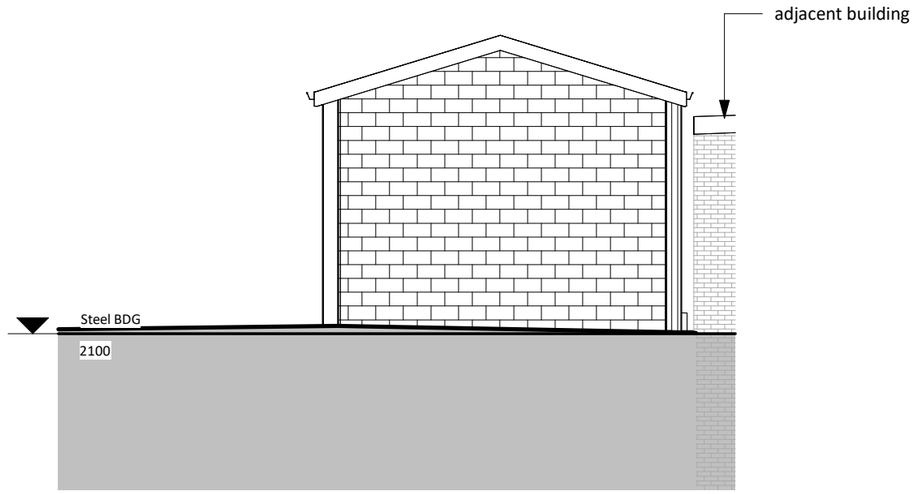

16 Side 2 Proposed
1 : 100

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No.	Description	Date

PURPOSE OF ISSUE
Planning

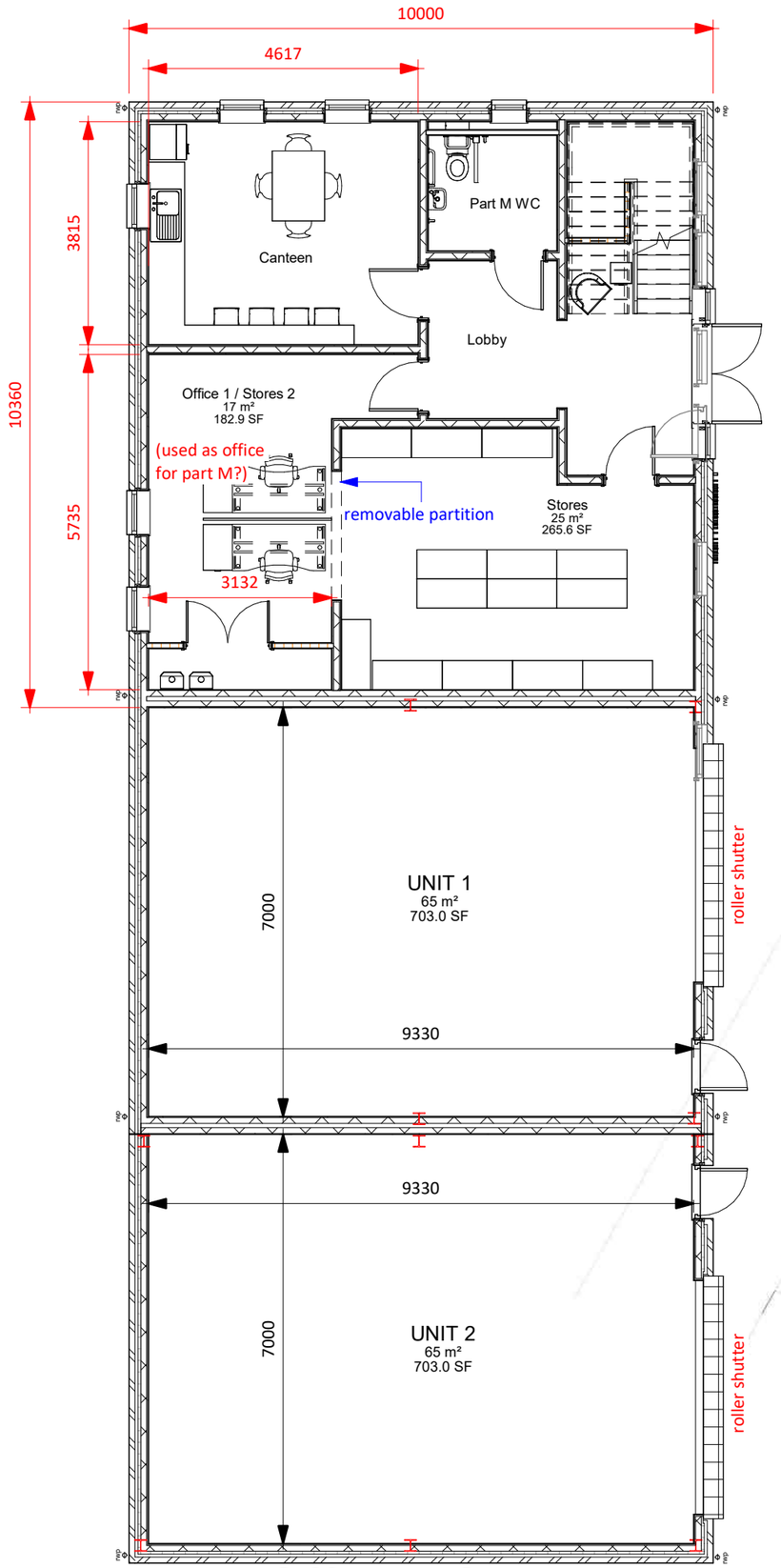
PROJECT
11 Landsdowne Road, Oldham

SHEET
Proposed Steel Store Elevations

CLIENT
Pipework Ltd

Date	Project number	Scale (@ A3)
14.03.23	J23-017	1 : 100

Drawn by	DRAWING NUMBER	REV
Author	P12	



02b Offices GF Proposed

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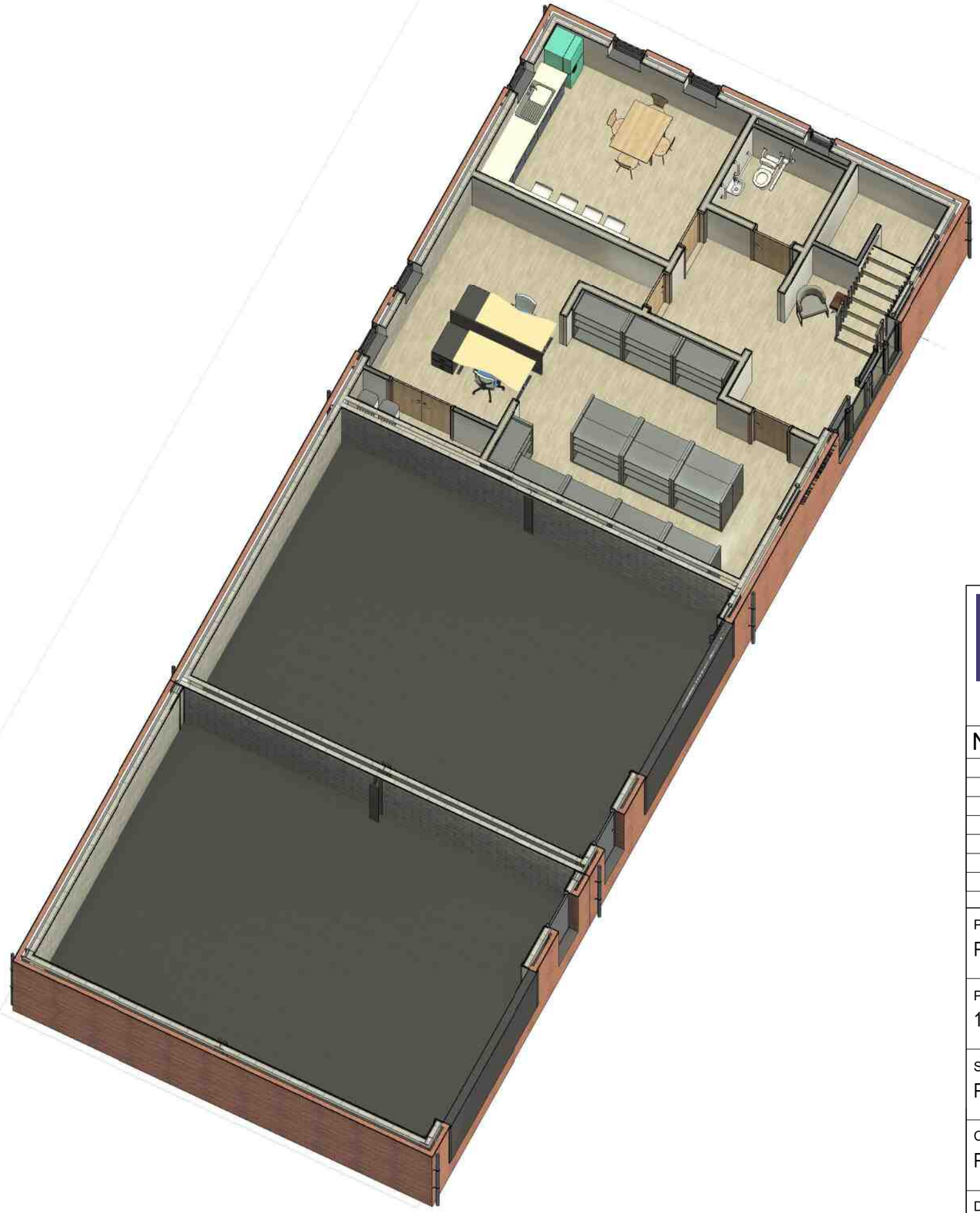

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Planning

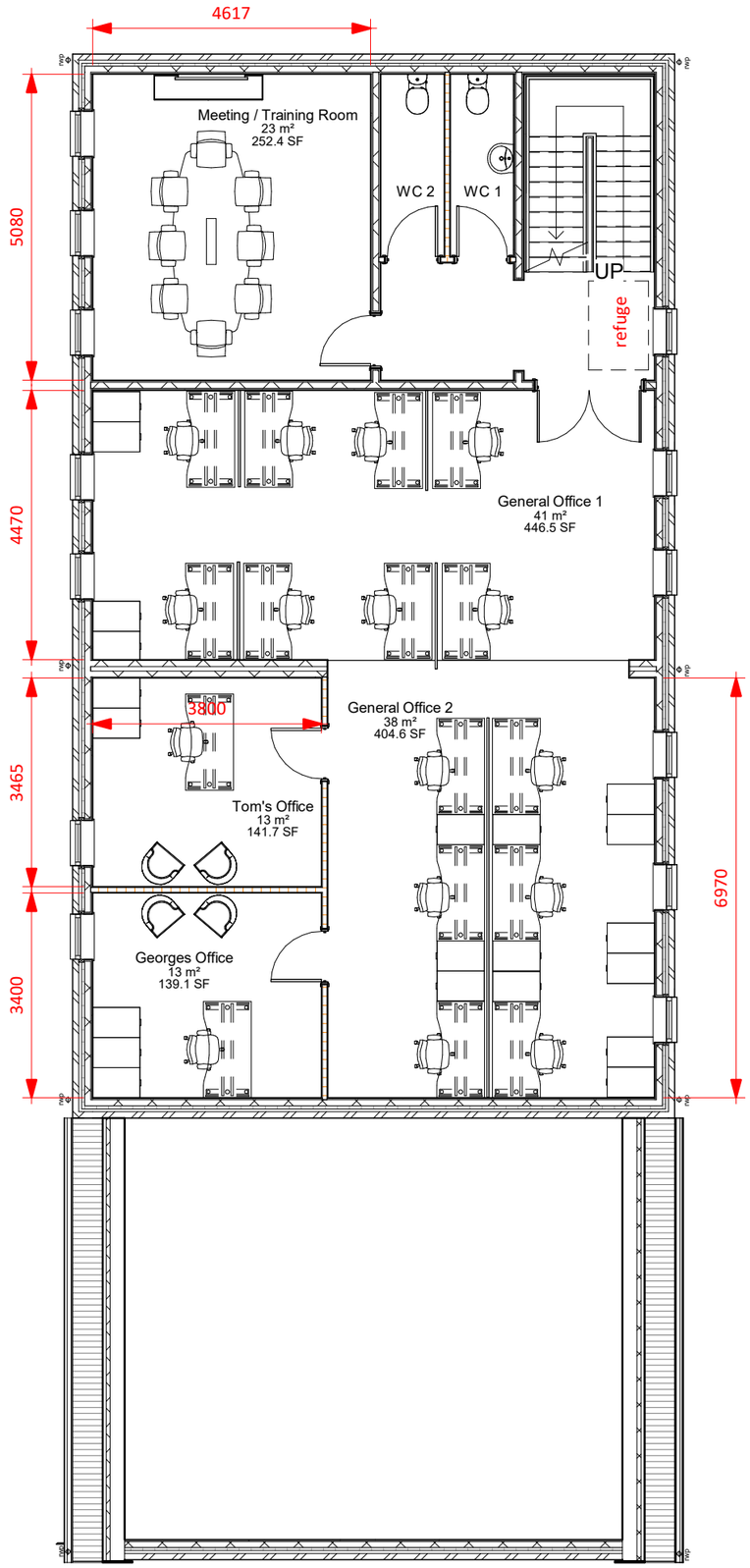
PROJECT
11 Landsdowne Road, Oldham

SHEET
Proposed Office/Unit GF Plan

CLIENT
Pipework Ltd

Date	Project number	Scale (@ A3)
14.03.23	J23-017	1 : 100

Drawn by	DRAWING NUMBER	REV
Author	P20	



03b Offices FF Proposed

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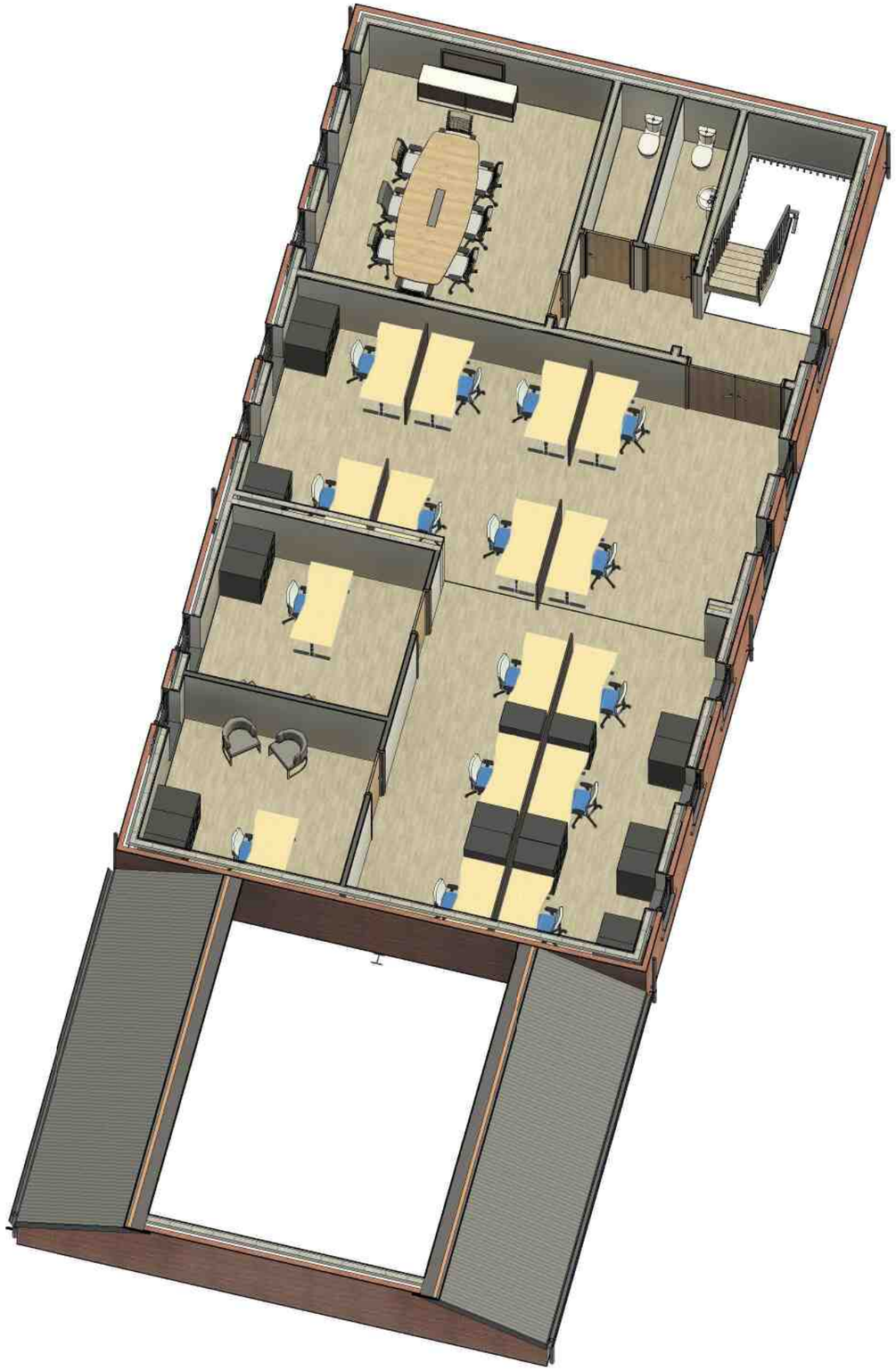

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Planning

PROJECT
11 Landsdowne Road, Oldham

SHEET
Proposed Office FF Plan

CLIENT
Pipework Ltd

Date	Project number	Scale (@ A3)
14.03.23	J23-017	1 : 100

Drawn by	DRAWING NUMBER	REV
bl	P21	

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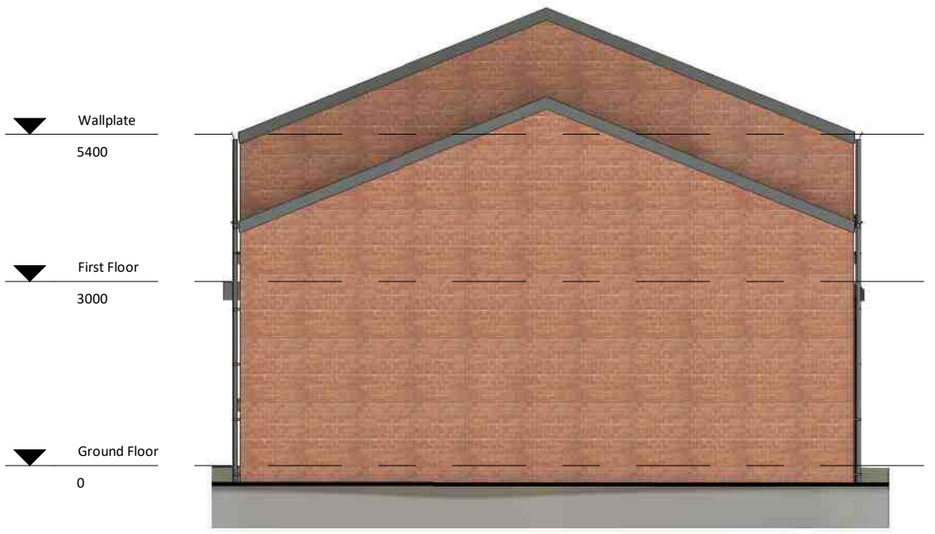
11 Front Proposed (Facing Yard)
1 : 100

11 Side 1 (Proposed)
1 : 100



11 Side 2 Proposed
1 : 100

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No.	Description	Date

PURPOSE OF ISSUE
Planning

PROJECT
11 Landsdowne Road, Oldham

SHEET
Proposed Offices/Unit Elevations

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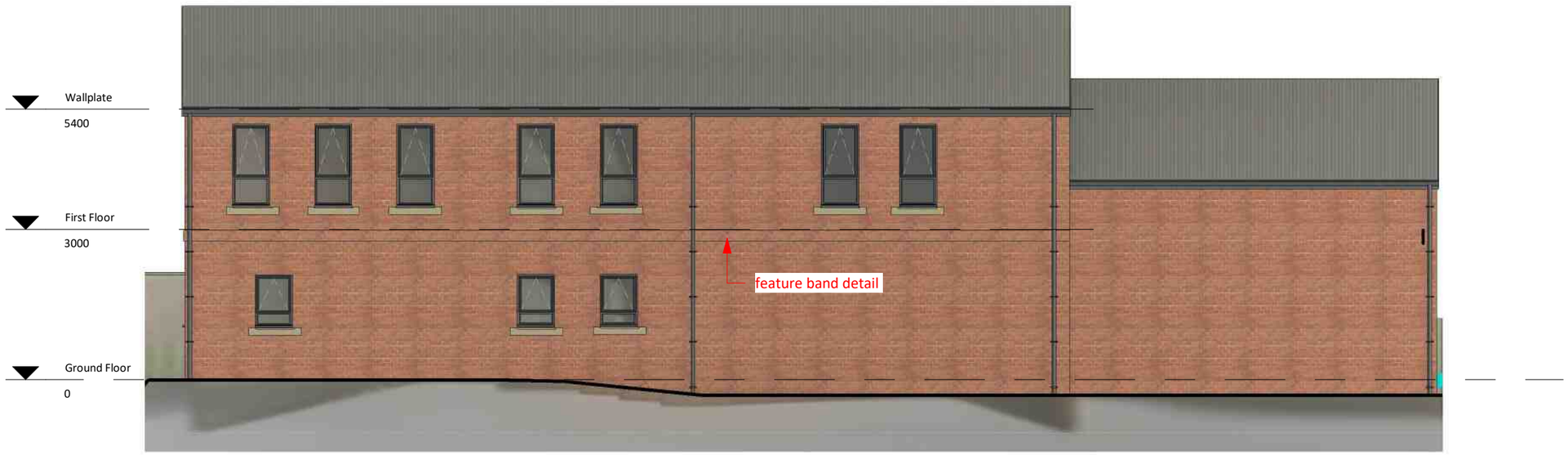
Pipework Ltd

Date	Project number	Scale (@ A3)
14.03.23	J23-017	1 : 100

Drawn by	DRAWING NUMBER	REV
bl	P22	



11 Rear Proposed (Lansdowne Rd)

1 : 100

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PURPOSE OF ISSUE
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11 Landsdowne Road, Oldham

SHEET
Proposed Offices Elevation 2

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Pipework Ltd

Date	Project number	Scale (@ A3)
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Drawn by	DRAWING NUMBER	REV
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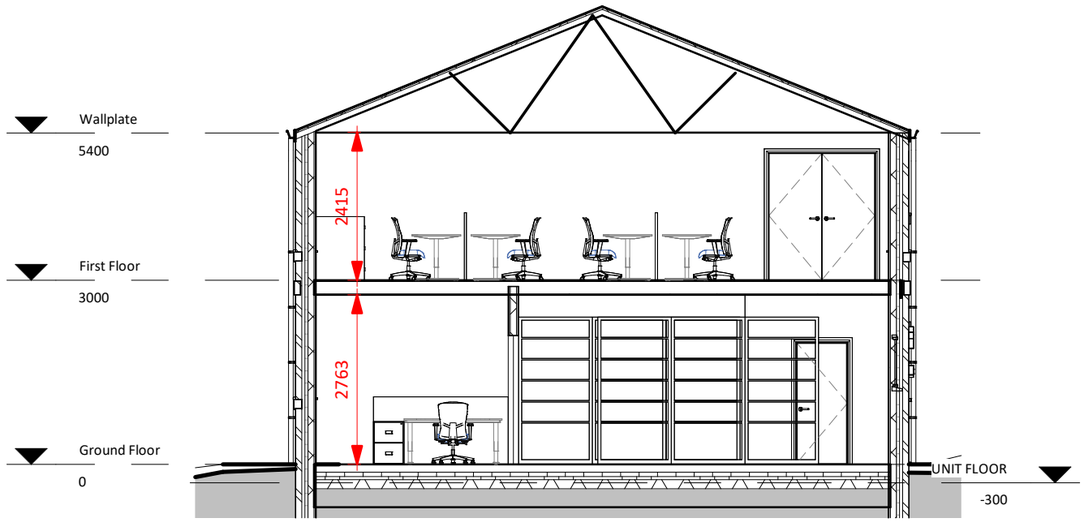

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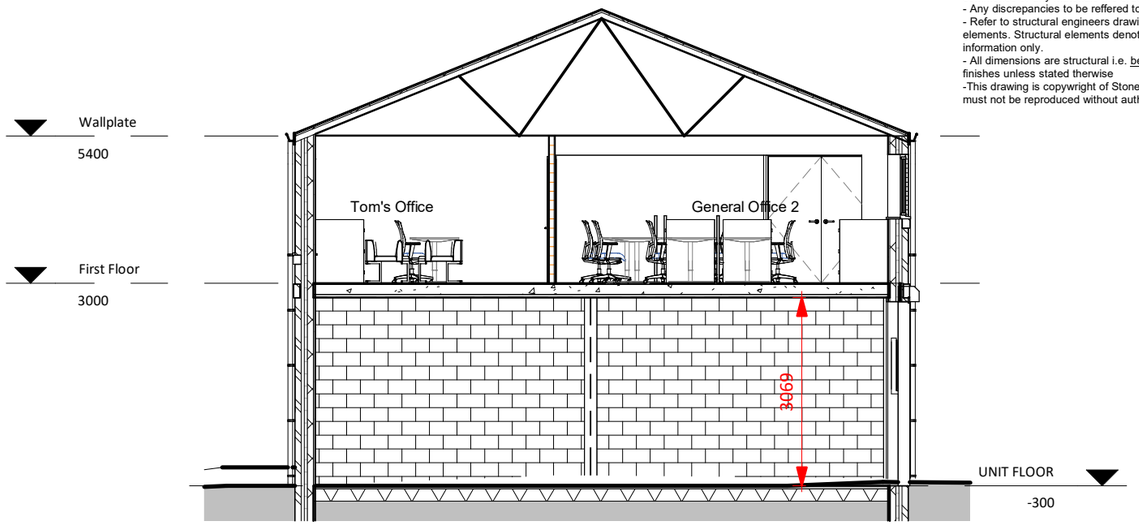

Section B-B
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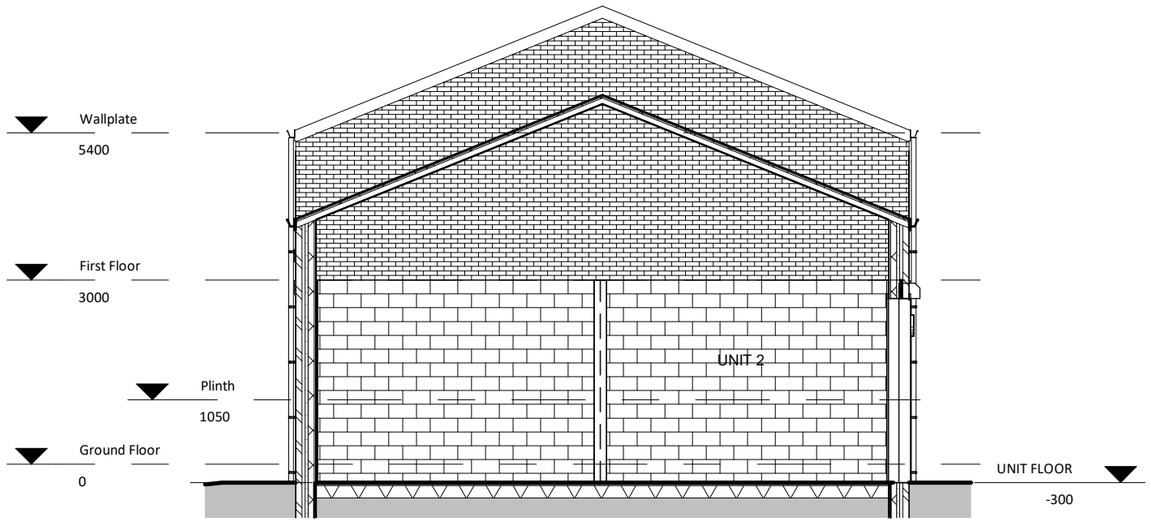

Section C-C
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PURPOSE OF ISSUE
Planning

PROJECT
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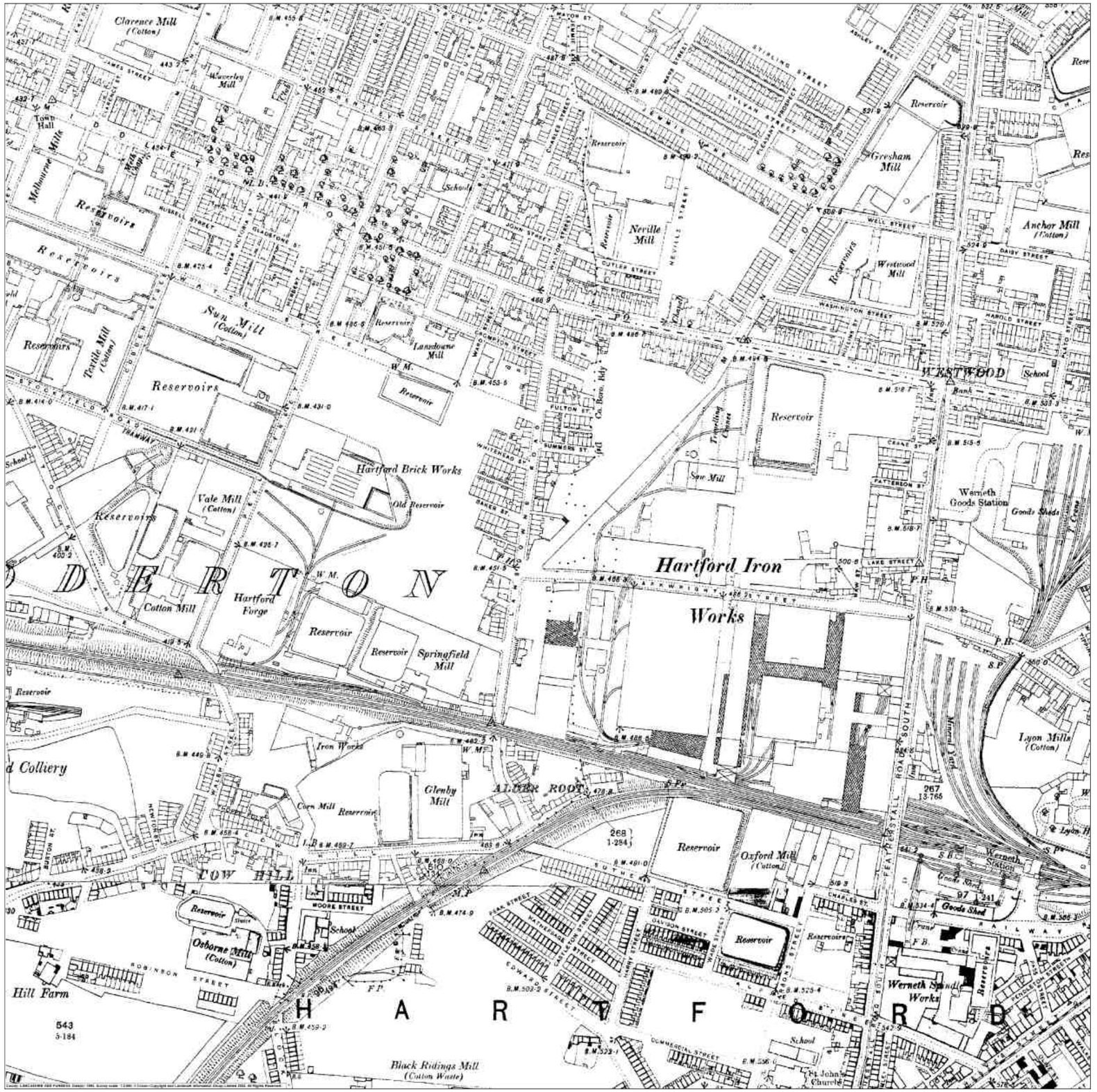
SHEET
Proposed Office / Unit Sections

CLIENT
Pipework Ltd

Date	Project number	Scale (@ A3)
14.03.23	J23-017	1 : 100

Drawn by	DRAWING NUMBER	REV
bl	P24	

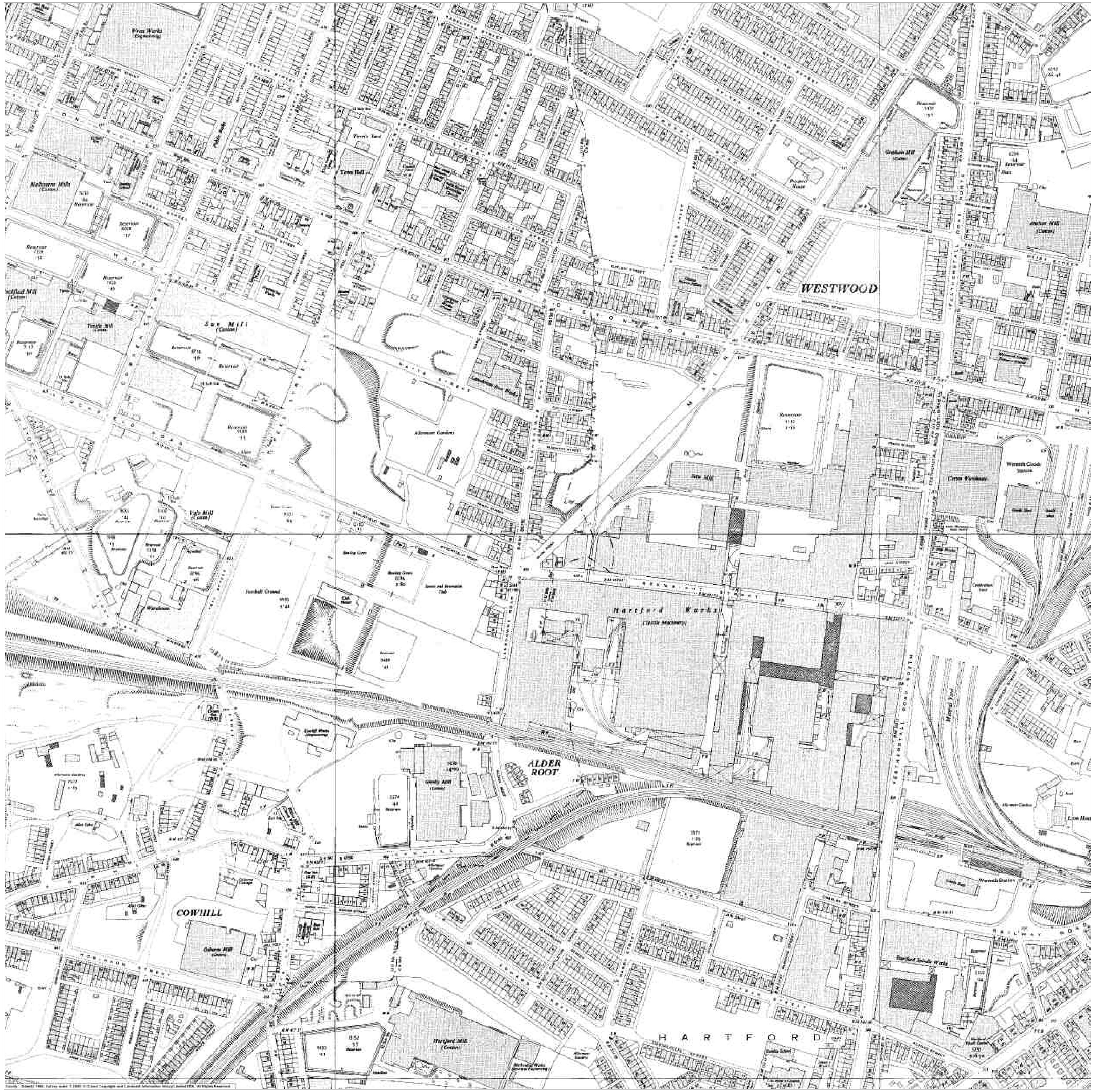


Landmark
INFORMATION GROUP

Landmark Historical Map
County: LANCASHIRE AND FURNESS
Published Date(s): 1893
Originally plotted at: 1:2,500

Landmark INFORMATION GROUP

Landmark Historical Map
County: LANCASHIRE AND FURNESS
Published Date(s): 1932
Originally plotted at: 1:2,500



Landmark Historical Map
County:
Published Date(s): 1955
Originally plotted at: 1:2,500

Annex

Background Threat and Risk

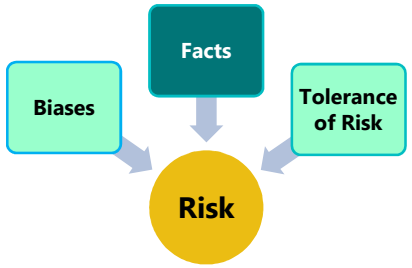
SOIL AND STRUCTURES

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

General Guidance on Material Suitability

Suitability (in general): A *soil* becomes a *material* once excavated. This Guidance Note advice with respect to the suitability of soils to remain on Site and the suitability of materials recovered from Site.

The materials are given preliminary classifications based on those set out within the Manual of Contract Documents for Highways Works[1].

Geotechnical suitability: If and where earthworks (cut and fill) are planned as part of the works then strength and compaction testing is typically recommended to inform the earthworks specification. Subject to the earthwork design details being finalised, it is common for additional geotechnical testing, e.g. compaction testing, to be recommended to confirm suitability.

Chemical suitability: Chemical suitability is assessed in the context of the historical and geological setting of the Site as well as against the proposed end use of the Site. This assessment forms a core part of the current planning framework as laid out within the Environment Agency's Land Contamination Risk Assessment guidance[2].

General Guidance on Materials Management

Materials management: In general, once material is excavated from the ground it could be deemed a 'waste' unless it has a specified use. This also applies to materials intended for re-use on Site.

For natural materials, re-use on Site is generally not regulated apart from in specific scenarios.

For non-natural deposits (Made Ground) additional protocols need to be followed (CL:AIRE Code of Practice[3]) to demonstrate that the material is suitable for re-use and therefore, not a waste.

[1] *Manual of Contract Documents for Highways Works, Volume 1 Specification for Highway Works – Series 600 Earthworks (2016)*
[2] *Land contamination risk management (LCRM) - GOV.UK (www.gov.uk)*
[3] *CL:AIRE The Definition of Waste: Development Industry Code of Practice Version 2 (2011)*

Guidance Note

Unforeseen Material

SOIL AND STRUCTURES

Some unforeseen material has been encountered in the ground. This material is suspected as being potentially harmful or polluting. What should you do?

Seek the advice of the project Engineer (*the Engineer may need to seek advice from a ground investigation consultant*).

What will the Engineer do?

The Engineer (or someone on the project team) will contact the local planning authority's contaminated land team to notify them of the encounter. The purpose of this contact is to agree a strategy for responding to and dealing with the unforeseen material. This strategy should be agreed in advance of any work on or around the unforeseen material recommencing.

What will the response strategy involve?

The responsive strategy will depend on the nature of the material encountered but may be as simple as confirming that the material will be excavated and disposed of off-site at a suitably licensed facility.

Do regulators have to be notified?

Advance notification is always recommended to avoid any response strategy being deemed inappropriate. There may or may not be a legal requirement for notification depending on the nature of the material encountered. In any case, the local planning authority's pollution control or contaminated land team should be able to assist finding the most cost-effective means of dealing with the material.

Purpose of this Guidance Note

> Support developers working on small development sites; and,

> Support decision making in scenarios where the likelihood of potentially harmful or polluting material being present in the ground has been assessed as low or unlikely (i.e. no remediation strategy has been put in place) but cannot be discounted.

General Commentary

A core aim of '*contaminated land*[1]' planning condition(s) is to ensure that, once completed, the development can be deemed '*suitable for use*'. Or, in other words, to ensure that end users (residents and visitors) will not be exposed to unacceptable levels of risk.

On any site where development works have previously taken place there is always the potential for potentially harmful or polluting material to have been introduced into the ground. Common examples of this include; fragments of asbestos containing material from old out-buildings, ash deposits from where coal ash was formerly tipped in a garden or localised fuel spillages.

Whilst ground investigation aims to remove as much uncertainty as possible from the ground, it is rarely cost-beneficial to investigate 100 % of any given development site. For this reason, unforeseen or unexpected material may be encountered during development works.

[1] *'Contaminated land' is strictly a legal definition of land that has been determined as such under Part 2A of the Environmental Protection Act. The term 'contamination' is often used as short-hand for material that may be chemically unsuitable (potentially harmful or polluting).*