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**REMEDIATION STRATEGY
for land off
28 PADDOCK ROAD, STAINCROSS, BARNSELEY
SOUTH YORKSHIRE**



Prepared for
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**REMEDIATION STRATEGY
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1 INTRODUCTION.

G&M Consulting Ltd (G&M) was commissioned by Andrew Bailey Architects to prepare a Remediation Strategy for land off 28 Paddock Road, Staincross, Barnsley, South Yorkshire.

It is understood that outline planning approval (2017/1387) has been granted by Barnsley Metropolitan Borough Council for the demolition of the existing dwelling and outbuildings and erection of up to 6 dwellings. This report has been prepared in support of the discharge of Condition No 6 of the above approval.

The site has been subject to previous intrusive investigation work, refer to Section 3.1 of this report. This Strategy document incorporates findings and recommendations of this work and provides details of the requirements to remediate the site. This Strategy is intended to detail the approach to be taken to ensure that the risks to sensitive receptors are suitably mitigated, potential risks associated with proven contamination, during the preparatory works are controlled, and that any potential contamination not previously revealed during the recent investigation work is dealt with in an appropriate manner.

The main aims of this strategy are to:

- Satisfy the Local Authority Environmental Protection Department that the remediated site will provide a site ready for development and that it is suitable for its proposed residential with areas of gardens/soft landscaping end use, whilst ensuring that environmental receptors are not put at an unacceptable short-term risk during the development work.
- Ensure construction workers are not put at an unacceptable short-term risk during the development of the site.
- In the interests of sustainability, to promote the use of site-won materials where possible, providing they are suitable for the proposed end use.

It is assumed, in the preparation of this Strategy, that the findings and recommendations of the previous investigation work, on which this strategy document is primarily based, have been submitted to, and approved by, the local authority.

Based on the findings of the previous investigation works it is proposed to incorporate a clean capping layer, up to a minimum of 0.60 m thickness, of subsoils and topsoil into areas of soft landscaping and private gardens, within the new development.

Should changes or amendments to the proposed layout, development levels, and / or end use be made, then these should be confirmed by Andrew Bailey Architects, and if necessary, amendments made to this Strategy document as appropriate.

No work should be undertaken until the Strategy is approved by the relevant regulators.

2 THE SITE.

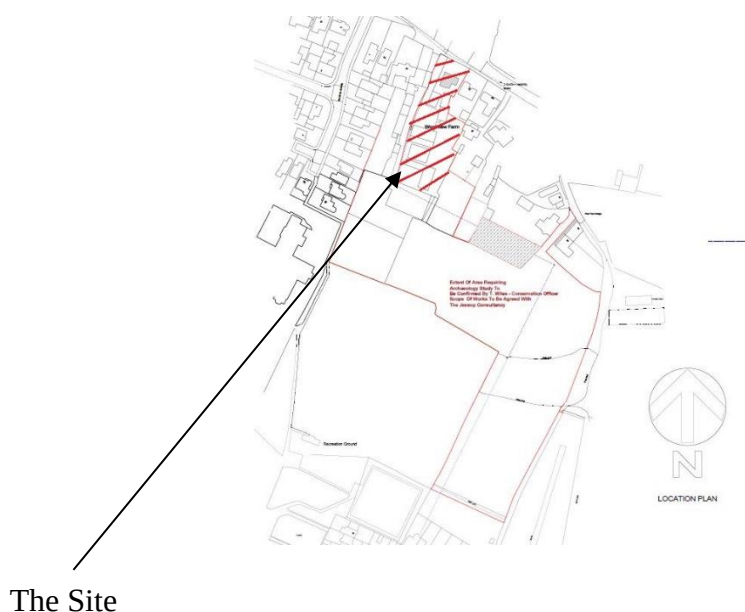
2.1 Site Location.

The site is located on the southern side of Paddock Road in the Staincross area of Barnsley, located approximately 3.75km north of the town centre; the approximate centre of the site has the National Grid Reference, SE 33465 10239. A site location plan is shown on Drawing No. C398/RS/1, presented in Appendix A of this report.

2.2 Current Site Description.

Currently the site is a roughly rectangular plot of land covering an area of approximately 0.55 hectares. The site as a whole fronts, to the north, on to Paddock Road where it is only a narrow plot of land approximately 20 m wide and running south for approximately 90m widening out after 35 m to a width of about 30 m. The area of the site discussed in this report is currently occupied (at the time of writing of this report) by a residential building with associated outbuildings along the boundary of the site with Paddock Road (from which the site is accessed) the site then broadens out, becoming a set of three terraced levels with a slight slope towards the south of the site. This area is currently the site of small construction stockpiles and laydown areas. The site is bounded to the east and west by residential properties with associated gardens and to the south by open fields.

The area of investigation of this report (area of red hatching), is shown below;



3 BACKGROUND INFORMATION.

3.1 Introduction.

The principal source of information used in the preparation of this Strategy document are as follows;

- Preliminary Investigation of land at 28 Paddock Road, Staincross, Barnsley. Report Ref C398, dated February 2021.

- Soakaway Tests on land off 28 Paddock Road, Staincross, Barnsley. Report Ref C398/02/ATS, dated 15th November 2020.
- Land off Paddock Road, Staincross, Barnsley, South Yorkshire, Mining Investigation Report. Report Ref C398, dated March 2021.
- ‘Geoenvironmental Appraisal of Land off 28 Paddock Road, Staincross, Barnsley, South Yorkshire’. Report Ref C398/1, prepared by G&M, dated April 2021.

Details of the environmental aspects, hydrogeology, geology and regulatory issues associated with the site and subsequent intrusive investigation fieldwork are presented in the above referenced reports.

For completeness, a copy of the text of the above referenced geoenvironmental appraisal document is presented in Appendix B of this strategy.

3.2 Proven Ground Conditions

Topsoil comprising soft dark brown slightly gravelly very sandy clay was noted in WS01, WS02 and WS03 close to the residence along Paddock Road, at depths varying between 0.1 m and 0.45 m bgl. The topsoil is underlain by made ground and should therefore also be considered as made ground.

Made ground was proved to depths of between 0.10 m and 0.90 m bgl in both window sample holes and trial pits. The deepest made ground found within the central part of the site in WS03 (0.9m) and TP18 (0.9m).

In general, the made ground comprised a dark brown slightly gravelly locally gravelly very sandy clay. The gravel component comprised concrete, brick, sandstone and mudstone.

In boreholes WS02 and WS07 the made ground comprises a dark brown/black slightly clayey, locally very sandy gravel of concrete, brick and sandstone to depths of between 0.55 m and 0.6 m bgl. In borehole WS03 the made ground proved to a depth of 0.9 m bgl is yellowish brown slightly clayey sandy gravelly cobbles of sandstone. The gravel content is noted to be sandstone and coal.

Material derived in-situ by weathering of coal measure strata will reflect the nature of the underlying bedrock from which it is derived. As the rock types vary across the site so will the nature of the derived material. In general, the weathered material is soil like near the surface, grading with depth into the rock with an increase amount of rock fragments (lithorelicts) with depth. Because the material grades with depth boundaries are often difficult to accurately define.

In boreholes WS03, WS04, WS05 and WS06 the made ground is underlain by slightly gravelly, locally very gravelly sand, to depths of between 0.55 m and 1.6 m bgl. The gravel component was recorded as sandstone. In WS05 a low cobble content of sandstone was noted. In WS01 gravel of sandstone was encountered to a depth of 0.55 m bgl.

The above granular soils in boreholes WS03, WS05 and WS06 and the made ground in boreholes WS07, WS08 and WS09, and trial pits TP1, TP2 and TP18, located in the central and southern parts of the site, was underlain by a gravelly, locally very gravelly clay, with a low cobble content in places. The gravel component was recorded as fine to coarse lithorelicts of mudstone, coal and sandstone. These clays were encountered to depths of between 0.9 m and 2.2 m bgl. The depth of gravelly clay within trial pit TP18, was not proven at the base of the pit at 2.0 m bgl.

In boreholes WS03, WS05, WS06, WS07 and WS09, the sands and clays were underlain by extremely weak thinly laminated mudstone, at depths of between 0.9 m and 2.2 m bgl; recovered as subangular fine to coarse gravel sized fragments.

Within TP2, WS01 and WS08, the sands and clays are noted to be underlain by a weak to moderately strong yellowish orange thinly laminated sandstone, at depths between 0.55 m and 1.45 m bgl; recovered as gravelly fine to coarse sand. In WS02 the made ground is directly underlain at a depth of 0.55 m bgl by sandstone recovered as gravelly sand. In WS04 an SPT refusal at 0.9 m bgl, is presumed to indicate the bedrock, as no sample at or beyond this depth was recovered.

In TP1 a very weak to weak fractured coal was encountered within the gravelly clay sequence, between 0.8 m and 1.5 m bgl. Within WS05, a 0.45m band of highly weathered extremely weak black coal was noted from 1.5 m to 1.95 m bgl, recovered as a gravelly silt. This coal was identified as the Meltonfield Coal in the mining investigation report, refer to Section 1.1 of this report. The dip is shown to be 5° to the north east, the coal will therefore underlie the northern section of the site at relatively shallow depth.

Within BH01 and BH08, drilled as part of the mining investigation of the site, bedrock was encountered at depths of 1.50m and 2.40m bgl respectively. The bedrock comprises an interbedded sequence of mudstone and sandstone with two coal seams encountered in BH01 and three seams encountered in BH08, as follows;

Borehole Number	Meltonfield Coal	Two-Foot Coal	Abdy Coal
BH01	Not Encountered	10.50-11.00m bgl	21.5-22.4m bgl
BH08	2.40-2.90m bgl	13.1-14.1m bgl	25.5-26.3m bgl

3.3 Summary of Identified Pollutant Linkages

The conceptual site model detailed within the geoenvironmental appraisal identified the following complete pollutant linkages which could result in an unacceptable risk to the proposed end-user/s and construction workers (Human Health) and the built development, on the site.

Source	Risk	Potential Contaminants	Exposure Pathway	Primary Receptor/s	Complete Pollutant Linkage
Made Ground - on site	Moderate/High	Elevated levels of Arsenic, PAH speciates; Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(a)pyrene, Dibenz(a,h)anthracene. Localised Asbestos fibres	Skin contact Ingestion	Construction workers, built development, End users of site,	Yes: Residential properties are likely to have gardens and areas of soft landscaping, clean capping of gardens and areas of soft landscaping will be required. Asbestos fibre risk to construction workers to be managed.

Made Ground - on site	High	Ground gas	Migration (lateral and vertical) Inhalation, explosion	End users of site / built development	Yes: further assessment required; monitoring ongoing (3 further visits over a six week period still to be undertaken at the time of writing of this strategy) <u>Currently a complete pollutant linkage assumed until monitoring period completed and reported.</u> Basic Radon protective measures are required for the site.
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4 REMEDIATION STRATEGY.

4.1 Summary.

The Remediation Strategy follows the principles of Land Contamination Risk Management (LCRM) - Environment Agency October 2020.

The LCRM recommends that remedial action proposed for the site should be justified. Remedial action has been justified due to the pollution linkages identified within this report. The remediation options have been developed to meet the technical objectives for the development with the major drivers behind the recommendations being:

- To achieve successful remediation within a particular timescale and budget;
- Familiarity with the methodology by the developer/ground worker;
- Confidence that the remediation can be carried out by good technical practices; and,
- Likely success of the proposed method of remediation.

It has been assumed, in the preparation of this Strategy, that the proposed end use is a residential development, with areas of private garden and that development ground levels will not change significantly from those encountered during the fieldwork. If either of these assumptions are incorrect, then amendments to the suggested options within this report may be required.

4.2 Options Appraisal

The driver for remediation of the site is the presence of made ground soils within the proposed areas of gardens/soft landscaping that contain elevated Arsenic, PAH speciates and localised occurrences of asbestos fibres within the soil matrix, considered to pose an unacceptable long-term risk to human health (end-users). Remediation of these soils within the areas of proposed soft landscaping is discussed further within this Strategy document.

The method chosen for remediation must be achievable by the groundworker, using techniques that they are familiar with. It is therefore considered that the remediation proposals should either comprise the complete removal of the contaminants source (the made ground soils), or the provision of a cover system to sever the contaminant pathways in the proposed areas of garden, where the end users may reasonably be expected to come into contact with the soils and where soil dust may be derived.

Both approaches are considered to be equally straightforward, and both would be an effective approach to reducing risk to the end users of the site to an acceptable level.

Where made ground is left beneath areas of proposed hardstand (building footprints, car parking, estate roads etc), it is considered to pose a **negligible** risk to end users, as pathways are severed due to capping by the hardstanding.

5 STRATEGY DETAIL.

5.1 General.

The main requirements of the remediation and preparatory works are given below in the approximate sequence of works. Pertinent elements of the works are discussed in greater detail in subsequent sections of this document:

- Site strip and clearance of all vegetation and any surface debris materials present on site;
- Controlled demolition of existing buildings present on site.
- Grub up all relict structures, including areas of hardstanding. Where possible and practical on site, crushing, screening and classifying to provide a secondary aggregate for re-use in the proceeding development works, if required.
- Removal and disposal from site to a suitably licenced facility, of unsuitable made ground soils identified in the previous site investigation works in areas of gardens / soft landscaping or encountered as part of the site strip or foundation construction. The contractor undertaking the preparatory works shall be responsible for this and for ensuring that all relevant regulations, permits/licences and recording keeping are met.
- Gas protection measures installed to the new proposed dwellings; see section 5.7.
- Placement of ‘clean cover soil capping layers to areas of proposed private gardens, using clean soils to achieve a minimum 600mm thick clean cover layer incorporating a minimum thickness of at least 150mm topsoil and a geotextile marker layer at the base. Where such soils are imported to site appropriate chemical testing shall be carried out and provided to the local authority, prior to import for written approval; see section 6
- Construction of clean cover soil capping layer to be validated on completion by a suitably qualified geoenvironmental engineer. Thickness of the capping layer should be validated physically on site, and a programme of laboratory testing will be implemented to confirm chemical suitability; see Section 6
- A watching brief to identify any previously unidentified sources of contamination. If any grossly contaminated soils, liquid or dumped wastes, materials suspected to contain asbestos or similar are encountered during the preparatory/development works, then advice should be sought from a suitably qualified geoenvironmental engineer; see section 5.5 and 5.6.
- A validation report will be produced by a suitably qualified geoenvironmental engineer on completion of the works. This report will serve to provide a record of the remediation works

including the results of the chemical testing to confirm the works were undertaken in accordance with the relevant legislation, this Strategy and planning conditions; see section 7.

5.2 Excavation and Disposal of Materials from Site

It is proposed that where made ground materials are present within areas of proposed gardens, these materials will require capping in order to construct a clean capping soil system, refer to Section 6 of this report. Made ground soils from these areas may require disposal from site.

The previous investigation work identified elevated concentrations of Arsenic, PAH speciates and localised occurrences of asbestos fibres, within the made ground soils.

In order to minimise the potential for dust emissions, the following measures may be employed during the remediation works;

- Excavation and stockpiling works to be undertaken in a controlled systematic manner;
- Damping down during the excavation works as required;
- Stockpiles to be sealed or covered where necessary;
- Any vehicles used for disposal of materials from site to be sheeted to prevent fugitive dust emissions.

Waste Management Strategy

Any unsuitable materials which are to be exported from site, should be despatched to a suitably licenced landfill facility, in accordance with the requirements of the Duty of Care (DoC) Regulations, April 2006 and where appropriate, the HWR, 2005 or any superseding legislation.

The Contractor is responsible for arranging laboratory analysis for waste classification and (if necessary) waste acceptance criteria (WAC) purposes and shall be submitted to the operator of the point of disposal to make a preliminary assessment

The waste disposal routes for excavated soils and other materials to landfill, recycling or treatment facilities will be determined by the Contractor and will follow relevant guidance and legislation.

The Contractor will provide all relevant documentation on completion of the work, including:

- methods used to classify the waste and the results of the classification;
- results of WAC analysis (if required);
- the place of disposal;
- waste volumes; and
- waste transfer notes and other Duty of Care information. (A transfer note shall be completed, signed and retained by all parties involved. The transfer note shall state the volume of waste, the nature of the material and statement of its chemical composition).

The above information/documentation shall be included within the verification report detailed in Section 7 of this strategy.

5.3 Material Import Protocol

All materials and imported aggregates should be sourced from a reputable supplier and require certification to determine the materials suitability for use where scheduled for placement on site prior to importation. Separate certification is required for each type of material utilised. All imported materials will need to be accompanied with chemical certification to demonstrate its suitability for use on-site.

Imported materials should be compliant with the description in Appendix 2 of the CL:AIRE DoWCoP. This refers to the direct use of clean, naturally occurring soil and mineral materials. By using only naturally occurring soil and mineral materials, waste legislation would not apply, i.e. the site will not require an Environmental Permit or Waste Exemption. The materials must be sourced from:

- Greenfield sites not subject to past contaminative use; or
- Brownfield sites where the natural soils have been extensively characterised and proven to be clean.

Evidence of suitability for use must be provided, i.e. from desk-based research for a greenfield site; or from site investigation data from a brownfield site. A Materials Management Plan will be prepared and a Declaration produced by a Qualified Person in accordance with DoWCoP.

Imported aggregate for uses such as temporary surfacing to haul road or set-up areas or piling mats etc., will need to adhere to the same site controls. Where recycled aggregates are sourced, the producer of the aggregate must show the material has been fully recovered and is no longer a waste. To do this the producer must follow the quality protocol for the production of aggregate from inert waste, as outlined by WRAP.

5.4 Health and Safety.

On the basis of the results obtained, the revised conceptual model confirms potential high risks to construction workers from Arsenic, PAH speciates and localised occurrences of asbestos fibres in the made ground soils. However, risks can be readily adequately mitigated by appropriate PPE and hygiene precautions and good working and soil management practices.

Contamination may pose a short-term (acute) or long-term (chronic) risk to workers during construction and maintenance. The potential risks must be specifically assessed as part of the health and safety evaluation for the works to be performed in accordance with prevailing legislation.

During the site development it will be necessary to protect health and safety of site personnel. General guidance on these matters is given in the Health and Safety Executive (HSE) document 'Protection of Workers and the General Public during the Redevelopment of Contaminated Land' (HS(G)66). In summary the following measures are suggested to provide a minimum level of protection.

- All ground workers should be issued with protective clothing, hard hats, footwear and gloves;
- All personnel shall wear hard hats, high visibility clothing and protective footwear at all times;
- Hand washing facilities shall be provided;
- No smoking except in designated areas; and,
- Good practices relating to personal hygiene shall be adopted.

Where appropriate work shall be carried out in accordance with the requirements of the Control of Asbestos Regulations 2012.

Specific Risk Assessments and Method Statements may need to be prepared by the contractor responsible for the development works, to take into account potential issues detailed above.

This Strategy document should be forwarded to any organisation undertaking groundworks in order for them to assess the risk to their own personnel.

5.5 Unforeseen Contamination Protocol

There is a possibility that contamination or structures are encountered that were not identified by past intrusive investigation.

Should areas of significant previously unidentified contamination be encountered during the development works, then works should stop immediately and advice sought from a suitably qualified geoenvironmental engineer. Site staff will be made aware of the history of the site and will be expected to report suspected contamination based on;

- Unusual appearance such as colour
- Unusual texture such as fibrous or glassy
- Presence of liquids or sludges
- Aromatic, stringent or pungent odour
- Eye or throat irritation

Dependent on the advice of the geoenvironmental engineer, the suspected contamination will be dealt with using existing procedures or details may be submitted to the local authority and a remediation procedure agreed.

5.6 Watching Brief

Whilst no historical mining is recorded in the immediate vicinity of the site, a coal seam outcrops through the centre of the site, therefore there is a potential for crop workings in the vicinity. It is therefore recommended that a watching brief should be maintained on excavations and if deep or disturbed made ground is encountered then the advice from a suitably qualified consultant should be sought prior to continuing with further work. Further information on mining is given in the mining investigation report, referenced in Section 3.1 of this report.

5.7 Gas Protection Measures.

The previous investigation work determined that gas protection measures were required to the new properties, commensurate with the NHBC Amber 1 (CS2) categorisation. At the time of writing of this strategy document, gas monitoring has only been undertaken on three occasions to date, therefore the following comments are only a preliminary assessment. A full assessment will be made once monitoring is complete and an addendum report will be issued.

According to the desk study, refer to Section 3.1 of this strategy, basic radon protection measures are required for the protection of the proposed buildings at this location.

Gas protection measures should be installed to the development in accordance with BS8485:2015+A1:2019. Based on a Type A development (Table 3 of the standard) and an Amber 1 (CS2), a gas protection score (GPS) of 3.5 will need to be achieved (Table 4 of the standard).

BS8485 lists various measures for gas protection, each is given a value, by which a cumulative score can be obtained. The protection measures are provided by:

- Structural barrier (GPS between 0 and 2.5)
- Ventilation (GPS between 0.5 and 2.5)
- Membrane (GPS 2)

A minimum of two of the measures should be used to achieve the score.

The various options are detailed in Tables 5, 6 and 7 of BS8485 and expanded on in various Annexes to the standard.

Based on the above criteria, proposed protection measures which would achieve the gas protection score are shown as follows;

Gas Protection Element	BS8485 Table	Score
Beam and Block sub-floor	5	0
Vented sub-void	6	1.5
Gas resistant membrane	7	2
		3.5

The choice of the proposed protection measures however, remains with Andrew Bailey Architects.

Validation of the membranes shall be in accordance with the following best practice guidance;

- Verification Requirements for Gas Protection Systems – Version 1.1, December 2016. (Yorkshire and Lincolnshire Pollution Advisory Group),

For completeness, a copy of this guidance is presented in Appendix C of this strategy.

The installation of the membranes should be validated by a suitable qualified and experienced person, and the records submitted as part of the information pack detailed in section 7 of this report.

6 COVER MATERIALS.

6.1 General.

Due to the presence of contamination in the made ground and because of its unsuitability as a growing medium, the following is recommended within any areas of proposed soft landscaping in private garden areas. presence of Arsenic, PAH speciates and localised asbestos fibres within the existing shallow made ground materials, it is proposed to incorporate a suitable thickness of clean capping soils.

The design of the capping layer is subject to regulatory consultation.

Where made ground is left beneath the area of the footprint of the dwelling and other areas of proposed hardstand (buildings, driveways, paths, car parking estate roads etc), it is considered to pose a **negligible** risk to end users, as pathways are severed due to capping by the hardstanding.

Where soft landscaping is proposed in these areas, the clean capping soils should be increased, as detailed below;

Table- 1 Clean Cover Layer Thickness.

	No-Dig Layer (mm)	Subsoil (mm)	Topsoil (mm)	Total (mm)
Soft landscaped/ garden areas	50	450	150	650

The clean capping thickness shall conform to the requirements of BRE 465:2004 'Cover Systems for Land Regeneration'

The 'no-dig' layer should comprise a naturally derived granular product, which acts as a visual marker and minimises the risk of cross contamination of the overlying clean soils with the underlying made ground, where left in-situ. Alternatively, a geotextile (Terram 1000 or equivalent) may be used instead of the granular product.

Should all the made ground be removed from the areas of soft landscaping then, providing that no visual or olfactory evidence of suspected contamination is noted, within the underlying natural subsoils, no specific depth of cover would be required, beyond that needed to provide a suitable thickness of growing medium. Therefore, following removal of any made ground materials, further samples shall be taken on a 5 m grid across the area of the resultant natural in-situ surfaces, prior to placement of the overlying subsoil and topsoil. Samples should be tested for the determinands and assessed against the Generic Assessment Criteria (GAC) detailed in Table 2 presented in Section 6.4 of this Strategy, see below. Should failures occur then further soil shall be removed from the area of the sample failure and additional samples taken. Should further failures occur then the clean capping soils in these areas should be increased to 600 mm, in line with the requirements of Table 1, above.

If any imported materials are to be stockpiled on site prior to use then these stockpiles should be located on 'clean' surfaces and placed on a geotextile separator to minimize the risk of any cross contamination. Any stockpiles should be sealed, by 'blading', to reduce water ingress and softening. It is recommended, however, to avoid any cross contamination that the import of any soils onto site should be left until the final stages of landscaping works and placed as soon as reasonably practicable.

6.2 Topsoil.

Shall be placed by the contractor responsible for the development works. It shall be ensured that topsoil is of an appropriate quality, naturally derived, and that concentrations of contaminants do not exceed the maximum concentrations stipulated in Table 2 presented in Section 6.4 of this Strategy, see below.

Any imported topsoil shall conform to the requirements of BS3882:2015.

6.3 Subsoil.

Subsoil materials for the use in the 'clean' cover layer shall be a naturally derived product and shall be clean and free of foreign debris, building waste materials, timber or other deleterious matter.

Materials to be imported to site shall be sampled at source and the test results made available to the local authority prior to any material being delivered to site.

It shall be ensured that the subsoil is of an appropriate quality and that concentrations of contaminants do not exceed the maximum concentrations stipulated in Table 2 presented in Section 6.4 of this Strategy, see below.

6.4 Chemical Suitability.

All materials for use in the 'clean' cover layer shall be analysed at a UKAS and MCERTS accredited laboratory for testing in accordance with the following schedule:

For this site, measured values shall be compared to the GACs derived for a residential with plant uptake end use. The threshold guideline values are given in the table below;

Table 2. Clean Capping - Guidance Values.

Determinand	GAC (1% SOM) (mg/kg, unless otherwise stated)
Arsenic	37 ⁽²⁾
Cadmium	11 ⁽¹⁾
Chromium (Hexavalent)	21 ⁽²⁾
Lead	200 ⁽²⁾
Mercury	40 ⁽¹⁾
Selenium	250 ⁽¹⁾
Copper	2400 ⁽¹⁾
Nickel	180 ⁽¹⁾
Zinc	3700 ⁽¹⁾
pH	<5
Water Soluble Sulphate	0.5 g/l ⁽⁴⁾
PAH	
Acenaphthene	210 ⁽¹⁾
Anthracene	2400 ⁽¹⁾
Acenaphthylene	170 ⁽¹⁾
Benzo(a)anthracene	7.2 ⁽¹⁾
Benzo(b)fluoranthene	2.6 ⁽¹⁾
Benzo(k)fluoranthene	77 ⁽¹⁾
Benzo(g,h,i)perylene	320 ⁽¹⁾
Benzo(a)pyrene	5.0 ⁽²⁾
Chrysene	15 ⁽¹⁾
Dibenz(a,h)anthracene	0.24 ⁽¹⁾
Fluoranthene	280 ⁽¹⁾
Fluorene	170 ⁽¹⁾
Indeno(1,2,3-cd)pyrene	27 ⁽¹⁾
Naphthalene	2.3 ⁽¹⁾
Pyrene	620 ⁽¹⁾
Phenanthrene	95 ⁽¹⁾
TPH	
Aliphatic EC 5-6	42 ⁽¹⁾
Aliphatic EC >6-8	100 ⁽¹⁾
Aliphatic EC >8-10	27 ⁽¹⁾
Aliphatic EC >10-12	130 ⁽¹⁾
Aliphatic EC >12-16	1100 ⁽¹⁾
Aliphatic EC >16-35	65,000 ⁽¹⁾
Aromatic EC 5-7	70 ⁽¹⁾
Aromatic EC >7-8	130 ⁽¹⁾
Aromatic EC >8-10	34 ⁽¹⁾
Aromatic EC >10-12	74 ⁽¹⁾

Determinand	GAC (1% SOM) (mg/kg, unless otherwise stated)
Aromatic EC >12-16	140 ⁽¹⁾
Aromatic EC >16-21	260 ⁽¹⁾
Aromatic EC >21-35	1100 ⁽²⁾
Other	
Monohydric Phenol	120 ⁽¹⁾
Asbestos	Fibres Present

¹ LQM/CIEH (2015) S4UL's for Human Health Risk Assessment. 2nd Ed. (for a sandy soil with 1% SOM and pH 7.0)

² DEFRA C4SL's, DEFRA 2015

³ BRE (2005) Special Digest 1, 3rd Edition, Concrete in aggressive ground. Upper limits for DS-1 Design Sulphate Class concrete.

6.5 Placement.

The contractor undertaking the development works shall be responsible for the placement of the clean cover materials.

The thickness and quality of the capping layer shall be validated in accordance with the following best practice guidance;

- Validation Requirements for Cover Systems – Version 3.4, November 2017. (Yorkshire and Lincolnshire Pollution Advisory Group)

For completeness, a copy of this guidance is presented in Appendix D of this strategy.

Following placement of the clean cover layer, care will be taken to prevent cross contamination of the capping layer with underlying materials.

7 POST RECLAMATION REQUIREMENTS.

Following the development works a validation report shall be prepared and submitted to the local authority for approval.

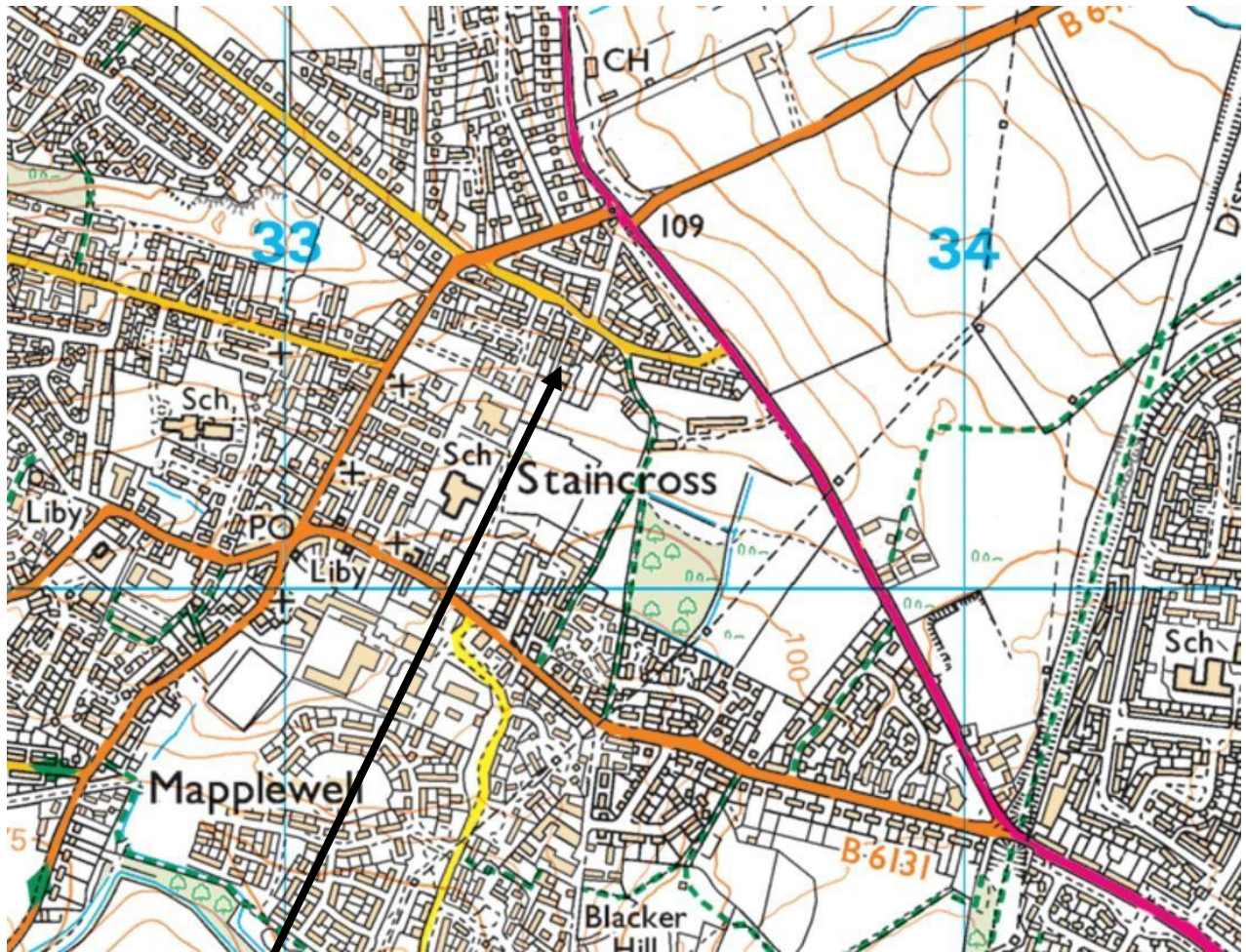
The validation report shall include the following:

- Description of the works undertaken.
- Validation of the gas protection measures.
- Waste Transfer Notes, including any made ground materials disposed of from site.
- Clean capping chemical validation report, where clean cap soils are placed to areas of gardens and soft landscaping.
- Chemical validation test results.
- Statement that the works have been carried out in accordance with the agreed Strategy.



APPENDIX A

DRAWINGS



The Site

Site Location Plan Drawing No C398/RS/1

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PROPOSED RESIDENTIAL DEVELOPMENT

28 PADDOCK ROAD

STAINCROSS

LOCATION PLAN

1:1250@A4

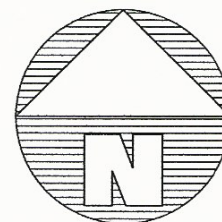


Linwood

Barnsley Road

Dodworth

Barnsley S75 3JR





APPENDIX B

PREVIOUS INVESTIGATION REPORT

Report No: C398/1
Date: April 2021

**GEOENVIRONMENTAL APPRAISAL
for land off
28 PADDOCK ROAD, STAINCROSS, BARNSELEY,
SOUTH YORKSHIRE**



Prepared for
Andrew Bailey Architects

Prepared by
G&M Consulting Ltd, The Chestnuts, Brackenhill Road, Haxey, Doncaster DN9 2LR





REPORT NUMBER:	C398/1	REPORT STATUS:	Final
REPORT TYPE:	Geoenvironmental Appraisal		
REPORT DATE:	April 2021		
SITE:	Land off 28 Paddock Road, Staincross, Barnsley		
PREPARED FOR:	Andrew Bailey Architects		
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GEOENVIRONMENTAL APPRAISAL
of land off
28 PADDOCK ROAD, STAINCROSS, BARNSELEY, YORKSHIRE

1.0 INTRODUCTION.

G&M Consulting Ltd (G&M) was commissioned by Andrew Bailey Architects, to undertake a geoenvironmental appraisal of land to the rear of and occupied by 28 Paddock Road, Staincross, Barnsley, Yorkshire. It is understood that outline planning approval (2017/1387) has been granted by Barnsley Metropolitan Borough Council for the demolition of the existing dwelling and outbuildings and erection of up to 6 dwellings. This report has been prepared in support of the discharge of Condition No 6 of the above approval.

The location of the site is shown on Drawing No C398/1/1, presented in Appendix A of this report.

1.1 Project Brief.

A number of phases of investigation, including intrusive work, have already been carried out on the site by G&M, which are covered in the following reports;

- Preliminary Investigation of land at 28 Paddock Road, Staincross, Barnsley. Report Ref C398, dated February 2021.
- Soakaway Tests on land off 28 Paddock Road, Staincross, Barnsley. Report Ref C398/02/ATS, dated 15th November 2020.
- Land off Paddock Road, Staincross, Barnsley, South Yorkshire, Mining Investigation Report. Report Ref C398, dated March 2021.

These reports cover a larger area which extends to the south of the site.

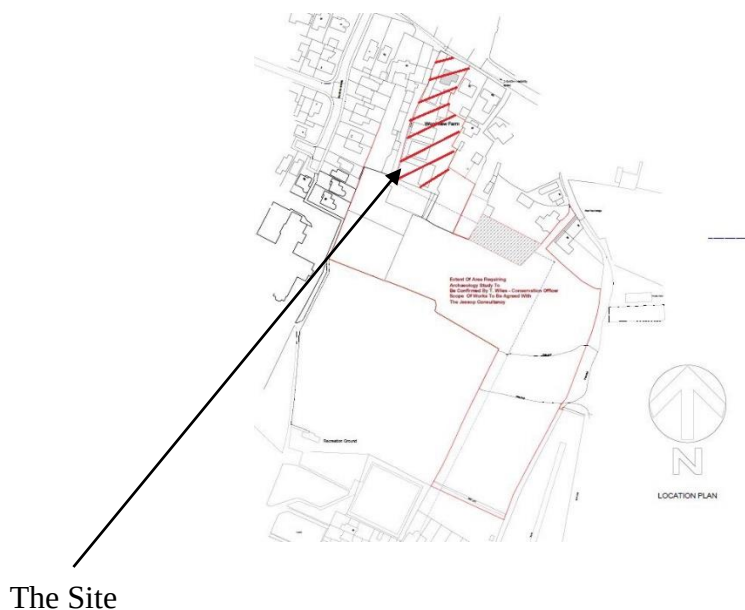
Based on the results of the above reports, it was proposed by G&M to undertake a Phase 2 geoenvironmental intrusive site investigation of the area of development.

This report details the results of the intrusive investigation and makes recommendations with regards to the proposed development. This report should be read in conjunction with the preliminary investigation report, referenced above, which contains a description of the site, environmental setting and initial conceptual site model (CSM) from which the investigation rationale was derived.

Fieldwork was undertaken on the 15th of February and 11th March 2021 and comprised the mechanical excavation of three trial pits and drilling of nine window sample boreholes with the installation of six combined gas and groundwater monitoring wells. Following completion of the fieldwork selected soil samples were scheduled for a range of chemical and geotechnical laboratory tests. At the time of writing of this report, ground gas monitoring of the wells is currently underway.

Currently the site is a roughly rectangular plot of land covering an area of approximately 0.55 hectares. The site as a whole fronts, to the north, on to Paddock Road where it is only a narrow plot of land approximately 20 m wide and running south for approximately 90m widening out after 35 m to a width of about 30 m. The area of the site discussed in this report is currently occupied (at the time of writing of this report) by a residential building with associated outbuildings along the boundary of the site with Paddock Road (from which the site is accessed) the site then broadens out, becoming a set of three terraced levels with a slight slope towards the south of the site. This area is currently the site of small construction stockpiles and laydown areas. The site is bounded to the east and west by residential properties with associated gardens and to the south by open fields.

The area of investigation of this report (area of red hatching), is shown below;



1.2 Limitations.

This investigation report, which is designed to meet the requirements of all relevant current guidance, presents the factual information and interpretation of the data obtained during this appraisal and recommendations relevant to the defined objectives.

The comments and opinions presented in this report are based on the findings of a review of available information and ground conditions encountered during the intrusive investigation work. There may be other conditions prevailing on the site which have not been disclosed by this investigation and which have not been taken into account by this report. Responsibility cannot be accepted for conditions not revealed by the investigation. Any diagram or opinion of the possible configuration of ground conditions between exploratory holes is conjectural and given for guidance only and confirmation of intermediate ground conditions should be considered if deemed necessary.

During the course of the works G&M did not notice the presence of any Japanese Knotweed, or other such invasive plant species. However, it should be noted that G&M are not qualified ecologists and as such cannot guarantee the absence of knotweed or other invasive vegetation. If necessary the possible presence of such vegetation should be confirmed by a qualified ecologist if necessary.

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2.0 GROUND INVESTIGATION.

2.1 Design and Strategy

The Phase 1 desk study prepared previously, referenced above, and which covers a larger area, was used as the basis for the design of an appropriate intrusive ground investigation. The main findings of the desk study as given in the summary to the report were as follows:

1. *Historical maps relating to the site indicate that the northern portion of the land has been occupied since 1850s by a collection of buildings. The building layout and number expanded throughout the sequence of maps. The buildings are inferred to be predominantly agricultural structures, with a residential house being constructed on the northernmost tip of the site facing on to Paddock Road sometime during the mid 20th century. The site was labelled 'Woodview Farm' on a number of map issues.*
2. *Examination of historical maps has revealed the presence of coal mining activity within close proximity to the site. 'North Gawber Colliery' was situated to the south of the site and maps depict significant earthworks on land surrounding the colliery, inferred to be accumulations of mine tailings. Mining activities may have given rise to some localised contamination, including the potential for ground gases to emanate from underlying strata.*

The aim and purpose of the ground investigation was to verify the nature and depth of made ground and shallow subsoils across the site, determine the ground gas regime, to allow informed decisions on potential remediation options that might be required in order to break the direct contact exposure pathways that were identified at the Phase 1 stage.

Exploratory Hole Type	Purpose
Window Sample Boreholes and Machine Excavated Trial Pits	To determine the general nature of shallow soils underlying the site, including the; ◦ Nature, distribution and thickness of any potential made ground. ◦ Nature, degree and extent of ground contamination. ◦ Determination of the presence of shallow underlying natural ground ◦ Install combined gas and groundwater monitoring installations. ◦ To help identify and inform suitable remedial options

The scope of the intrusive investigation is detailed in the next section.

2.2 Scope of Works.

Fieldwork was undertaken on the 4th November 2020, 5th January 2021, 15th February and 11th March 2021, and comprised;

- Drilling of nine window sample boreholes, referenced WS1 to WS9 inclusive, to depths of between 0.90 m to 2.95 m below ground level (bgl), with the installation of six combined gas and groundwater monitoring installations.
- Excavation of three trial pits, referenced TP1, TP02 and TP18, to depths of between 1.50 m and 2.00 m bgl, excavated as part of a separate report investigating historic mining and drainage design on the site.
- Drilling of two rotary open holes, referenced BH1 and BH8, to depths of 7.6 m and 30.0 m bgl respectively, constructed as part of the separate report investigating historic mining.

The investigation was scoped using guidance presented in BS 10175:2011+A2:2017, CIRIA C665:2007, the principals of Land Contamination Risk Management (LCRM) - Environment Agency October 2020 and BS EN 1997:2004 and 2007.

The exploratory hole positions were set out and the fieldwork supervised by a G&M engineering geologist. The locations of the holes are shown on Drawing No C398/1/2, presented in Appendix A of this report.

The window sampling was carried out using a Dando Terrier tracked drilling rig. This uses a drop weight to drive steel sampling tubes with a plastic liner. The diameter of the hole reduces with depth to reduce friction on driving the sampling tubes.

The mechanically excavated trial pits were undertaken using a 3 tonne tracked excavator. The pits were backfilled with arisings, compacted using the bucket, in the approximate order in which they were excavated.

The combined gas and groundwater monitoring installations comprised 50 mm diameter HDPE pipe, consisting of a lower slotted section of casing surrounded by single size non-calcareous gravel. The upper section of the well was constructed from plain casing sealed with a bentonite/cement seal. A flush metal lockable security cover was concreted into place to complete the well installation at the ground surface.

Details of the installations are shown below;

Exploratory Hole No	Drilled Depth (m bgl)	Depth of Monitoring Well (m bgl)
WS1	1.45	1.20
WS3	2.95	1.75
WS6	2.45	1.90
WS7	2.45	2.00
WS8	1.45	1.00
WS9	2.25	2.00

A full set of photographs taken of the trial pits dug during the fieldwork is presented in Appendix E of this report.

2.3 Strata Description.

Depths and descriptions of strata encountered together with details of the samples recovered are presented on the exploratory hole record sheets presented in Appendix B of this report. Procedures and principles contained in BS EN ISO 14688-1 (2002), as amplified by BS 5930 (2015) were followed.

The depths of strata on the record sheets are recorded from current ground levels at each location.

2.4 Sampling

Small disturbed samples of soil were taken for geotechnical testing and placed in plastic tubs.

Undisturbed samples, 70 mm in diameter, (U70) were also taken where ground conditions allowed.

Small disturbed samples of soil for chemical analysis, were also taken and placed in amber glass jars as appropriate. Between boreholes, equipment was thoroughly cleaned and dried.

In accordance with best practice (BS10175:2011) samples for chemical analysis were collected in appropriate containers, kept in a chilled cool box whilst on site, retained in a fridge (below 2°C) until the day of collection, packed in a chilled cool box on the day of collection and transported in this to the laboratory.

2.5 In-Situ Testing

Standard penetration tests (SPT) were carried out in the boreholes in accordance with BS EN ISO 22476-3:(2005+A1:2011).

The undrained strength of soils were measured in-situ, where possible, using a hand shear vane.

The test results are presented on the exploratory hole records presented in Appendix B of this report.

2.6 Laboratory Testing

Schedules for contamination and geotechnical testing were drawn up by G&M.

Selected soil samples were tested for a range of potential contaminants, under a sub-contract with i2 Analytical Ltd (i2), a UKAS/MCERTS accredited laboratory. The analytes tested are listed in Section 4.2 of this report. The results of soil analysis, as received from the laboratory, are presented in Appendix C of this report.

Selected soil samples for geotechnical testing were delivered to Professional Soils Laboratory (PSL) an external accredited geotechnical laboratory. The results of soil analysis, as received from the laboratory, are presented in Appendix C of this report.

The summary of geotechnical tests is presented below;

SUMMARY OF GEOTECHNICAL LABORATORY TESTING			
Number of tests	Test	Test Method	Notes
Classification Tests			
7	Moisture content	BS1377: Part 2.	Including results provided as part of Atterberg and Triaxial testing
4	Liquid and plastic (Atterberg) limits.	BS1377: Part 2.	-
3	Undrained triaxial compression tests.	BS1377: Part 7.	-
Chemical Tests: Soil			
7	Water soluble sulphate and pH value.		Undertaken as part of the contamination testing

3.0 GROUND CONDITIONS AND MATERIAL PROPERTIES

A complete record of all the strata encountered is given on the attached exploratory hole logs. In general, these show made ground over what is presumed to be weathered coal measures strata, underlain by bedrock

3.1 Topsoil/Made Ground

Topsoil comprising soft dark brown slightly gravelly very sandy clay was noted in WS01, WS02 and WS03 close to the residence along Paddock Road, at depths varying between 0.1 m and 0.45 m bgl. The topsoil is underlain by made ground and should therefore also be considered as made ground.

Made ground was proved to depths of between 0.10 m and 0.90 m bgl in both window sample holes and trial pits. The deepest made ground found within the central part of the site in WS03 (0.9m) and TP18 (0.9m).

In general, the made ground comprised a dark brown slightly gravelly locally gravelly very sandy clay. The gravel component comprised concrete, brick, sandstone and mudstone.

In boreholes WS02 and WS07 the made ground comprises a dark brown/black slightly clayey, locally very sandy gravel of concrete, brick and sandstone to depths of between 0.55 m and 0.6 m bgl. In borehole WS03 the made ground proved to a depth of 0.9 m bgl is yellowish brown slightly clayey sandy gravelly cobbles of sandstone. The gravel content is noted to be sandstone and coal.

3.2 Weathered Coal Measures

Material derived in-situ by weathering of coal measure strata will reflect the nature of the underlying bedrock from which it is derived. As the rock types vary across the site so will the nature of the derived material. In general, the weathered material is soil like near the surface, grading with depth into the rock with an increase amount of rock fragments (lithorelicts) with depth. Because the material grades with depth boundaries are often difficult to accurately define.

In boreholes WS03, WS04, WS05 and WS06 the made ground is underlain by slightly gravelly, locally very gravelly sand, to depths of between 0.55 m and 1.6 m bgl. The gravel component was recorded as sandstone. In WS05 a low cobble content of sandstone was noted. In WS01 gravel of sandstone was encountered to a depth of 0.55 m bgl.

The above granular soils in boreholes WS03, WS05 and WS06 and the made ground in boreholes WS07, WS08 and WS09, and trial pits TP1, TP2 and TP18, located in the central and southern parts of the site, was underlain by a gravelly, locally very gravelly clay, with a low cobble content in places. The gravel component was recorded as fine to coarse lithorelicts of mudstone, coal and sandstone. These clays were encountered to depths of between 0.9 m and 2.2 m bgl. The depth of gravelly clay within trial pit TP18, was not proven at the base of the pit at 2.0 m bgl.

3.3 Bedrock

In boreholes WS03, WS05, WS06, WS07 and WS09, the sands and clays were underlain by extremely weak thinly laminated mudstone, at depths of between 0.9 m and 2.2 m bgl; recovered as subangular fine to coarse gravel sized fragments.

Within TP2, WS01 and WS08, the sands and clays are noted to be underlain by a weak to moderately strong yellowish orange thinly laminated sandstone, at depths between 0.55 m and 1.45 m bgl; recovered as gravelly fine to coarse sand. In WS02 the made ground is directly underlain at a depth of 0.55 m bgl by sandstone recovered as gravelly sand. In WS04 an SPT refusal at 0.9 m bgl, is presumed to indicate the bedrock, as no sample at or beyond this depth was recovered.

In TP1 a very weak to weak fractured coal was encountered within the gravelly clay sequence, between 0.8 m and 1.5 m bgl. Within WS05, a 0.45m band of highly weathered extremely weak black coal was noted from 1.5 m to 1.95 m bgl, recovered as a gravelly silt. This coal was identified as the Meltonfield Coal in the mining investigation report, refer to Section 1.1 of this report. The dip is shown to be 5° to the north east, the coal will therefore underlie the northern section of the site at relatively shallow depth.

Within BH01 and BH08, drilled as part of the mining investigation of the site, bedrock was encountered at depths of 1.50m and 2.40m bgl respectively. The bedrock comprises an interbedded sequence of mudstone and sandstone with two coal seams encountered in BH01 and three seams encountered in BH08, as follows;

Borehole Number	Meltonfield Coal	Two-Foot Coal	Abdy Coal
BH01	Not Encountered	10.50-11.00m bgl	21.5-22.4m bgl
BH08	2.40-2.90m bgl	13.1-14.1m bgl	25.5-26.3m bgl

3.4 Geotechnical Properties

Geotechnical laboratory testing was only undertaken on the gravelly clays described above.

The results of the Atterberg limit tests show the clay at shallow depth to be of high to very high plasticity. The results of the tests are summarised below:

Liquid limit	53% to 82%
Plastic Limit	26% to 34%
Plasticity Index	27% to 48%
Natural Moisture Content	23% to 44%

A modified Plasticity Index is calculated in the range 25% to 45% based on the percentage of material passing the 0.425mm sieve. The modified plasticity index indicates the clay to be of medium to high volume change potential as defined in Chapter 4 of the NHBC Standards, Chapter 4.2 “Building Near Trees”. The sample indicating the high-volume change potential was taken from WS06 and may relate to weathered material derived from a seat earth. Seat earths are materials which develop below coal seams, such as that encountered in TP1 and WS05 and are often termed fireclay because they have certain refractory properties, different from other rocks in the coal measure sequence. The samples with the medium volume change potential are from WS07 and WS08, which because of the dip, will be derived from different bedrock material.

Three quick undrained triaxial test were carried out on undisturbed samples of clay recovered from the window sample holes at depths of between 1.00 m and 2.50 m bgl. The tests returned results for the undrained shear strength (Cu) of between 51 kPa and 85 kPa, indicating medium and to high strength clay.

Hand shear vanes carried out in the cohesive subsoils in trial pits and window samples at depths of between 0.70 m and 1.40 m returned average results for Cu of between 50 kPa and 74 kPa indicating medium strength clay.

A single SPT carried out in the granular soil encountered between 0.9 m and 1.6 m bgl in WS03 recorded an N value of 10, indicating a medium dense material.

SPTs were carried out at the base of all window samples, which all met refusal i.e. 50 blows were reached prior to a penetration of 300mm being achieved. The results are given on the relevant window sample log and suggest that bedrock had been encountered based on the lack of penetration achieved.

3.4 Groundwater

No ground water was encountered during site works, however, monitoring visits carried since completion of site works have recorded ground water in the monitoring wells installed by G&M. The table below

summaries the standing groundwater levels recorded. Currently three monitoring visits have been made to site, post fieldwork.

Exploratory Hole No	Drilled Depth (m bgl)	Depth of Monitoring Well (m bgl)	Groundwater Level (m bgl) Visit 1 – 18/03/21	Groundwater Level (m bgl) Visit 2 – 24/03/21	Groundwater Level (m bgl) Visit 3 –09/04/21
WS01	1.45	1.20	Dry	Dry	Dry
WS03	2.95	1.75	0.56	0.61	0.91
WS06	2.45	1.90	1.54	1.43	1.33
WS07	2.45	2.00	1.39	1.44	1.54
WS08	1.45	1.00	0.22	0.35	0.77
WS09	2.25	2.00	1.50	1.50	1.48

It should be borne in mind that water levels are likely to fluctuate with season/rainfall and may therefore be substantially higher at wetter times of year than those found during this investigation.

3.5 Visual / Olfactory Evidence of Contamination

The made ground was found to include varying proportions of brick, coal, concrete, mudstone and sandstone which can produce elevated concentrations of certain contaminants, such as toxic and phytotoxic metals, sulphate and PAH.

3.6 Ground Gas and Vapours

Ground gas monitoring has been carried out on three occasion to date, and the results are summarised below. Full details of the ground gas monitoring are included in Appendix D of this report

Well	Methane (range) % v/v	Carbon Dioxide (range) % v/v*	Oxygen (range) % v/v*	VOC (ppm)	Flow (range) l/hr*
BH01	ND	1.0-1.3	18.9-19.8	0.2	0
BH03	ND	0.1	20.3-20.7	0.1	0
BH06	ND	3.2-8.4	12.1-19.8	0.0	0
BH07	ND	0.7-5.1	16.1-20.1	0.1	0
BH08	ND	0.2-2.1	20.521.6	0	0
BH09	ND	0.2-1.3	20.1-20.9	0	0

ND - Not Detected. NR - * peak reading

Barometric air pressure for the visits was between 996 mb and 1014 mb.

The scheduled programme of monitoring comprises six visits over a three month period. It is proposed to undertake three further monitoring visits, as far as possible/practicable, to coincide with worst case weather/environmental conditions identified in CIRIA C665. On completion of the monitoring, a full set of results will be issued in an addendum report.

4.0 RESULTS OF CHEMICAL TESTING

4.1 General

For this site, measured values were compared to Generic Assessment Criteria (GAC) derived for a residential with plant up take end use.

Chemical analysis was undertaken on representative soil samples recovered from across the site. The determinands were selected to provide information on the distribution of potential contaminants. The general analytical suite was supplemented with additional analysis where former land usage, as determined from the desk study, or visual or olfactory observations suggested the presence of additional contaminants.

The majority of initial screening levels (GAC's) used in the production of this assessment have been taken from the guidelines introduced by:

- DEFRA C4SL's, DEFRA 2015.
- Joint Land Quality Management Ltd (LQM) and Chartered Institute of Environmental Health (CIEH), Generic Assessment Criteria for Human Health Risk Assessment, S4UL's, Land Quality Press 2015.

Usually statistical testing is undertaken for the Planning Scenario by the methods described in CL:AIRE "Professional Guidance: Comparing Soil Contamination Data with a Critical Concentration", September 2020. This statistical testing is undertaken to determine whether there was sufficient evidence that the true mean concentration of each determinand was less than the relevant critical concentration for that component. However, given the fact that a proportion of the sampling was carried out on a targeted basis, detailed statistical assessment of the data has not been conducted, instead individual contaminant concentrations have been compared to their relevant assessment criteria.

4.2 Testing Schedule

Following completion of the fieldwork samples were selected for testing as follows;

Laboratory Analysis	Made Ground	Natural Soils
Total concentrations of arsenic, cadmium, chromium (incl hexavalent), copper, lead, nickel, selenium, zinc, mercury	12	3
Water soluble sulphate, pH	3	4
Phenol	11	1
Speciated PAH	11	2
TPH	3	-
BTEX	3	-
GCMS Pesticide Screen	2	-
SVOC's	1	-
Asbestos	4	-

4.3 Soil Analysis

The chemical analysis results and screening criteria are summarised below. The results for the made ground and natural soils have been combined for an initial assessment.

Summary of Total Soil Concentrations

Determinand	GAC (1% SOM) (mg/kg, unless otherwise stated)	No. of samples above screening value	No. of samples tested	Maximum concentration above GAC (mg/kg, unless otherwise stated)
Metals/Metalloids				
Arsenic	37 ⁽²⁾	2	15	WS04 (0.20m – 330) WS05 (0.10m – 330)
Cadmium	11 ⁽¹⁾	0	15	
Chromium (VI)	21 ⁽²⁾	0	15	
Lead	200 ⁽²⁾	0	15	
Mercury	40 ⁽¹⁾	0	15	
Selenium	250 ⁽¹⁾	0	15	
Copper	2400 ⁽¹⁾	0	15	
Nickel	180 ⁽¹⁾	0	15	
Zinc	3700 ⁽¹⁾	0	15	
Inorganics				
pH	<5	0	7	
Water Soluble Sulphate	0.5 g/l ⁽³⁾	0	7	
Organics				
PAHs				
Acenaphthene	210 ⁽¹⁾	0	13	
Anthracene	2400 ⁽¹⁾	0	13	
Acenaphthylene	170 ⁽¹⁾	0	13	
Benzo(a)anthracene	7.2 ⁽¹⁾	4	13	WS05 (0.10m – 11) WS09 (0.10m – 17) TP18 (0.20m – 7.7) TP18 (0.80m – 12)
Benzo(b)fluoranthene	2.6 ⁽¹⁾	7	13	WS05 (0.10m – 7.4) WS07 (0.20m – 3.9) WS07 (0.50m – 6.8) WS08 (0.20m – 5.5) WS09 (0.10m – 16) TP18 (0.20m – 6.7) TP18 (0.80m – 12)
Benzo(k)fluoranthene	77 ⁽¹⁾	0	13	
Benzo(g,h,i)perylene	320 ⁽¹⁾	0	13	
Benzo(a)pyrene	5.0 ⁽²⁾	6	13	WS05 (0.10m – 8.4) WS07 (0.50m – 6.6) WS08 (0.20m – 5) WS9 (0.10m – 15) TP18 (0.20m – 6) TP18 (0.80m – 11)
Chrysene	15 ⁽¹⁾	0	13	
Dibenz(a,h)anthracene	0.24 ⁽¹⁾	4	13	WS08 (0.20m – 0.71) WS09 (0.10m – 1.9) TP18 (0.20m – 0.95) TP18 (0.80m – 14)
Fluoranthene	280 ⁽¹⁾	0	13	
Fluorene	170 ⁽¹⁾	0	13	
Indeno(1,2,3-cd)pyrene	27 ⁽¹⁾	0	13	
Naphthalene	2.3 ⁽¹⁾	0	13	
Pyrene	620 ⁽¹⁾	0	13	
Phenanthrene	95 ⁽¹⁾	0	13	
TPHs				
Aliphatic EC 5-6	3,200(1)	0	3	
Aliphatic EC >6-8	7,800(1)	0	3	
Aliphatic EC >8-10	2,000(1)	0	3	

Aliphatic EC >10-12	9,700(1)	0	3	
Aliphatic EC >12-16	59,000(1)	0	3	
Aliphatic EC >16-35	160,000(1)	0	3	
Aromatic EC 5-7	26,000(1)	0	3	
Aromatic EC >7-8	56,000(1)	0	3	
Aromatic EC >8-10	3,5000(1)	0	3	
Aromatic EC >10-12	160,000(1)	0	3	
Aromatic EC >12-16	360,000(1)	0	3	
Aromatic EC >16-21	280,000(1)	0	3	
Aromatic EC >21-35	280,000(1)	0	3	
Benzene	27(1)	0	3	
Toluene	5,600(1)	0	3	
Ethylbenzene	570(1)	0	3	
M xylene	62,000(1)	0	3	
O xylene	6,600(1)	0	3	
P xylene	59,000(1)	0	3	
Others				
Monohydric Phenol	120 ⁽¹⁾	0	12	
Asbestos	Fibres present	1	4	WS05 (0.10m – Chrysotile – Loose Fibres)

¹ LQM/CIEH (2015) Generic Assessment Criteria for Human Health Risk Assessment. 2nd Ed. (for a sandy soil with 1% SOM and pH 7.0)

² DEFRA C4SL's, DEFRA 2015

³ BRE (2005) Special Digest 1, 3rd Edition, Concrete in aggressive ground. Upper limits for DS-1 Design Sulphate Class concrete.

Arsenic was found to be elevated in two samples tested from the made ground. The PAH species Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(a)pyrene, and Dibenzo(a,h)anthracene were found to be elevated in made ground samples across the site.

None of the samples tested from the natural sub-soils recorded concentrations in excess of the relevant screening values detailed above.

Asbestos, noted to be loose fibres of Chrysotile, were recorded to be in the made ground sample at 0.10m in WS05.

As a precautionary measure, and considering the previous agricultural use of the site, a herbicide/pesticide screen was carried out on two samples of made ground, (0.5m in WS02 and 0.3m in WS06). No compounds were recorded in either sample.

5.0 QUALITATIVE RISK ASSESSMENT AND REVISED CONCEPTUAL MODEL

The preliminary conceptual site model, developed from the desk study information, as presented in the G&M report, has been revised in light of the ground investigation and chemical analysis results presented above. The revised conceptual model has been developed for the proposed future land use (Residential). This summarises the understanding of surface and sub-surface features, the potential contaminant sources, transport pathways and receptors

Human Health – further considerations:

- Localised elevated levels of Arsenic, Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(a)pyrene, Dibenzo(a,h)anthracene.
- Localised asbestos fibres found in WS05.
- Elevated hazardous ground gas, carbon dioxide and radon (desk study).

Summary of Identified Pollutant Linkages

In summary the revised conceptual site model has identified the following potential pollutant which could result in an unacceptable risk to the proposed end-use, denoted as a moderate or higher potential of significant pollutant linkage on the conceptual site model.

Source	Risk	Potential Contaminants	Exposure Pathway	Primary Receptor/s	Complete Pollutant Linkage
Made Ground - on site	Moderate/High	Elevated levels of Arsenic, Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(a)pyrene, Dibenz(a,h)anthracene. Localised Asbestos fibres	Skin contact Ingestion	Construction workers, built development, End users of site,	Yes: Residential properties are likely to have gardens and areas of soft landscaping, clean capping of gardens and areas of soft landscaping will be required. Asbestos fibre risk to construction workers to be managed.
Made Ground - on site	High	Ground gas	Migration (lateral and vertical) Inhalation, explosion		Yes: further assessment required; monitoring ongoing (3 further visits over a three-month period) <u>Currently a complete pollutant linkage assumed until monitoring period completed and reported.</u> Basic Radon protective measures are required for the site.

6.0 CONCLUSIONS AND RECOMMENDATIONS.

6.1 General.

G&M Consulting Ltd (G&M) was commissioned by Andrew Bailey Architects, to undertake a geoenvironmental appraisal of a plot of land at 28 Paddock Road, Staincross, Barnsley, Yorkshire. It is understood that outline planning approval (2017/1387) has been granted by Barnsley Metropolitan Borough Council for the demolition of existing dwelling and outbuildings and erection of up to 6 dwellings. This report has been prepared in support of the discharge of Condition No 6 of the above approval.

The location of the site is shown on Drawing No C398/1/1, presented in Appendix A of this report.

It has been assumed that ground levels will not change significantly from those described in this report, or that the proposed end use of the site will not change from that detailed above. If this is not the case, then amendments to the interpretation and conclusions in this report may be required.

At the time of writing details of the proposed foundation loadings have not been issued to the writer, the following discussions are therefore based on general assumptions and should be reassessed in view of the final development.

6.2 Geotechnical Considerations

Foundations

Made ground is considered unsuitable for foundations due to its potential variability. Foundations should therefore be taken to below the made ground.

Foundations taken to the underlying natural soils using traditional spread foundations could be adopted for the development. As the ground conditions vary across the site the depth of foundation will differ depending on the underlying materials. Where rock is shallow then foundations should be taken into the rock. Where clay is present then normally its volume change potential will control the depth of foundation. However, in places over deepening of the foundations to accommodate the volume change potential may take foundations into different materials, even to rock, which then negates the requirement of the volume change potential. It is therefore recommended that the foundations of each property should be assessed individually.

Where clay is present, based on the worst case of high volume change potential, foundations should be placed at a minimum depth of 1.0 m bgl where constructed outside the influencing distance of trees. If trees are proposed to be planted or retained as part of the development then the foundations should be taken deeper. The depth of foundation would depend on the species of the trees planted/retained and distance from the buildings. Guidance on foundation depths is given in the NHBC Standards.

It is suggested that the design of foundations placed in the cohesive soils at the suggested depth detailed above, use an undrained shear strength of 50 kPa.

Based on the undrained shear strength for the clay a net safe bearing capacity of 100 kPa is estimated for preliminary design purposes, with settlement estimated to be less than 25 mm for the likely loads from housing. Foundations taken deeper or placed in the shallow rock could utilise a high bearing capacity.

It is recommended that the footings are suitably reinforced to take into account the variability of the weathering and strength characteristics of the cohesive subsoils.

The bearing capacity of soil below a foundation is a function of the undrained shear strength of the soil, together with the type of foundation, including its depth and width. The bearing capacity should therefore be checked once foundation designs are finalised.

Floor Slabs and Pavements

Ground bearing floor slabs with a suitable sub-base layer may be adopted if the material is re-engineered or replaced. If not, then suspended floor slabs would be required.

All formation level soils should be proof-rolled and all loose, soft, organic or otherwise unsuitable materials should be removed and replaced with a suitable, well-compacted granular fill. Hard spots such as old foundations should also be removed.

Excavations

The shallow soils encountered are considered suitable for excavation by standard mechanical plant such as a wheeled backhoe excavator. The use of hydraulic or pneumatic breakers will most likely be required when dealing with any relict foundations, walls etc. or if excavations are taken in to rock.

If coal is encountered in excavations it should be blinded with lean mix concrete to prevent the possibility of spontaneous combustion. Also if encountered at foundation depth the excavation should be taken deeper to place the foundations below the coal.

No groundwater was encountered in the exploratory holes during the fieldwork, however, standing water has been recorded at high levels in the monitoring wells and may therefore be encountered in excavations. It is likely that if ground water control is required this could be done by pumping from sumps. Any water arising from the site should be disposed of in accordance with current regulatory guidelines. It should be noted that groundwater levels may change due to seasonal or other variations. Surface water run-off from rainfall may also enter excavations. Advice on suitable dewatering techniques is given in CIRIA Report C515 Groundwater Control – design and practice.

All excavations should be planned and due consideration should be given to providing temporary support or suitable battering. Excavations should be regularly inspected by a competent person to ensure continued safety. Further advice on the safety of excavations is given in *Health and Safety in Construction*.

Whilst no historical mining is recorded in the immediate vicinity of the site, a coal seam outcrops through the centre of the site, therefore there is a potential for crop workings in the vicinity. It is therefore recommended that a watching brief should be maintained on excavations and if deep or disturbed made ground is encountered then the advice from a suitably qualified consultant should be sought prior to continuing with further work. Further information on mining is given in the mining investigation report, referenced in Section 1.1 of this report.

Buried Concrete

This assessment of the potential for chemical attack on buried concrete is based on current guidance contained in BRE Special Digest 1 ('SD1', 2005) *Concrete in Aggressive Ground Part 1: Assessing the aggressive chemical environment*. Third Edition.

Soil pH values recorded in seven samples of made ground and natural soils range from 6.2 to 9.1 with corresponding water-soluble sulphate (SO₄) results in the range 0.013 g/l to 0.26 g/l. From these results a 'Characteristic Value' of 6.2 is derived for pH and 0.26 g/l for water soluble sulphate. Assuming brownfield conditions and using Table C2 from SD1, a Design Sulphate Class for the site of DS-1 is indicated with an ACEC class of AC-1 assuming mobile ground water conditions and AC-1s for static groundwater conditions.

6.3 Contamination Constraints to Development

Risk Evaluation for Proposed Land Use

Localised elevated levels of Arsenic, Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(a)pyrene, Dibenzo(a,h)anthracene were identified within the made ground/topsoil. Loose Chrysotile Asbestos fibres were also found in the shallow made ground soils in WS05. Based on the contaminant > pathway > receptor philosophy, areas of hardstanding i.e. building footprints, roadways, surfaced parking etc. will remove any pathways and therefore no further remediation would be required in these areas. In the areas of gardens and soft landscaping a clean cap will be required to break any pathways for exposure of end users to residual contamination, where made ground materials remain on site.

It is possible that areas of unidentified contamination or made ground may be encountered during the development works. If any visible fragments of asbestos, areas of noxious, odorous, fibrous or liquid etc. contamination are encountered, then works should stop immediately and further advice sought from a suitably experienced and qualified consultant. It is recommended that a watching brief be maintained during the development work for this purpose.

Future site users

The development proposals indicate the future end use of the site to be residential with areas of private gardens and soft landscaping. This is considered to represent a high sensitivity end use.

Based on the source>pathway>receptor philosophy and the chemical results obtained as part of this investigation, it is considered that the made ground tested generally pose a moderate/high risk to end users through ingestion, dermal contact or inhalation and that remedial action will be required to break this linkage.

Due to the presence of contamination in the made ground and because of its unsuitability as a growing medium, if made ground is left on site in areas of private gardens or soft landscaping, there will be a need to import clean cover soils. This is to provide a healthy medium for plant growth and to remove any remaining pathways for exposure of end users to residual contaminants. It is recommended that a minimum of 600mm of clean capping soils (including 150mm of topsoil) are placed or if made ground is thinner than this clean material is placed to the top of the natural soils. This thickness is subject to regulatory approval.

Prior to demolition of the existing buildings present on site, an asbestos survey should be carried out by a suitably experienced contractor/consultant to assess the extent of any building materials containing asbestos.

If any asbestos containing materials are found to be present on site, should be removed in a controlled manner, and disposed of to a suitably licenced facility. Disposal of these materials should be in accordance with Section 6.5 of this report.

Controlled Waters Receptors

Considering the fact that the results from the made ground are predominantly underlain by cohesive subsoils, that would limit any lateral or vertical migration of mobile contaminants, and that the made ground soils will be either removed or capped with hard stand or clean capping soils (thereby effectively eliminating surface water infiltration and leachate generation), it is considered that the soils are considered to pose a negligible/low risk to controlled waters and that no further remediation is considered necessary. This opinion is subject to regulatory approval.

Construction and Maintenance Workers

It is considered that there is a high short term risk during the ground works to construction and maintenance workers. The primary exposure pathways are considered to be dermal contact and soil ingestion arising from dust and asbestos fibres found in WS05.

Based on the current information it is recommended that good health and safety procedures should be adopted by ground workers, including no eating or smoking on site, designated clean and wash areas and protective clothing, e.g. overalls, gloves, dust masks etc. Good working and soil management practices including dampening down areas to prevent dust and sheeting of any stockpiles, should also be implemented.

Any potential risks must be specifically assessed as part of the health and safety evaluation for the works to be performed in accordance with prevailing legislation. Site practices must conform to the specific legislation requirements and follow appropriate guidance (e.g. HSE, 1991; CIRIA 1996).

Adjacent site users

Provided good ‘housekeeping’ practices are observed during the ground works, health and safety compliance is achieved, and wastes are appropriately handled, stored and disposed, then it is considered that there is a low short term risk to adjacent site users during the works.

Utilities

The results of the chemical testing and details of the proposed enabling works should be provided to the appropriate utility companies to determine the necessity for service protection

Built Development

This assessment of the potential for chemical attack on buried concrete is based on current guidance contained in BRE Special Digest 1 (‘SD1’, 2005) Concrete in Aggressive Ground Part 1: Assessing the aggressive chemical environment. Third Edition.

Soil pH values recorded in seven samples of made ground and natural soils range from 6.2 to 9.1 with corresponding water-soluble sulphate (SO₄) results in the range 0.013 g/l to 0.26 g/l. From these results a ‘Characteristic Value’ of 6.2 is derived for pH and 0.26 g/l for water soluble sulphate.

Based on the results, using Table C2 (SD1) for brown field sites the results for the water soluble sulphate indicate a Design Sulphate Class for the site of DS-1, with an ACEC class of AC-1s for static groundwater conditions and AC-1 assuming mobile ground water conditions.

6.4 Ground Gas (Interim Findings)

Gas monitoring has only been undertaken on three occasion to date, therefore the following comments are only a preliminary assessment. A full assessment will be made once monitoring is complete and an addendum report will be issued.

Guidance on the assessment of ground gas is given in CIRIA C665 (2007) ‘*Assessing Risks Posed by Hazardous Ground Gases to Buildings*’ and BS8485:2015+A1:2019 ‘*Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings*’.

The gas monitoring carried out to date has recorded no methane and a peak carbon dioxide concentration of 8.4%, with no gas flow. A worst case gas screening value (GSV) of 0.0084 l/hr has been calculated for carbon dioxide. As no gas flow was recorded the limit of detection of 0.1 l/hr of the gas monitor used, has been used to calculate the GSV.

Based on the above GSV, the ground gas regime for the proposed structure would initially be assessed as Characteristic Situation CS1, based on Table 8.5 and 8.6 of CIRIA C665. However, as the carbon dioxide concentrations recorded in WS6 and WS7 are above 5%, then in accordance with the above standards the CS value is increased by one band to CS2 (Refer to Table 8.5, CIRIA C665). CS2 would require basic gas protection measures to be installed in the building. Guidance on the appropriate gas protection measures are given in BS8485:2015+A1:2019. The measures used are generally a combination of a ventilation layer, floor slab or raft foundation and gas roof membrane, the options used would depend to some extent on the foundation construction adopted.

According to the desk study basic radon protection measures are required for the protection of the proposed building at this location.

6.5 Disposal of Soils

The removal of any hazardous materials from the site should be undertaken in accordance with the Control of Asbestos Regulations (2012), Health and Safety at Work etc. Act 1974 (and all regulations made under the Act), the Control of Substances Hazardous to Health Regulations 2002 (SI 2002/2677)

and Waste Regulations including Duty of Care Regulations 1991. There will also be a requirement to classify the waste in accordance with the European Waste Catalogue.

6.6 Regulatory Approval

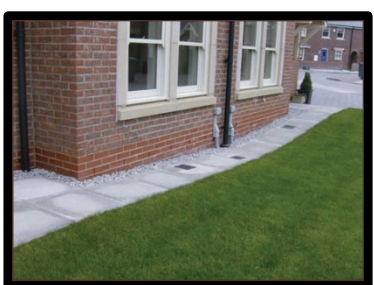
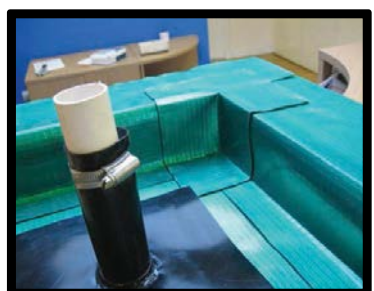
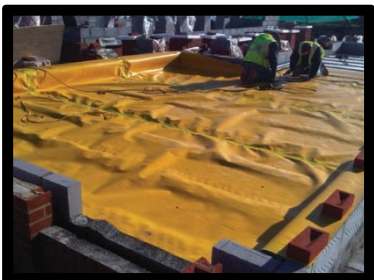
The conclusions and recommendations presented above are considered practical based on the findings of this investigation. The conclusions and recommendations cannot, however, be guaranteed to gain regulatory approval, and therefore this report should be submitted to the regulators for their comment/approval as part of any planning approval.

The above recommendations comprise a general outline of possible or likely works. A remediation strategy report should be produced and agreed with the regulatory authorities prior to development.



APPENDIX C

YALPAG - Verification Requirements for Gas Protection Systems



VERIFICATION REQUIREMENTS FOR GAS PROTECTION SYSTEMS

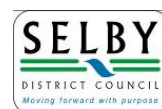
Technical Guidance for
Developers,
Landowners and
Consultants



Yorkshire and Lincolnshire
Pollution Advisory Group

Version 1.1 – December 2016

The purpose of this guidance is to promote consistency and good practice for development on land affected by contamination. The Local Planning Authorities in Yorkshire, Lincolnshire and the North East of England who have adopted this guidance are shown below:



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Disclaimer

This guidance is intended to serve as an informative and helpful source of advice. It is intended to review this guidance annually, but readers must note that legislation, guidance and practical methods are inevitably subject to change and therefore should be aware of current UK policy and best practice. This note should be read in conjunction with prevailing legislation and guidance, as amended, whether mentioned here or not. Where legislation and documents are summarised this is for general advice and convenience, and must not be relied upon as a comprehensive or authoritative interpretation. Ultimately it is the responsibility of the person/company involved in the verification of land contamination to apply up-to-date working practices and requirements.

Acknowledgments

The authors and YALPAG would like to specifically acknowledge and thank CIRIA for the permission to use sections, including tables and photographs, of the CIRIA C735 document. Mallett, H, Cox (nee Taffel-Andureau), L, Wilson, S, Corban, M (2014) *Good practice on the testing and verification of protection systems for buildings against hazardous ground gases*, CIRIA, C735, London (ISBN: 978-0-86017-739-5). Go to: www.ciria.org

The author, Leeds City Council (Brad Hall, Julia Reynolds), would like to acknowledge the assistance provided by the following people and organisations: East Riding of Yorkshire Council, Doncaster Metropolitan Borough Council, Wakefield Council, Hugh Mallett of BuroHappold, Neil Salvage of PAGEotechnical and John Naylor of Ground-Gas Solutions.

Consultation

The YALPAG Local Planning Authorities were consulted over a four week period in 2015 during the production of this guidance. Consultation comments were considered by the review panel and a number of revisions were made to the guidance to reflect these comments.

Introduction

This guidance has been produced to help developers ensure that they can demonstrate that gas protection systems are appropriate for the development and level of risk associated with a site and that they have been installed correctly and can be relied upon to provide the required level of protection and ultimately demonstrate that, in terms of gas risk, the development is suitable for use. It is intended to improve the quality of reports submitted to Local Planning Authorities on this matter and to give contractors/consultants a point of reference to obtain approval for such work from their client.

The verification of gas protection systems should be an integral part of remediation and agreed between developers and Local Planning Authorities at an early stage in the development.

Failure to comply with this guidance may result in delays to the development. Relevant planning conditions cannot be discharged until the Local Planning Authority is satisfied appropriate verification has been undertaken to confirm that the development is safe.

Available UK guidance regarding gas risk assessment includes:

- CIRIA C665 Assessing risks posed by hazardous ground gases to buildings;
- NHBC Report Edition No: 4 Guidance on evaluation of development proposals on sites where methane and carbon dioxide are present;
- BS 8485:2015 Code of practice for the design of proactive measures for methane and carbon dioxide ground gases for new buildings.

In particular, readers of this document should refer to the detailed guidance on verification published by CIRIA (CIRIA C735 Good Practice on the testing and verification of protection systems for buildings against hazardous ground gases, 2014). This guidance note should be considered as supplementary advice to be used in conjunction with these documents.

This document does not cover risks associated with radon. Please contact individual Local Planning Authority for further information.

The following YALPAG technical guidance documents for developers, landowners and consultants are also available;

- Verification Requirements for Cover Systems.
- Development on Land Affected by Contamination.

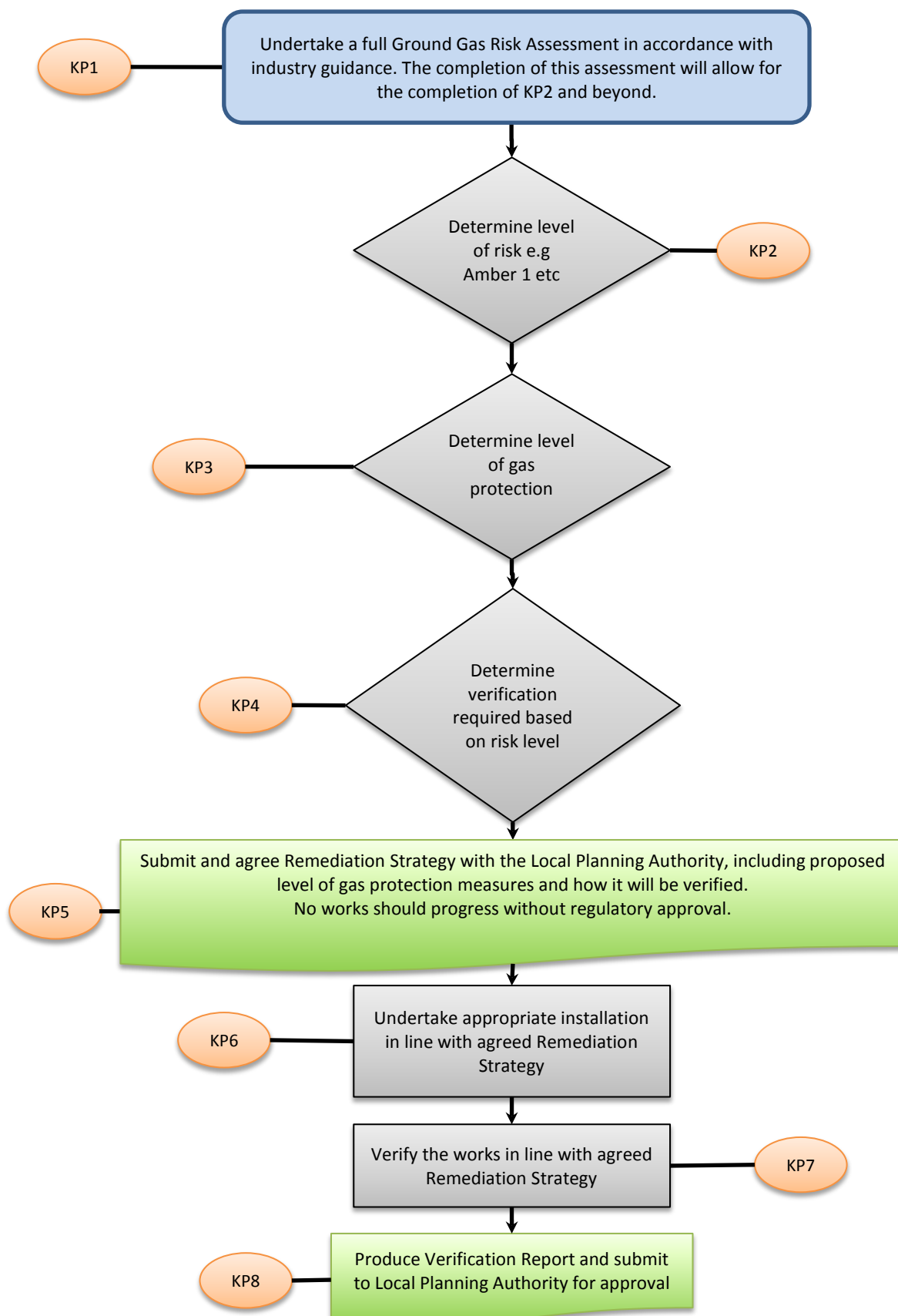
The Process of Verification

Implementation and verification plans for gas protection systems should always be site specific and based on the gas risk assessment and conceptual site model (CSM) for the site in question.

For gas protection systems, acceptable verification will normally comprise the provision of clear evidence that the level of protection is appropriate to the established risk and has been installed by suitably experienced personnel in line with the manufacturer's instructions and appropriate guidance. Critical factors to be considered are:

- What should be installed?
- How should it be installed?
- Who should install it?
- How will correct installation be demonstrated?

Overview Flowchart



Key Points

KP1 Ground Gas Risk Assessment	Undertake an appropriate gas risk assessment for the site in accordance with industry guidance*. On completion of the risk assessment and the generation of the appropriate Gas Screening Value (where required) and on a full understanding of the gas regime/ CSM, move to KP2 to determine the level of risk for the site. <i>*Where the desk study has identified the need for gas monitoring to be carried out it would always be expected that site specific gas monitoring data would be used in the gas risk assessment.</i>
KP2 Level of Risk	The level of gas risk needs to be determined by using the appropriate gas guidance document/s relative to the development (e.g. low rise housing, residential apartment blocks with areas of public open space, commercial or public buildings etc). For example Amber 1 (Low rise housing) equates to Low Risk in Table A1 CIRIA 735. Once the level of risk has been determined move to KP3 and determine the appropriate level of gas protection.
KP3 Level of Gas Protection	The level of gas protection should be based on the level of risk established by the gas risk assessment and CSM. It should provide the appropriate gas protection for the <i>lifetime of the development</i>. Detailed specification of gas protection measures in accordance with appropriate guidance to include (but not be limited to): • Submission of appropriate drawings (site specific plans and details to clearly show where the measures will be installed and how they fit into the design of the building and foundations). • Full written description of the protection measures to be included. • Detailed justification of the protection measures being used along with reference to the guidance document(s) being used.
KP4 Level of Verification Required	The level of qualification and experience of the installer will determine the level of verification required. Verification should always be carried out by an appropriate independent person such as an experienced and suitably trained verification consultant or third party qualified and experienced installer (see KP6). See Appendix 1 for full details of verification requirements for installation of gas protection measures and the associated verification requirements.

KP5 Submission and Agreement of Remediation Strategy	No installation of gas protection measures should be carried out at the site until the full details (KP1 to KP4) have been approved by the Local Planning Authority and formalised in an agreed Remediation Strategy (including Verification Plan). The Remediation Strategy, incorporating the detailed Verification Plan, should include (but not be limited to): • A summary of the ground gas risk assessment. • The gas protection measures proposed. • Who will undertake the installation including levels of experience and/ or qualifications. • How the works will be verified/ tested and by who. • How the works will be reported to the Local Planning Authority. See Appendix 2 for details of Remediation Strategy requirements.
KP6 Installation of Gas Protection	Installation should only be done once the Remediation Strategy has been agreed with the Local Planning Authority and should be carried out in line with the agreed Remediation Strategy. Any deviation away from the agreed Remediation Strategy should be agreed in writing with the Local Planning Authority prior to commencement of installation. See Appendix 4 for examples of good and poor gas protection installation.
KP7 Verification of Gas Protection	The verification of the gas protection measures should be undertaken in accordance with the Verification Plan set out in the agreed Remediation Strategy. Any deviation to works away from the agreed Remediation Strategy should be agreed in writing with the Local Planning Authority prior to installation. See Appendix 5 for an example Verification proforma.
KP8 Submission of Verification Report	The Verification Report must be produced in line with the agreed Remediation Strategy and Verification Plan. All aspects of the Remediation Strategy must be addressed in the Verification Report along with full details and justification of any deviation. See Appendix 3 for details of the required contents of the Verification Report. Please note, the required contents should be agreed within the submitted and approved Remediation Strategy at KP 5.

Appendix 1 – Requirement for Installation and Verification

Copied directly from Annex 1 CIRIA C735

Mallett, H, Cox (nee Taffel-Andureau), L, Wilson, S, Corban, M (2014) Good practice on the testing and verification of protection systems for buildings against hazardous ground gases, CIRIA, C735, London (ISBN: 978-0-86017-739-5). Go to: www.ciria.org

The tables in this appendix should be used for guidance only and are not intended to be used in lieu of sound professional judgment, which should take into account the risk factors affecting the development (the gas regime, the number of buildings, the complexity of design, and the expertise of the installation workforce) on a site-specific basis. The tables should not be used independent of, and without reference to, the accompanying text in the main guide C735.

Situation A – all development types except situation B – non reinforced slabs (from Wilson et al, 2007)

Gas regime/risk	Slab type	Installer experience	Suggested levels of verification and integrity testing
Low risk CS2 (*with venting) Basic radon protection area	Non reinforced All slabs	General builder/groundworker/landfill operative (no relevant qualification ¹)	Verifier (consultant ⁴ or qualified and experienced installer ¹) to conduct a thorough verification (visual) inspection prior to all concrete pours. Contractor to supply sign off sheets (verification evidence) including photographs to independent verifier.
		Qualified ¹ and experienced installer (minimum one operative to hold qualification)	Verifier (consultant ⁴ or third party qualified and experienced installer) to conduct a thorough verification (visual) inspection prior to 25 to 50 per cent of concrete pours (min one visit). Installer to supply sign off sheets (verification evidence) including photographs to independent verifier for all other pours.
Intermediate risk CS2 (no venting) or CS3 (*with venting) Full radon protection area		General builder/groundworker/landfill operative (no relevant qualification ¹)	Verifier (consultant ⁴ or qualified and experienced installer ¹) to conduct a thorough verification (visual) inspection prior to all concrete pours. All joints, pipe penetrations etc independently air lanced to ASTM D4437. Contractor to supply sign off sheets (verification evidence) including photographs to verifier. Consideration given to need for/scope of integrity testing (eg initially on say 25 to 50 per cent of pours then falling to 10 to 25 per cent if acceptable results obtained and no concerns raised by visual inspections).
Gas regime/risk	Slab type	Installer experience	Suggested levels of verification and integrity testing
Intermediate risk CS2 (no venting) or CS3 (*with venting) Full radon protection area	Non reinforced All slabs	Qualified ¹ and experienced installer (minimum one operative to hold qualification)	Verifier (consultant ⁴ or third party qualified and experienced installer ¹) to conduct a thorough verification (visual) inspection prior to 25 to 50 per cent of concrete pours (min two visits). 25 per cent all joints, pipe penetrations etc independently air lanced to ASTM D 4437. Remaining 75 per cent joints, pipe penetrations etc tested to recognised standard by installer (as detailed in method statement/CQA plan). Installer to supply sign off sheets (verification evidence) to verifier for all other pours. Consideration given to need for/scope of integrity testing (eg initially on 10 to 25 per cent of pours then falling to 0 to 10 per cent if acceptable results obtained and no concerns raised by visual inspections).
High risk VOCs etc CS3 (no venting) or CS4 and above (*with venting)		Qualified ¹ and experienced installer (50 per cent of operatives to hold qualification)	Verifier (consultant ⁴ or third party qualified and experienced installer ¹) to conduct a thorough verification (visual) inspection prior to all concrete pours. All joints, pipe penetrations independently air lanced to ASTM D 4437. Installer to supply sign off sheets (verification evidence) to verifier for all pours. Consideration given to need for scope of integrity testing (eg initially on 25 to 50 per cent of pours then falling to 10 to 25 per cent if acceptable results obtained and no concerns raised by visual inspections).

Notes

* Assumes venting designed to keep steady state concentration of CH₄ below one per cent in void, sites designed with higher levels of gas in the void should adjust the frequency of inspection and testing as appropriate

- 1 Relevant qualification is NVQ Level 2 in gas protection installation (see Section 3.3).
- 2 Before works start the contractor should produce a detailed installation plan including method statement, CQA procedures and qualifications, on receipt of these the verification protocol could be increased or reduced.
- 3 Consideration should be given to carrying out leak detection (ie smoke, tracer gas or dielectric testing) on the first plots on higher end sites CS3 and above. If an unacceptable amount of holes are found during these tests then the verification consultant should discuss with the relevant personnel, strategies to prevent this occurring, these could include changing material, improving subgrade preparation, putting up warning signs to reduce the amount of trafficking etc.
- 4 Verification consultant should be competent, experienced and suitably trained (see Section 3.2). A statement detailing their qualifications and relevant experience should be included in the verification plan.
- 5 Air lancing is the only integrity test that has an independently recognised international standard that is suitable for testing taped and welded seams.

Situation A – all development types except situation B – reinforced slabs (from Wilson et al, 2007)

Gas regime/risk	Slab type	Installer experience	Suggested levels of verification and integrity testing
Low risk CS2 (*with venting) Basic radon protection area	Reinforced All slabs	General builder/ groundworker/ landfill operative (no relevant qualification ¹)	Verifier (consultant ⁴ or qualified and experienced installer ¹) to conduct a thorough verification (visual) inspection prior to all concrete pours. Contractor to supply sign off sheets (verification evidence) including sub grade acceptance forms and photographs to independent verifier.
		Qualified ¹ and experienced installer (minimum one operative to hold qualification)	Verifier (consultant ⁴ or third party qualified and experienced installer ¹) to conduct a thorough verification (visual) inspection prior to 25 per cent concrete pours (min two visits), including vented void, subgrade etc. Installer to supply sign off sheets (verification evidence) including, sub grade acceptance forms, photographs to independent verifier for all other pours.
Intermediate risk CS2 (no venting) or CS3 (*with venting) Full radon protection area		General builder/ groundworker/ landfill operative (no relevant qualification ¹)	Verifier (consultant ⁴ or qualified and experienced installer ¹) to conduct a thorough verification (visual) inspection prior to all concrete pours including vented void, subgrade etc. All joints, pipe penetrations etc independently air lanced to ASTM D4437. Consideration given to the need for and scope of integrity testing (eg initially on say 50 to 25 per cent of pours then falling to 25 to 10 per cent if acceptable results obtained and no concerns raised by visual inspections).
		Qualified ¹ and experienced installer (minimum one operative to hold qualification)	Verifier (consultant ⁴ or third party qualified and experienced installer ¹) to conduct a thorough verification (visual) inspection prior to 50 per cent of concrete pours, including vented void, subgrade etc 25 per cent of joints, pipe penetrations etc independently air lanced to ASTM D4437. Remaining joints, pipe penetrations, corners etc tested to a recognised standard by installer (as detailed in method statement and CQA plan). Installer to supply sign off sheets (verification evidence) including, sub grade acceptance forms, photographs etc to independent verifier for all other pours. Consideration given to need for/scope of integrity testing (eg initially on 10 to 25 per cent of pours then falling to 0 to 10 per cent if acceptable results and no concerns raised by visual inspections).
		High risk VOC and hydrocarbons CS3 (no venting) or CS4 and above (*with venting)	Qualified ¹ and experienced installer (50 per cent of operatives to hold qualification)

Notes

- * Assumes venting designed to keep steady state concentration of CH₄ below one per cent in void, sites designed with higher levels of gas in the void should adjust the frequency of inspection and testing as appropriate.
- 1 Relevant qualification is NVQ Level 2 in gas protection installation (see Section 3.3).
 - 2 Before works start the contractor should produce a detailed installation plan including method statement, CQA procedures and qualifications, on receipt of these the verification protocol could be increased or reduced.
 - 3 Consideration should be given to carrying out leak detection (ie smoke, tracer gas or dielectric testing) on the first plots on higher end sites CS3 and above. If an unacceptable amount of holes are found during these tests then the verifier should discuss with the relevant personnel, strategies to prevent this occurring, these could include changing material, improving subgrade preparation, putting up warning signs to reduce the amount of trafficking etc.
 - 4 Verification consultant should be competent, experienced and suitably trained (see Section 3.2). A statement detailing their qualifications and relevant experience should be included in the verification plan.
 - 5 Air lancing is the only integrity test that has an independently recognised international standard that is suitable for testing taped and welded seams.

- 6 Where a sufficiently robust protection layer (protection fleece, protection boards or insulation) are laid directly on the membrane, inspection after placement of the reinforcement should not be necessary.

Situation B – low rise housing with ventilated void (from NHBC and Wilson et al, 2007)

Gas regime/risk	Slab type	Installer experience	Suggested levels of verification and integrity testing
Low risk Amber 1	All slabs with min 150 mm ventilated sub floor void	General builder/ groundworker/ landfill operative (no relevant qualification ¹)	Verifier (consultant ⁴ or qualified and experienced installer ¹) to conduct thorough verification (visual) inspection of first plot and after placement of reinforcement if no protection provided. Subsequent inspections carried out at approx. frequency of 1 in 10 plots (minimum 5). Contractor to supply sign off sheets (verification evidence) including photographs for all other plots. Consideration given to need for/scope of integrity testing if concerns identified by visual inspections ³ .
		Qualified ¹ and experienced installer (minimum one operative to hold qualification)	Verifier (consultant ⁴ or third party qualified and experienced installer ¹) to conduct thorough verification (visual) inspection of first plot and after placement of reinforcement if no protection provided. Subsequent inspections carried out at approx. frequency of 1 in 20 plots. Contractor to supply sign off sheets (verification evidence) including photographs for all other plots. Consideration given to need for/scope of integrity testing if concerns identified by visual inspections ³ .
Intermediate risk Amber 2		General builder/ groundworker/ landfill operative (no relevant qualification ¹)	Verifier (consultant ⁴ or qualified and experienced installer ¹) to conduct thorough verification (visual) inspection of first 10 plots and after placement of reinforcement if no protection provided. All joints, pipe penetrations etc air lanced to ASTM D4437. Subsequent inspections (including air lancing) carried out at approx. frequency of 1 in 20 plots Contractor to supply sign off sheets (verification evidence) including photographs for all other plots. Consideration given to need for/scope of integrity testing (eg initially on 30 to 50 per cent of plots then falling to 0 to 10 per cent of plots if acceptable results obtained and no concerns raised by visual inspections).
		Qualified ¹ and experienced installer (minimum one operative to hold qualification)	Verifier (consultant ⁴ or third party qualified and experienced installer ¹) to conduct thorough verification (visual) inspection of the first 5 plots and after placement of reinforcement if no protection provided. All joints, pipe penetrations etc air lanced to ASTM D4437. Subsequent inspections (including air lancing) carried out at a frequency of about 1 in 20 plots. Contractor to supply sign off sheets (verification evidence) including photographs for all other plots. Consideration given to need for/scope of integrity testing (eg initially on 10 to 25 per cent of plots then falling to 0 5 per cent of plots if acceptable results obtained and no concerns raised by visual inspections) ³ .
High risk Red VOC and hydrocarbons		Qualified ¹ and experienced installer (all operatives to hold qualification)	Verifier (consultant ⁴ or third party qualified and experienced installer ¹) to conduct thorough verification (visual) inspection of all plots, and after placement of reinforcement if no protection provided. All joints, pipe penetrations etc air lanced to ASTM D4437. Consideration given to need for/scope of integrity testing (eg initially on 30 to 50 per cent of plots then falling to 0 to 10 per cent of plots if acceptable results obtained and no concerns raised by visual inspections) ³ .

Notes

- * Gas regime defined by characteristic situation as set out by Wilson et al (2007), and all other recent good practice guidance and British Standards.
- ** Assumes venting designed to keep steady state concentration of CH₄ below one per cent in void, sites designed with higher levels of gas in the void should adjust the frequency of inspection and testing as appropriate.
- 1 Relevant qualification is NVQ Level 2 in gas protection installation (see Section 3.3).
- 2 Before the works start the contractor should produce a detailed installation plan including method statement, CQA procedures and qualifications, on receipt of these the verification protocol could be increased or reduced.
- 3 Consideration should be given to carrying out integrity testing/leak detection (ie smoke, tracer gas or dielectric testing) on the above basis and/or if an unacceptable amount of damage/loss of integrity is found during visual inspections. In this instance the consultant should discuss with the relevant personnel, strategies to prevent this recurring. This could include changing material, improving subgrade preparation, putting up warning signs to reduce the amount of trafficking etc.
- 4 Verification consultant should be competent, experienced and suitably trained (see Section 3.2). A statement detailing their qualifications and relevant experience should be included in the verification plan.
- 5 Air lancing is the only integrity test that has an independently recognised international standard suitable for testing taped and welded seams and should be used at the frequency suggested in the table.

Appendix 2 – Remediation Strategy and Verification Plan for Gas Protection Systems

The Remediation Strategy should include a detailed verification method statement. This should address how the gas protection measures will be installed and what verification information will be provided to demonstrate the installation has been carried out in accordance with the appropriate guidance.

As a minimum the report should include (but not be limited to):

- A summary of the gas risk assessment.
- The gas protection measures proposed (including reference to the appropriate guidance documents) and confirmation they will meet the gas protection requirements for the lifetime of the development.
- Technical drawings showing how the gas protection measures will be incorporated.
- Formal qualifications/experience/training of the person carrying out the installation.
- Formal qualifications/experience/training of the person carrying out the verification.
- Clear demonstration of the independence of the person carrying out the verification.
- The manufacturer's specification of the gas protection membrane to be used.
- Full details of what the verification process will comprise and at what stage verification will be carried out.
- Details of how any non-conformance will be dealt with.
- Details of the number of plots to be validated. (Deviation from verification of every plot will need to be justified and agreed with the Local Planning Authority in line with Appendix 1 of this document).
- Timeline of when during the build, each of the gas protection measures will be installed.
- Details of management measures proposed to ensure how damage to the membrane will be prevented prior to the floor being installed, post installation.
- Details of how all site personnel (including follow on trades) will be made aware of the presence of the membrane and that damage to the membrane must be prevented.
- Details of the extent of overlap and method of sealing (these must be in line with manufacturer's instructions and evidence provided).
- Confirmation that a signed (plot specific unless agreed otherwise) statement confirming that the gas protection measures were installed as agreed and that the membrane was free from tears and punctures and was lapped and sealed as agreed at joins and around services and sub floor voids were clear and free from debris will be included in the Verification Report.
- Confirmation that plot specific photographs showing the installed membrane will be included in the Verification Report.

Appendix 3 – Checklist for Gas Verification Reports

The Verification Report should include a summary of all the works undertaken, relating to gas protection measures including all elements detailed within the Remediation Strategy.

As a minimum the report should include (but not be limited to):

- Site details.
- Planning Application details.
- Summary of Gas Risk Assessment (including original CSM).
- Details of who carried out installation (qualifications/experience/training).
- Details of who carried out verification (qualifications/experience/training).
- Description of protection measures installed with reference to method statements and drawings and manufacturers specification of the materials used.
- Details of the verification inspection regime.
- Supporting information, plans, air vent installation, photographs, as built drawings.
- Summary of verification data (completed proformas, test results)
- Details of non-conformances and how they were rectified.
- Clear statement saying remedial objectives been achieved supported by lines of evidence including reference to CSM.
- Where necessary further works and/ or long term management.

Appendix 4 – Examples of Good and Poor Installation

Copied directly from Appendix A4 CIRIA C735

Mallett, H, Cox (nee Taffel-Andureau), L, Wilson, S, Corban, M (2014) Good practice on the testing and verification of protection systems for buildings against hazardous ground gases, CIRIA, C735, London (ISBN: 978-0-86017-739-5). Go to: www.ciria.org

GOOD PRACTICE PHOTOGRAPHS



Figure A4.7 Geovent protruding out of the frontage of the unit. Gas membrane along the sides of the slab preventing lateral gas ingress (courtesy Alderburgh Group)



Figure A4.8 Geovent beneath the 2000g taped gas membrane lined up with collector pipes (courtesy Alderburgh Group)



Figure A4.9 On site schematics to aid construction workers build the gas protection system (courtesy Alderburgh Group)



Figure A4.10 Almost complete coverage available for inspection, minimal jointing, service entries suitable distance from walls, light traffic (courtesy Smith Grant)



Figure A4.11 Gas membrane continued through cavity wall and above air bricks (courtesy Hydrock)



Figure A4.12 Good edge detail across cavity (courtesy PAGEotechnical Ltd)



Figure A4.13 Gas proof DPC adhered on top of gas membrane using butyl strips across cavity space (courtesy NHBC)



Figure A4.14 Good perimeter seal (courtesy PAGEotechnical Ltd)



Figure A4.15 LDPE type gas membrane overlap and double sided tape. Sand blinding to protect underside of gas membrane (courtesy A Proctor Group)

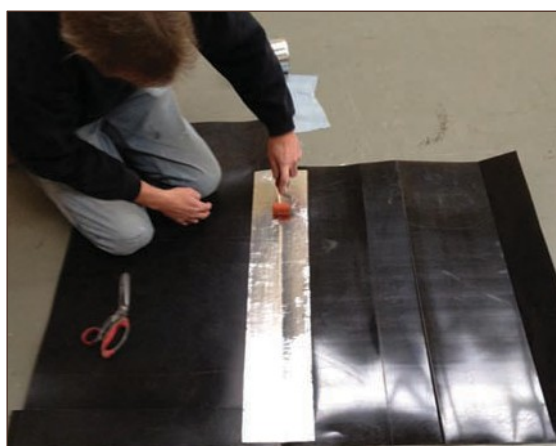


Figure A4.16 Example HDPE type gas membrane and steam roller used to ensure self-adhesive tape is correctly installed (courtesy A Proctor Group)

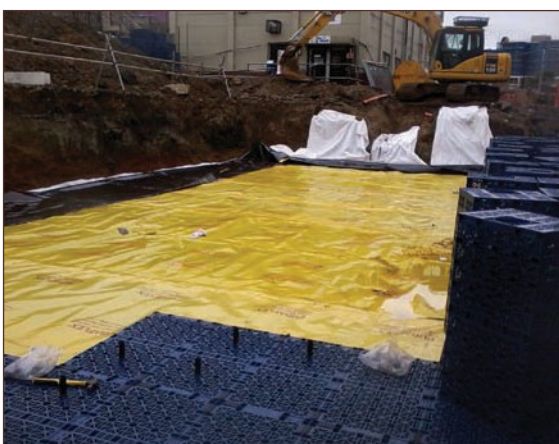


Figure A4.17 Gas membrane installed in attenuation tank (courtesy Industrial Textiles & Plastics Ltd)

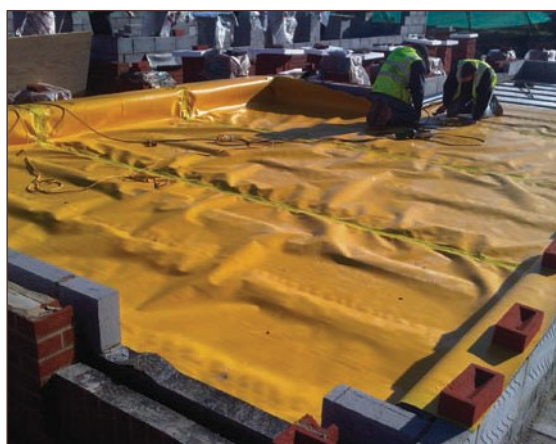


Figure A4.18 Gas membrane installed as part of foundation barrier (courtesy Industrial Textiles & Plastics Ltd)



Figure A4.19 Well-constructed joints with gas resistant DPC, lap and double sided butyl joints visible beneath semi-transparent gas membrane, secondary seal with proprietary single sided tape (courtesy Smith Grant)

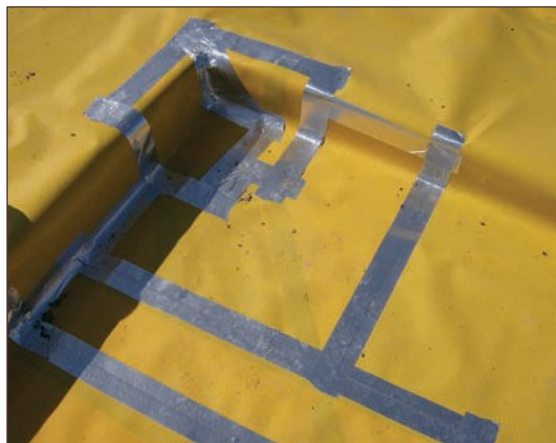


Figure A4.20 A pre-formed corner unit would have been preferable as fewer joints would have been formed, however the installer has achieved a good level of workmanship in this corner detail (courtesy Smith Grant)



Figure A4.21 Good prefabricated corner detail (courtesy MEC Environmental Ltd)

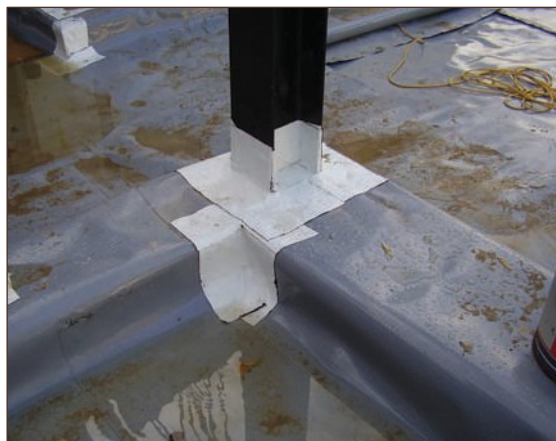


Figure A4.22 Good detail around stanchion and corner (courtesy PAGeotechnical Ltd)



Figure A4.23 Complex column seal (courtesy PAGeotechnical Ltd)

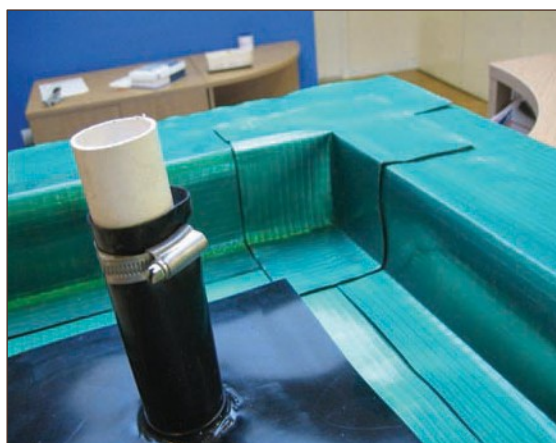


Figure A4.24 Prefabricated corner detail and top hat (courtesy A Proctor Group)

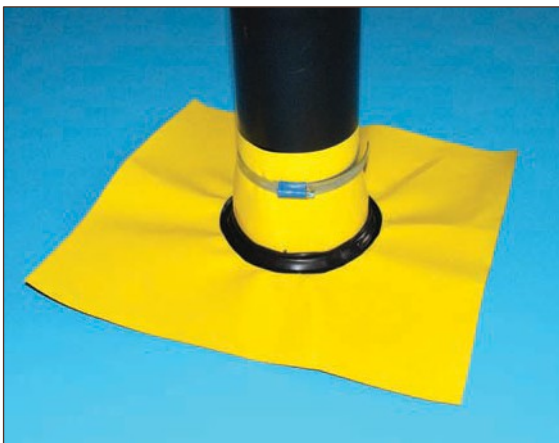


Figure A4.25 Top hat around service entry (courtesy Industrial Textiles & Plastics Ltd)

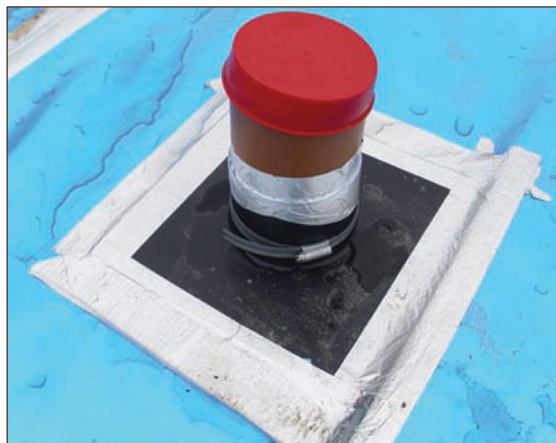


Figure A4.26 Well-constructed service entry: top hat fits well with service pipe and taped down to gas membrane, secondary seal with proprietary single sided tape (courtesy Smith Grant)



Figure A4.27 Top hats placed around service entries secured with jubilee clip seals. Top hats secured to gas membrane with double sided butyl tape (courtesy Hydrock)



Figure A4.28 Bead of double sided butyl tape provided between interfaces of ID top hat and OD service pipe. When compressed with jubilee clip, forms an effective seal (courtesy Smith Grant)



Figure A4.29 Extrusion welding technique (courtesy Industrial Textiles & Plastics Ltd)



Figure A4.30 Thermal welding technique (courtesy Industrial Textiles & Plastics Ltd)



Figure A4.31 Extrusion welding (courtesy PAGeotechnical Ltd)

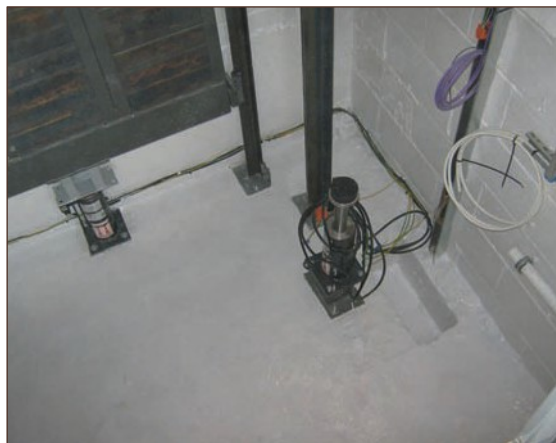


Figure A4.32 High quality installation of liquid gas membrane to lift pits, including resin gas protection on all screw penetrations (courtesy Card Geotechnics Limited)

A4.2.2 Good practice – passive venting systems



Figure A4.33 Good ventilation in internal sleeper walls, cast into prefabricated beams (courtesy Smith Grant)



Figure A4.34 Open void >300mm deep, good ventilation through internal sleeper walls (courtesy Smith Grant)



Figure A4.35 Good installation of passive gas venting trenches and 'egg-crate' (courtesy Card Geotechnics Limited)



Figure A4.36 Raised air bricks are preferable due to the reduced potential for blockade but the vent trench specified is provided with clean single sized stone (courtesy Smith Grant)

A4.2.3 Good practice – integrity testing



Figure A4.37 Tracer gas testing, whereby gas or smoke is applied under pressure beneath the installed gas membrane and detectors are used to screen for leaks above (courtesy NHBC)



Figure A4.38 Tracer gas testing (courtesy PAGEotechnical Ltd)



Figure A4.39 Scanning for leaks (courtesy PAGEotechnical Ltd)



Figure A4.40 CO₂ injection integrity testing (courtesy Landline Ltd)

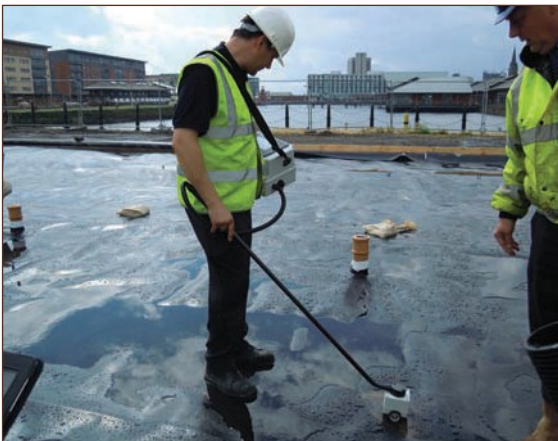


Figure A4.41 Small sand bags are marking holes made in the gas membrane used to check whether injected CO₂ has worked its way beneath whole area (courtesy Landline Ltd)



Figure A4.42 Air pressure testing (courtesy GSE Environmental)



Figure A4.43 Dielectric porosity testing for housing scheme (courtesy NHBC)



Figure A4.44 Air lance test, used to test the quality of welded seams along gas membrane joints (courtesy MEC Environmental Ltd)



Figure A4.45 Spark testing (courtesy GSE Environmental)



Figure A4.46 Testing a weld with 'dog bone' grips (courtesy MEC Environmental Ltd)

BAD PRACTICE PHOTOGRAPHS



Figure A4.47 Follow-on works purposefully penetrating gas membrane (courtesy Card Geotechnics Limited)



Figure A4.48 Loose nails and over construction debris likely to be left in place beneath gas membrane – poor preparation of gas membrane prior to sealing service penetration (courtesy Card Geotechnics Limited)



Figure A4.49 *Lifted gas membrane at corner position. Light penetrating through confirms damage to aluminium internal core layer (courtesy NHBC)*



Figure A4.50 *Large/heavy/sharp objects being moved over unprotected gas membrane (courtesy Card Geotechnics Limited)*



Figure A4.51 *Gas membrane torn by reinforcement (courtesy MEC Environmental Ltd)*



Figure A4.52 *Gas membrane cut by scaffolders and bricklayers after installation (courtesy MEC Environmental Ltd)*



Figure A4.53 *Gas membrane left exposed for long period of time, shows significant fraying at cavity edge (courtesy NHBC)*



Figure A4.54 *Gas membrane damage/tearing at edge of ground floor slab screed layer where it was left exposed to elements for period of time (courtesy NHBC)*



Figure A4.55 Gas membrane at stepped junction of slab to integral garage, appears to be susceptible to tearing when screed is poured. Screed may also weigh down on gas membrane if fitted too tight (courtesy NHBC)



Figure A4.56 Gas membrane at edge of concrete screed. Screed has been grinded to achieve desired levels, gas membrane shows extreme wear and damage as a result (courtesy NHBC)



Figure A4.57 Unprotected gas membrane damaged by heavy traffic (courtesy MEC Environmental Ltd)



Figure A4.58 Damage caused to gas membrane by follow-on trade who cut/shaped the dry lining board directly on the unprotected installed gas membrane (courtesy NHBC)



Figure A4.59 Gas membrane slit at the bottom of a cavity tray to enable water to drain away (courtesy Smith Grant)



Figure A4.60 Some stones could penetrate gas membrane if sufficient force is applied (courtesy Smith Grant)



Figure A4.61 'Stripping' occurs on gas membranes that contain aluminium foil. The foil gets too hot under the outer layer of LDPE or PP and the top layer of the gas membrane sticks to the roller which strips it off, leaving the aluminium completely exposed (courtesy MEC Environmental Ltd)

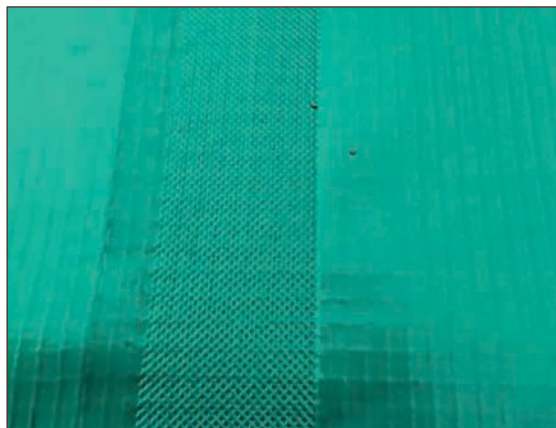


Figure A4.62 Wedge weld on an LDPE aluminium gas membrane, where the installer used metal nip rollers. This destroyed the top layer and probably the bottom layer, leaving aluminium exposed between the weaves. This failed dielectric testing along all joints (courtesy MEC Environmental Ltd)

A4.3.2 Bad practice – gas membranes installed incorrectly



Figure A4.63 Absence of surface preparation prior to laying of gas membrane, debris likely to pierce gas membrane (courtesy Card Geotechnics Limited)

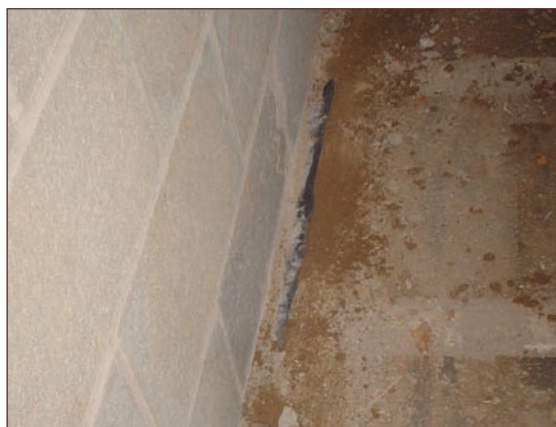


Figure A4.64 Insufficient length of gas membrane protruding through wall to overlap with gas membrane within building (courtesy Card Geotechnics Limited)



Figure A4.65 Wrinkling of gas membrane over joint has resulted in gaps (only visible due to the use of a transparent gas membrane) and the secondary seal uses ordinary gaffer tape rather than a proprietary product (courtesy Smith Grant)



Figure A4.66 Follow-on trades proceeded work before gas membrane joints sealed (courtesy Card Geotechnics Limited)



Figure A4.67 Traffic over mesh resulted in several punctures, in addition most joints were found to be poorly constructed. Taped joints are difficult to construct in adverse weather (courtesy Smith Grant)



Figure A4.68 A pre-formed corner unit would have been preferable. The installer could not produce sufficient quality despite the amount of tape applied (courtesy Smith Grant)



Figure A4.69 Attempt at corner detailing using non-proprietary duct tape (courtesy Smith Grant)



Figure A4.70 Inadequate corner detailing. The use of preformed proprietary products would have avoided such bad practice (courtesy NHBC)



Figure A4.71 No corner detailing leading to stress point on gas membrane (courtesy Smith Grant)



Figure A4.72 Joint between top hat and gas membrane has lifted due to poor fit and attempt to construct in very wet conditions (courtesy Smith Grant)



Figure A4.73 No bead of double sided butyl tape provided between interfaces of ID top hat and OD service pipe: cannot be compressed enough to form seal (courtesy Smith Grant)



Figure A4.74 Gap between OD of service pipe and ID of top hat too large: cannot be compressed enough to form seal, even with the application of additional tape (courtesy Smith Grant)



Figure A4.75 Jubilee clip on service entry insufficiently tightened so joint is uncompressed (courtesy Smith Grant)



Figure A4.76 No double sided tape used in joints (courtesy Smith Grant)



Figure A4.77 Small lap and no single sided tape used to achieve secondary seal (courtesy Smith Grant)



Figure A4.78 Gap in jointing over wall cavity big enough to insert fist (courtesy Smith Grant)



Figure A4.79 Gas membrane not continuous over internal wall. It had been deliberately cut open for unknown purpose (courtesy Smith Grant)



Figure A4.80 Column left unsealed (courtesy PAGEotechnical Ltd)



Figure A4.81 No seal to perimeter pipe (courtesy PAGEotechnical Ltd)



Figure A4.82 Gas membrane used to bridge cavity wall instead of DPC, leaving it exposed to damage by follow-on trades (courtesy Smith Grant)



Figure A4.83 Poor quality installation of liquid gas membrane. Liquid gas membranes come in two colours (black and white) allowing coverage of each coat to be easily assessed. Here the gas membrane has been spread too thinly and inconsistently. In addition, it appears to have been applied to a damp surface, causing blistering (courtesy Card Geotechnics Limited)



Figure A4.84 Taped joints are difficult to construct in adverse weather. Also difficult to inspect if covered with snow (courtesy Smith Grant)

A4.3.3 Bad practice – passive venting systems



Figure A4.85 Clean single sized stones with no fines acting as venting media, however no ventilation gaps in internal sleeper walls (courtesy Smith Grant)



Figure A4.86 Cavity is becoming blocked with detritus. The vent holes in the beam are no longer visible (courtesy Smith Grant)

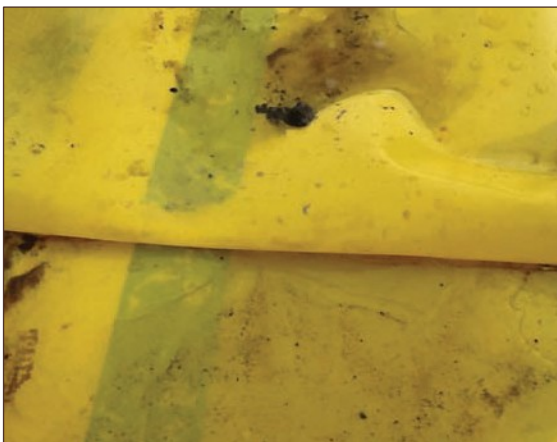


Figure A4.87 Tape joint with crease running through and air bubbles where gas membrane not in complete contact with tape. Rollers should have been used to produce a consistent seal (courtesy MEC Environmental Ltd)



Figure A4.88 Ventilator becoming detached to fit to external block work. This is due to builders requiring increased cavity widths to achieve thermal properties expected by Building Regulations (courtesy NHBC)



Figure A4.89 No ventilation in internal sleeper wall (courtesy Smith Grant)

Appendix 5 –Verification Proforma

Copied Directly From Appendix A5 CIRIA C735

Mallett, H, Cox (nee Taffel-Andureau), L, Wilson, S, Corban, M (2014) Good practice on the testing and verification of protection systems for buildings against hazardous ground gases, CIRIA, C735, London (ISBN: 978-0-86017-739-5). Go to: www.ciria.org

VISUAL INSPECTION OF GAS PROTECTION MEASURES

Site name:	Gas characteristic situation:
Job number:	Type of development and building/block checked: (residential/commercial/other)
Date:	Building description:
Visit by:	Foundation type: (suspended floor/raft/other)
Weather at time of inspection:	Gas protection type: passive/active

No.	Item	Comments (see notes)
1 Gas membrane		
1.1	Condition of sub-grade and underside of gas membrane	
1.2	Gas membrane type	
1.3	Gas membrane condition	
1.4	Joining tape product	
1.5	Lapping design	
1.6	Laps, welds and joints seals	
1.7	Service entries seals	
2 Passive venting		
2.1	Sub-floor void	
2.2	External wall airbricks	
2.3	Internal sleeper walls	
2.4	External vent trenches/ducts	
3 Active venting		
3.1	System details	
Additional notes:		

Notes: inspection checklist

1.1	Underside of gas membrane	Check that the sub grade does not contain rough/uneven surfaces, is appropriately clean and that there are no hard/sharp objects. That protective sand blinding or geotextile (if specified) is present and meets the design criteria.
1.2	Gas membrane type	Manufacturer and product specification, gauge, colour, brand/name, material batch/roll numbers, storage arrangements (protected from dirt/damage?)
1.3	Gas membrane condition	Open punctures, tears, rips, stretching? Excessive footprints/evidence of traffic? Presence of debris? Repairs? Signs of weakness such as raised or sunken indentations? Protection plan in place to restrict access to lain gas membrane?
1.4	Joining tape product	Product type, brand, thickness, material, width, colour? Use of double sided tape?
1.5	Lapping design	Joints lapped and sealed in accordance with manufacturer's requirements/ specification? Minimum overlap insured? Sections taped twice?
1.6	Laps and joints sealed	Welds complete? Appropriate joining/double sided tape used?
1.7	Service entries sealed	Top hats seal arrangements fixed around service entries? Use of Jubilee clips?
2.1	Sub-floor void	Is a check possible? Void former? Gravel (type/specification)? Height of void space? Is it clear?
2.2	External wall airbricks	Numbers, size, positions as design drawing?
2.3	Internal sleeper walls	Ventilation holes (honeycomb brickwork/pipe crossings?) – size, spacing, location in accordance with design?
2.4	External vent trenches/ducts	Located and constructed in accordance with design drawings? If open-topped gravel – gravel type/presence of fines? If pipe or other vent, check position and construction for functionality and absence of blockages. Ability of void former to withstand bearing of the superstructure?
3.1	Active venting	Type of air supply: mechanical, natural, combined? Location/condition/number of fans and vents? Location and size of inlets? Provision of air-cleaning devices and air heaters? Supply and exhaust ductwork? Alarm provision/installation? Gas monitoring system in under-floor void?

Photographs

No.	Description

The gas protection measures inspected:	a Are acceptable and comply with the specification
	b Are acceptable but attention is drawn to issues related to item no. xxx
	c Are not acceptable due to the issues related to item no. xxx

Name:

Signature:

Date:



APPENDIX D

YALPAG - Validation Requirements for Cover Systems



VERIFICATION REQUIREMENTS FOR COVER SYSTEMS

Technical Guidance for
Developers,
Landowners and
Consultants



**Yorkshire and Lincolnshire
Pollution Advisory Group**

Version 3.4 – November 2017

The purpose of this guidance is to promote consistency and good practice for development on land affected by contamination. The local authorities in Yorkshire, Lincolnshire and the North East of England who have adopted this guidance are shown below:



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Disclaimer

This guidance is intended to serve as an informative and helpful source of advice. It is intended to review this guidance annually, but readers must note that legislation, guidance and practical methods are inevitably subject to change and therefore should be aware of current UK policy and best practice. This note should be read in conjunction with prevailing legislation and guidance, as amended, whether mentioned here or not. Where legislation and documents are summarised this is for general advice and convenience, and must not be relied upon as a comprehensive or authoritative interpretation. Ultimately it is the responsibility of the person/company involved in the verification of land contamination to apply up-to-date working practices and requirements.

Acknowledgments

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Consultation

39 Local Authorities and 6 Environmental Consultants were consulted over a four week period in 2010 during the production of the initial guidance. At that time, consultation comments were considered by the review panel and a number of revisions were made to the guidance to reflect these comments. Given that no major changes have subsequently taken place, only Local Authorities were consulted during the production of this version [3.1] of the guidance.

Introduction

This guidance has been produced to help developers ensure that they can demonstrate that material brought onto a development site for gardens or areas of soft landscaping are suitable for use and do not present harm to people, the environment and/or property. It is intended to improve the quality of reports submitted to Local Authorities on this matter and to give contractors/consultants a point of reference to obtain approval for such work from their client. This guidance does not cover the geotechnical suitability of soils or material or chemical suitability that does not affect human health e.g. sulphates.

The verification of cover systems should be an integral part of the remediation project and agreed between developers and regulators at an early stage in the project.

There are some UK guidelines regarding verification, for example CLR 11¹ and the document on verification of remediation². This guidance note should be considered as supplementary advice in conjunction with these documents.

This guidance relates to the remediation of land contamination by using cover systems; however, the verification of the quality of imported material is equally important in other situations, such as raising levels for flood prevention or general landscaping works. This guidance could also be used in such instances.

The Process of Verification

Implementation plans for remedial works should always be site specific. Where a cover system and potentially, excavation, is the main remedial method or a component of an overall site remediation, specific goals will need to be set that are linked directly to the risk management strategy for the site in question.

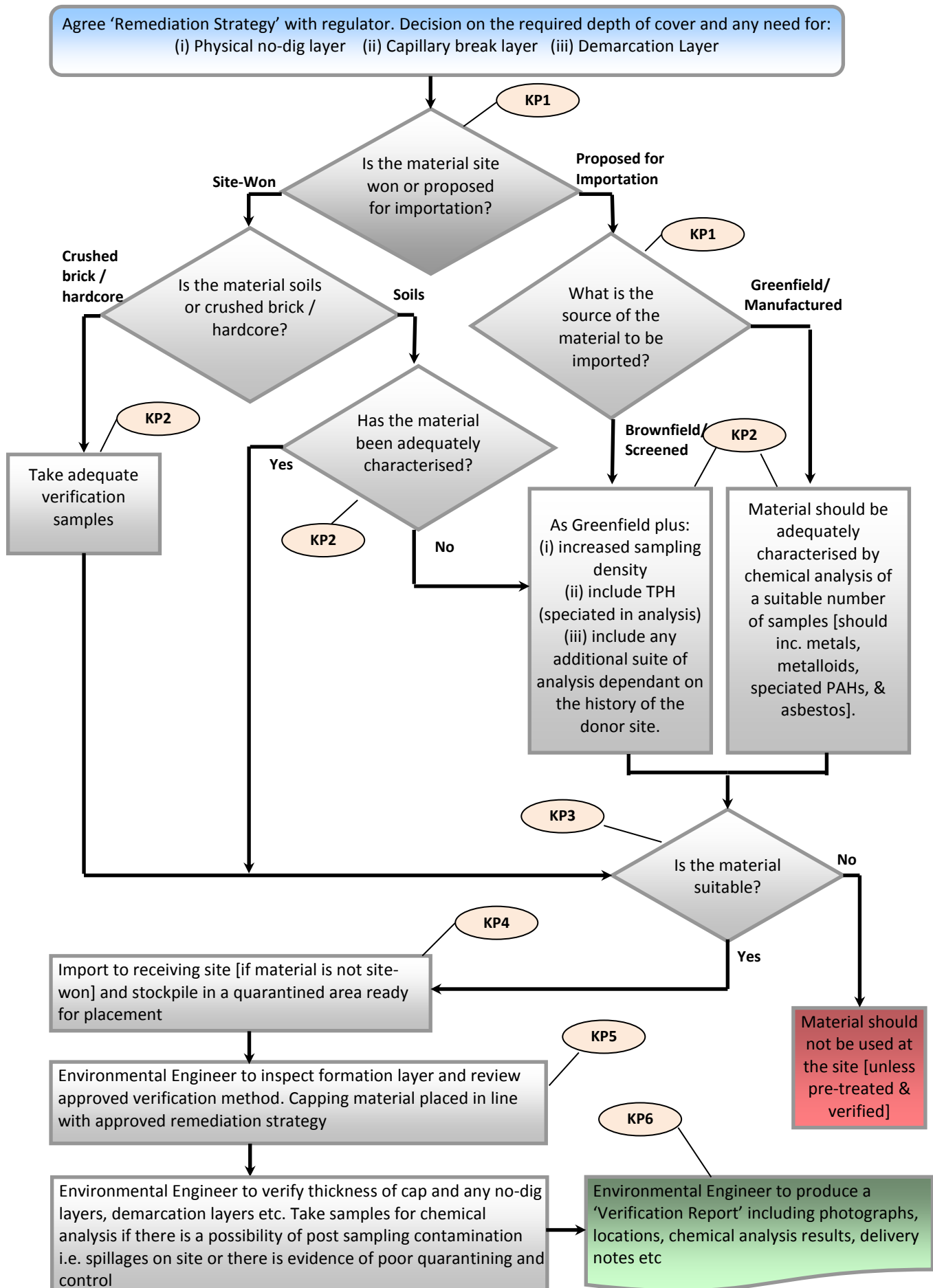
For cover and containment systems, verification will normally depend upon the provision of defensible measurements, observations and records. Critical factors to be considered are:

- What should be measured?
- When should they be measured?
- Where measurements need to be taken, what is the appropriate monitoring regime i.e. number and frequency of samples?
- Statistical constraints on sampling.

¹ "Contaminated Land Report 11 - Model Procedures for the Management of Contaminated Land". Environment Agency, September 2004.

² "Verification of Remediation of Contaminated Land. Environment Agency, 2010 [draft report].

Overview Flowchart



Key Points

KP1 Source of Material	Material can be sourced from site won material i.e. crushed brick /hardcore or site-won soils from existing open or landscaped areas. In the interest of sustainability, Local Authorities promote the use of such site-won material providing that they are suitable for the intended end use of the site. Alternatively, material can be sourced from other developments and commercial companies. Dependent on the source of the material it can be classified as either from a '<u>Greenfield/Manufactured</u>' or '<u>Brownfield/Screened</u>' source. Broadly speaking material can be classified as follows: Greenfield - if it can be demonstrated that it has not been developed and that no past contaminative uses have occurred at the site. Manufactured – from a commercial company who manufacture material by mixing or blending mineral soils (subsoil or sand) with an organic amendment (compost). Brownfield – material from a donor site that has previously been developed Screened – material from a company who deal with skip/demolition waste which is screened for unsuitable material i.e. bricks, wood, plastic etc.
KP2 Characterisation of Material	It is essential that material is inert and suitable for its intended use. Evidence of the source of the material should be provided to the Local Authority. What is required is a defensible method to ensure the verification proposals are site specific and that the level of sampling reflects the need to ensure that imported material are suitable for their intended use. When Should this be Done? Sampling of material should be undertaken as early as possible i.e. <u>prior to placement</u> [for site won material] and <u>prior to importation</u> [for imported material]. This is to avoid the costly exercise of re-excavating <u>unsuitable</u> material and the possibility of cross contamination. Where the assessor has confidence that the material is of sufficient quality (i.e. tested by supplier, used previously) it is acceptable to test the material on site but prior to placement. Although, if it is deemed <u>unsuitable</u> it would have to be either removed off site or pre-treated at the cost and time of the developer. What about Certificates from Commercial Suppliers? Where the material is provided by a commercial company, certificates or other industry Quality Protocol compliance i.e. WRAP, will normally be accepted. This is on the proviso that it (i) relates to

	the actual material being imported to the site and the type and amount of analysis is in line with what is prescribed in Appendix 1a and (ii) the certificates are less than two months old. <u>Extreme caution</u> should be given to importing material that has been recycled from demolition or skip waste as they could be easily be contaminated e.g. asbestos containing materials. [Please refer to questions you should be asking your supplier in Appendix 1b and include the responses in your report] British Standard Imported topsoils should be as specified in BS 3882:2007 as 'suitable for their intended purpose'. BS3882:2007 relates to nutrient content of topsoil and phytotoxic contamination and <u>does not</u> consider contaminants that pose a risk specifically to human health. Soils should be tested for contaminants that are considered to pose a risk to human health in addition to BS3882:2007 to ensure that they are suitable for their intended use. Initial Screening A visual / olfactory inspection of the material should be carried out by an Environmental Engineer to ensure that: • it is a suitable growing medium • it is free from obvious contamination i.e. staining / free product etc • it has not come from areas where Japanese Knotweed or other invasive or injurious plants, as specified by the Environment Agency, are suspected to have been growing. • it is not odorous (could be considered a statutory nuisance) • it is free from unsuitable material i.e. bricks, brick ties, timber and glass etc) • there are no visible signs of asbestos containing material (ACM's) Testing Schedule & Number of Samples Chemical testing will normally be required on any materials that are to be used as cover material, even where this includes first generation quarried material. This should be carried out by a suitably qualified Environmental Engineer. Please refer to the <u>Characterisation of Material Matrix</u> in Appendix 1a which details the number of samples to be taken; the testing schedule to be utilised dependant on the nature and source of the material and the acceptance criteria to be used.
KP3 Suitability of Material	Based on the characterisation of material above, the material should be either deemed suitable or unsuitable. Obviously unsuitable material should not be used [unless it is treated to reduce levels of contaminants below agreed target levels i.e. bioremediation – this would have to be agreed and included within the Remediation Strategy] and an alternative source of material should be sought by the developer. If the material is considered suitable it can be

	imported [if not site won] and stockpiled in a suitably quarantined area [refer to KP4].
KP4 Stockpiling & Quarantining of Material	It is essential that the 'suitable' material is either placed in its intended area straight away i.e. soft / landscaped areas or stockpiled in a suitable quarantine area to prevent on-site contamination. In the event that an assessor finds material has been stored in an unsuitable area, samples should be taken to confirm that no cross contamination has occurred [including a visual/olfactory check of the material]. The material should then be suitably quarantined or placed at its intended location immediately.
KP5 Verification of Required Depth	In line with the agreed 'Remediation Strategy', it is important to establish that the required depth has been achieved and is consistent across the site. There are two main ways to achieve this: <u>Depth testing in situ</u> – small trial pit excavated to allow measurement of its depth by tape measure or measuring staff. <u>Topographical surveys</u> – accurate survey of the base and final formation layer height to establish the depth of cover. Specific Local Authority Policy Please check with the local Contaminated Land Officer to establish: • which type of method for testing depth is accepted; and • the number of verification areas per property, plot, landscaped area or garden area [some Local Authorities recommend at least 2 per plot] Important Note: Where demarcation, physical no-dig and capillary break layers exist they should be verified for their thickness and presence during the time of their installation. Details of the demarcation layer should be agreed with the Contaminated Land Officer prior to placement. This will include the design, type and strength of the geotextile separator or visual warning membrane. The verification of depth and confirmation of such layers should be carried out by a suitably qualified environmental engineer.
KP6 Reporting	The purpose of verification documentation is to provide transparent reasoning why the remediation was required, a methodology about how it was to be undertaken and proof that the specified works have been undertaken and to provide confirmation that the site is 'suitable for its intended use'. The document is utilised not only to satisfy conditions of planning permissions but also is to be kept on record by the Local Authority should queries be raised during the lifetime of the development and to confirm to future purchasers that the site is suitable for use. Therefore, the presence of good quality photographs is essential to

	prove beyond doubt that the remediation has been done as specified both by method and position. It is also essential that other supporting documentation is included within a report e.g. laboratory analysis results, delivery tickets for material, certificates for imported material, trial pit logs etc. A checklist has been included in Appendix 2 to give an idea on what information should be recorded. The reporting should be carried out by a suitably qualified Environmental Engineer. To include details of any measures required to maintain the cover system integrity in the future e.g. successive construction phases (management plans) and longer term (restrictive covenants on title deeds). Photographic Evidence for Validating the Depth of Cover The Local Authority ideally would recommend the following programme of photographs to be taken of the placement of inert cover: • Photographs of any stockpiles and quarantine areas • Proof that the depth of inert cover has been installed • Proof of the quality of the material to be used as inert cover • Proof there is a geotextile separator and visual warning membranes if used between the made ground and suitable for use soils. • Proof of the method of placement and different layers if appropriate • Proof of the completed project • Inclusion of geographic background features which will aid locating the photograph • Inclusion of site identification boards within the photos which show the date, position taken i.e. corner of plot 3 and the site name. • Inclusion of photographs of site stockpiles and quarantine areas. The photographs have to prove beyond doubt that the images have been taken from the specific area stated. <u>Refer to Appendix 3 for examples of good photographic evidence.</u>
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Appendix 1a – Sampling & Testing Matrix

Type	Number of Samples	Testing Schedule	Assessment Criteria
Virgin Quarried Material	1 or 2 depending on the type of stone utilised, to confirm the inert nature of the material.	Standard metals/metalloids (should include as a minimum As, Cd, Cr, CrVI, Cu, Hg, Ni, Pb, Se, Zn)	This needs to be agreed with the Local Authority. The Assessment criteria needs to be UK based, e.g. LQM S4UL's, Defra C4SL's or other similarly derived GAC's.
Crushed Hardcore, Stone, Brick	Minimum 1 per 1000m ³	Standard metals/metalloids (As above) PAH (16 USEPA speciation) Asbestos	
Greenfield/ Manufactured Soils	Minimum 3 or 1 per 250m ³ (whichever is greater)	Standard metals/metalloids (As above) PAH (16 USEPA speciation) Asbestos	
Brownfield/ Screened Soils	Minimum 6 or 1 per 100m ³ (whichever is greater)	Standard metals/ metalloids (As above) PAH (16 USEPA speciation) TPH (CWG banded) Asbestos Any additional analysis dependant on the history of the donor site.	

Appendix 1b – Questions to Ask Your Soil Supplier Relating to Soil Quality

- What is the source of the material (refer to KP1)?
- Will all of the material be coming from the same source?
- Are you satisfied that the material is a suitable growing medium for the proposed end use?
- Has the supplier used an appropriate sampling protocol to ensure a representative sample is analysed? What volume of soil is represented by the analysis and does it comply with Appendix 1a?
- Does the testing include analysis of contaminants identified in Appendix 1a?
- Does the laboratory conducting the analysis have UKAS and MCERTS accreditation for the tests they are carrying out?
- Can I have a copy of the whole analysts report and does it include an interpretive section?
- Will the provided certificate be dated within the last 2 months?

Appendix 2 – Checklist for Verification Reports

Example only. Not to be considered as typical minimum requirements. Additional information should be included for non cover systems aspects of the remediation i.e. gas protection measures etc.

Site Details	
Site Name / location	
Developer name	
Development use	
Plot No / description of landscaped area (inc plan of inspection areas)	
National Grid Reference	
Inspection visit date	
Supporting Evidence	
Description of remediation (as per agreed Remediation Method Statement including depths / thickness checks, topographical readings)	
Material tracking information (including way tickets etc)	
Name of groundwork's remediation contractor	
Name of supervising environmental consultant	
Site Specific chemical analysis results	
Verification Photographs (inc. remarks)	
Recommendations	
Pass / fail	
If material fail, how will this be managed i.e. removed, treated	
Detail any further remedial works and / or inspection	
Signed off	

Failure to provide any of the above information may prevent planning conditions from being discharged.

Appendix 3 – Examples of Good Quality Photographs



Photograph 1: Depth check of inert cover within area of public open space. Physical break layer and topsoil visible.



Photograph 2: Depth check of inert cover with Site & Location Information Board.



Photographs 3 & 4:
Depth check of inert
cover within areas of
front gardens.





Photographs 5 and 6: Depth check of inert cover within rear gardens. Taut string line spans across excavation.



Photograph 7 shows the spatial location of the verification pit.



Photograph 8:
Excavation within public open space and verification pit showing the presence of a remediation break layer at the base, a crushed sandstone inert fill overlain by topsoil.



Photographs 9 and 10: Inert crushed sandstone being delivered with remediation break layer visible in Photograph 10. The spatial area of the remediation can be observed from these photographs (old terrace housing in Photograph 9 and traffic lights in photograph 10).





Photographs 11 and 12 show the remediation of the rear garden, with a significant depth (1.0m) of inert cover. Remediation break layer visible at the base of the excavation. Photograph 11 has been stitched to form a panoramic photograph and