LITHOS

Remediation Strategy

Land at Dewsbury Riverside Gateway

For Kirklees Council & Barton Wilmore

Report no: 3901/3

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Tel: 01937 545330 • info@lithos.co.uk • www.lithos.co.uk

CONTENTS

APPENDICES

Appendix A – Drawings

Drawing	Revision	Title
3901/1	-	Site location plan
3901/3	-	Site features
3901/7	-	Revised conceptual site model
3901/8	-	Coal mining & geological features
3901/13	-	Bedrock composition
3901/15	-	Extent of Middleton Main Coal requiring consolidation

Appendix B – Lithos protocol for importation & use of soil cover

Appendix C – Lithos Tier 1 screening values

Appendix D – Protocol for the placement of non-engineered fill

Appendix E – Protocol for inspection of gas measures

REMEDIATION STRATEGY
FOR LAND AT
DEWSBURY RIVERSIDE GATEWAY

1 INTRODUCTION

1.1 The commission and brief

1.1.1 Lithos Consulting Limited have been commissioned by Kirklees Council & Barton Wilmore to prepare a Remediation Strategy for land off Ravensthorpe Road about 2.5km southwest of Dewsbury town centre.

1.1.2 The area considered in this report is called the Dewsbury Riverside Central Gateway Development (c. 30 ha). The Central Gateway falls within a much larger area (c. 156 ha) called the Dewsbury Riverside Development which has been allocated for the construction of about 4,000 residential dwellings as well as three schools.

1.1.3 Lithos have issued a total of 8 reports relating to the larger Dewsbury Riverside Development. Of these reports, four cover the current area of interest:

1) 'Preliminary Geoenvironmental Appraisal – Land at Dewsbury Riverside', Ref. 2336/1A, issued to Miller Homes in April 2016; and,
2) 'Geoenvironmental Appraisal - Land at Dewsbury Riverside Phase 2', Ref. 2336/3, issued to Miller Homes in January 2018.
3) 'Preliminary Geoenvironmental Appraisal – Land at Dewsbury Riverside Gateway'; Ref. 3901/1 issued to Kirklees Council & Barton Wilmore in December 2020.
4) 'Geoenvironmental Appraisal – Land at Dewsbury Riverside Gateway'; Ref. 3901/2A, issued to Kirklees Council and Barton Wilmore in July 2021.

1.1.4 All relevant information and findings contained in Reports 1, 2 & 3 have been incorporated into Report 4 which can be read independently with no reliance on Reports 1, 2 or 3.

1.1.5 The appointed Remediation Contractor will need to familiarise themselves with Report 4 and comply with all relevant recommendations contained therein.

1.1.6 This document outlines the remediation objectives necessary to protect environmental receptors, and render the site suitable for the proposed development. A Method Statement should be prepared in order to detail how the objectives will be achieved.

1.1.7 The Method Statement should be accompanied by a Designer's Risk Assessment in accordance with the CDM Regulations, 2015. The Method Statement and Risk Assessment should be submitted to, and approved by the supervising Engineer or Site Manager.

1.1.8 The area of proposed development is essentially greenfield and contamination (relatively minor) is essentially restricted to the northeast (vicinity of the allotments and nursery car park). The new Spine Road is expected to pass through this area, but no built development is anticipated.

1.1.9 The site slopes down to the north with gradients of up to 1v:6h (typically around 1v:12h) and significant cut and fill earthworks will be required to create development terraces.

1.2 The proposed development

1.2.1 It is understood that consideration is being given to redevelopment of the site with 'traditional' two and/or three storey domestic dwellings, associated gardens, POS and adoptable roads and sewers.

1.2.2 To date an indicative layout has not been provided however of the total site area (30.3ha) it is understood that 9.1ha comprises Ravenshall School, Lady Wood and Lady Wood Extension (areas of woodland) where no development is proposed. The remaining 21.1ha predominantly comprises arable farmland (a car-park and allotments are located in the northeast) and is to be given to a residential development with dwellings, associated gardens, areas of POS and adoptable roads and sewers.

1.2.3 Barton Willmore have been commissioned by KC to prepare an indicative site layout and submit a Hybrid Planning Application. The planning application will include elements associated with a proposed access roundabout and spine road from Forge Lane.

1.2.4 Access to the development will be via a proposed spine road which will pass through the northeastern corner (currently a car park and allotments) and which will open out onto Ravenshall Road (which runs east to west beyond the northern boundary).

1.2.5 At this stage it is assumed that plots will be founded on 'traditional' strip footings founded in natural soils or bedrock. Footings will require reinforcement where underlain by consolidated shallow mineworkings. However earthworks regrade and the chosen method of placement of fill may necessitate alternative foundation solutions for some plots.

2 Background

2.1 Site description

2.1.1 Site details are summarised below:

Detail	Remarks
Location	2.5km southwest of Dewsbury town centre.
NGR	SE 228 195.
Approximate area	30 hectares (74 acres).
Known services	Overhead electricity. Underground (mains) gas, water, drainage culvert & (redundant) colliery gas pipeline.

2.1.2 A location plan and current salient features are shown on Drawings 3901/1 and 3901/3 in Appendix A.

2.1.3 The majority of the site is essentially greenfield and has been occupied by farmland since pre-1855. An area of c. 3ha in the west is occupied by Lady Wood; an area of ancient woodland which historical mapping shows has been subject to coal mining.

2.1.4 Opencast coal mining has taken place in the west of the site (but outside the area given to development) and across land to the south.

2.1.5 Spoil heaps were placed and refuse tipping occurred from c. 1930 to c. 1980 in the west (an area now referred to as Lady Wood Extension) which was planted with trees in 2000. The area of refuse tipping is recorded by the Environment Agency as an area of landfill which was operated by Thornhill Power Station; fill likely included inert and industrial waste. Further areas of landfill are recorded from 20m north and from 200m east.

2.1.6 Small buildings have been present in the northeast from pre-1855. However, these were demolished and replaced with a car park and allotment gardens (which remain in-place) in c. 1930.

2.1.7 Ravenshall School is located in the north and occupies an area of about 2.0ha. The school was constructed in c. 1980 and expanded in c. 2000.

2.2 Ground investigation

2.2.1 Lithos undertook a ground investigation across the northern c. 7.2ha in 2017 for Miller Homes. However, the bulk of Lithos' ground investigation across the wider area being developed was undertaken in line with a scope of works which was set out by Kirklees Council in their invitation to tender for ground investigation works.

2.2.2 Lithos has undertaken ground investigation in several phases between April 2017 and January 2021 comprising the following exploratory holes:

Technique	Exploratory holes	Total	Remarks
Trial Pits	TPs 301 – 322 & 501 - 535	57	Vane tests in cohesive soils
Soakaway tests	In TPs 531 – 534	4	-
Dynamic sample boreholes	WSs 501 – 515	15	Monitoring wells installed in 8 BHs
Rotary open probeholes	PHs 201 – 204, 207 – 219 & 501 - 532	49	Monitoring wells installed in 17 PHs. Spot coring to retrieve coal samples.

2.2.3 A total of 44 samples were submitted for chemical testing to assess the impact of any contamination in the Made Ground and to assess the suitability of Topsoil for re-use. A total of 34 samples were submitted for geotechnical testing to determine the engineering properties of natural soils and rock.

2.2.4 Gas/groundwater monitoring wells were installed in 8 dynamic sample boreholes and 17 probeholes. On completion, the wells were monitored for hazardous gasses on 6 occasions over a three month period.

Made Ground

2.2.5 The majority of the site is essentially greenfield and does not include made ground. However, made ground was encountered in three areas:

- Beneath **Lady Wood Extension** made ground is related to historical tipping, reaches up to 2.4m (likely much deeper in areas) and comprises;
  - Made Ground Topsoil
  - Ash & Clinker
  - Cohesive Made Ground
  - Granular Made Ground
- Beneath the **allotments & car** park made ground is related to former buildings and construction of the car park, reaches up to 0.9m depth (typically 0.6m) and comprises;
  - Made ground Topsoil
  - Burnt Shale
  - Sub-Base
  - Cohesive Made Ground
  - Granular Made Ground
- Localised Cohesive Made Ground was also encountered in **TP525** to 1.2m depth which is expected to be associated with construction of the gas utility which crosses the centre-west.

2.2.6 It should be noted that whilst the most significant made ground has been encountered beneath Lady Wood Extension no development or works are proposed across this area.

Obstructions

2.2.7 Some former buildings have been present in the northeast (allotments & nursery car park) and the far-west (Lady Wood). To date no obstructions have been encountered in these areas but the presence of some relict foundations, floor slabs etc cannot be entirely discounted.

Natural ground

2.2.8 Natural ground was encountered in the majority of exploratory holes beneath a veneer of Topsoil which was typically c. 300mm thick.

2.2.9 Across the centre-north and northeast, natural soils comprised Cohesive Glacial Deposits (medium to high strength gravelly clay, with a low to medium cobble content and rare boulders). The Glacial Deposits thicken to the north and northwest.

2.2.10 Across the centre, south and west natural soils predominantly comprised Cohesive Residual Soils (medium to high strength gravelly clay).

2.2.11 Bedrock was encountered from between 0.7m and 3.1m depth (generally shallower to the south and deeper to the north & east), and comprised Lower Coal Measures; interbedded sandstone siltstone and mudstone. The approximate distribution of the different rock types is shown on Drawing 3901/13.

Groundwater

2.2.12 Bedrock is classified as a Secondar A Aquifer and is only protected by a relatively thin veneer of residual soils across the centre and north. Monitoring of the wells shows that groundwater is shallowest in the lowest lying areas of the site (the north) and deeper across the south. Levels vary from c. 0.7m to c. 40m depth (c. 46mAOD to 83mAOD).

2.2.13 Groundwater ingress was encountered in 14 trial pits, generally across the centre-north and generally when excavating through sandstone bedrock. Ingress was always encountered in the form of relatively minor seepages.

Mining

2.2.14 The Coal Authority have records of 40 mine entries within, or within 20m of, the site boundary, the majority of which are located in Lady Wood and Lady Wood Extension in the west where no development is proposed. However one mine entry is located in the centre of the site, two mine entries are located in the north and one mine entry is located within the grounds of Ravenshall School (northeast of the site; no development proposed).

2.2.15 There is also anecdotal evidence of a 'walk-in' mine (likely a drift/adit) being located in the centre of the site.

2.2.16 Recorded locations of these shafts are indicated on Drawing 3901/8, and details for each are summarised below:

Shaft reference	Source of data	Location	Remarks
422419-027.	Coal Authority data	Centre	No further information provided.
423419-006 & 423419-005		Northeast	
423419-004.		Northeast (school grounds)	
n/a	Anecdotal	Centre	Walk-in mine entry with rail tracks.

2.2.17 Areas of former opencast coal extraction are present in the west of the site, as well as across land to the south. However, no opencast has been found to date beneath the area where development is proposed.

2.2.18 Lithos' mining investigation was undertaken in accordance with a scope of works outlined by Kirklees Council. Further coal mining investigation will be required to reduce uncertainty in relation to coal mining beneath this site.

2.2.19 To date shallow workings have been encountered in the Middleton Main Coal Seam beneath the north of the site (see Drawing 3901/15) and these will require consolidation by means of drill and grout.

2.2.20 However, further shallow workings, including workings which may have been backfilled with spoil or 'packed', may well pe present across the centre and south.

Contamination

2.2.21 Contamination encountered is restricted to two areas; soils beneath Lady Wood Extension and soils beneath the Allotments and car-park.

2.2.22 Made Ground beneath **Lady Wood Extension** comprises materials placed during refuse tipping; the area is recorded as an area of landfill and the source of the material appears to (at least partly) be from Thornhill power station. Made Ground beneath this area has been found to contain a number of inorganic determinands, sporadic asbestos fibres and is potentially combustible.

2.2.23 However no development is proposed in this area and the 'traditional' pathways between the source (made ground) and the most sensitive receptors (end users) are far less significant than if this made ground were present beneath plots, gardens and landscaped areas. Root growth will act to stabilise shallow soils and 'bind' inorganic contaminants within the soil mass reducing the potential for wind-blown dust etc. Furthermore, digging is not envisaged, although animal burrows may fetch contaminated soils to the surface.

2.2.24 In summary, risks to health associated with transient activities in this area are likely to be negligible and no "remediation" is anticipated at this stage.

2.2.25 Made Ground Topsoil within the **allotments** has been found to be slightly 'contaminated' with inorganic contaminants (namely lead & arsenic). This material is not considered suitable for re-use, but consideration could be given to additional sampling and testing, notably bioaccessibility testing, to determine whether it could remain near surface in gardens and areas of POS, or even be considered suitable for re-use at surface.

2.2.26 Cohesive Made Ground (**allotments & nursery car park**) has yielded slightly elevated concentrations of TPHs & benzo(a)pyrene. Whilst BaP exceeds the Lithos' Tier 1 value for a residential end use with no soil cover, it is below the Tier 1 value for a residential end use with 600mm soil cover and consequently is considered suitable for isolation beneath clean cover or areas of hardstand/building floor slabs.

2.2.27 Assessment of the site investigation data enabled formulation of a conceptual model, which is presented as Drawing 3901/7 in Appendix A.

2.2.28 In terms of the proposed redevelopment plausible pollutant linkages, and feasible remediation options, can be summarised as follows:

Receptors	Pathways	Contaminants	Plausible pollutant linkage? (and remediation options where required)
Greenfield Areas			
No significant contamination encountered to date.			
Nursery car park & allotments			
Human health (Future residents) ◊	Consumption of contaminated vegetables	Metals, hydrocarbons in the made ground	**No;** area lies on the line of a proposed highway. Hardstand will sufficiently isolate end users from contaminants.
	Ingestion		
	Dermal contact		
	Inhalation (dust and/or vapours)		
	Infiltration of water supply pipes	Hydrocarbons in the made ground	Water company may insist of "protectaline" pipework
Buildings	Migration & accumulation of explosive gas	Methane	To be assessed on completion of monitoring and gas risk assessment
Surface watercourse & groundwater	Surface water run-off & infiltration through made ground.	Hydrocarbons & inorganics in made ground.	**No;** contamination relatively minor and construction of impermeable highway & highways drainage will significantly reduce contact between waters and contaminants in made ground.
Lady Wood Extension			
Human health (Future residents) ◊	Consumption of contaminated vegetables	Metals, asbestos & combustibility.	**No;** development not anticipated across this area.
	Ingestion		
	Dermal contact		
	Inhalation (dust and/or vapours)		
Buildings	Migration & accumulation of explosive gas	Methane & carbon monoxide.	**No;** development not anticipated across this area.
	Combustion & generation of hazardous gas	Combustibility of Ash & Clinker.	**No;** development not anticipated across this area & woodland growth precludes bonfires etc.
Surface watercourse & groundwater	Surface water run-off & infiltration through made ground	Metals, hydrocarbons in the made ground	**No;** ongoing growth of vegetation will reduce over/through ground flow & stabilise shallow soils.

◊ transient risks to construction workers will be addressed by the adoption of appropriate health and safety measures in accordance with the Health and Safety at Work Act 1974 and regulations made under the Act including for example the COSHH Regulations.

Hazardous gas

2.2.29 There are areas of known landfill, backfilled quarries, opencast and underground workings beneath the site and in the surrounding area. Consequently, monitoring wells have been installed in 8 dynamic sample boreholes and 17 probeholes.

2.2.30 In accordance with the Kirklees Council scope the wells have been monitored for hazardous gasses on 6 occasions over a three month period, further monitoring visits over a longer period of time will be required to undertake a Gas Risk Assessment in accordance with the guidance given in CIRIA Report C665[1].

2.2.31 Current data indicates a gas screening value for the site that could fall within NHBC classification of Green. However, low oxygen concentrations, shallow fluctuating groundwater, and the presence of shallow mineworkings suggest a more precautionary approach is necessary.

2.2.32 Based on the site conceptual model and need to protect new dwelling from changing ground gas conditions, it is more likely that parts of the site will fall within **Amber 1** or **Amber 2** classification.

3 EARTHWORKS REGRADE

3.1.1 Within the area of proposed development, land falls to the north at a typical gradient of 1v:12h; maximum about 1v:6h. It is envisaged that significant cut and fill earthworks will be undertaken prior to/as part of the construction process to create development terraces.

3.1.2 Acceptability of both the weathered Coal Measures and Glacial Deposits for use in the proposed controlled earthworks will need detailed appraisal by the Earthworks Designer in light of the required performance characteristics. An Earthworks Compaction Specification should be prepared.

3.1.3 To date no details relating to proposed earthworks and final levels have been made available, but earthworks are likely to have an impact on foundation solutions, most notably where the depth of placed fill exceeds 2.5m.

3.1.4 Any digital terrain modelling undertaken, or commissioned, by Kirklees Council should consider implications for slope stability, retaining walls, foundations, highway gradients and drainage. The digital terrain modeller should consider:

- Achievement of a materials balance (thereby avoiding the need for any significant import or export of soils)
- The likelihood of excavation in hard rock
- Any reduction of the depth of competent cover above mineworkings.
- Groundwater control in the event that flooded mineworkings (or unrecorded adits) are encountered in areas of more significant cut.
- Acceptable highway and drive gradients
- Implications for foundations
- Bulking of excavated arisings even after placement with compaction
- The thickness of the soil cover required in garden areas

3.1.5 Any digital terrain modelling undertaken should be made available to Kirklees Council's Engineering Designer.

[1] CIRIA C665: Assessing risks posed by hazardous ground gases to buildings (2007).

3.1.6 Final site levels should then be issued by the Engineering Designer, via an External Works Drawing, which should show:

- Proposed finished floor levels
- Proposed finished road levels
- Garden & driveway levels and gradients

4 REMEDIATION STRATEGY (General)

4.1 Aims

4.1.1 Remediation aims are to:

- Resolve contamination issues in order to protect environmental receptors, and render the site suitable for the proposed development
- Provide a stable development platform (to agreed levels and gradients) for subsequent construction of the proposed development and associated infrastructure
- Satisfy requirements of the Local Planning Authority and the National House Building Council (NHBC)

4.2 Overview

4.2.1 The following remediation works are required:

- Supplementary ground investigation (see Section 5.5)
- General site clearance of surface materials and vegetation (allotments)
- Break-up of hardstand (car-park)
- Crushing of all suitable artificial hard material (i.e. concrete/brick etc)
- Excavation of up to a maximum depth of 2m beneath proposed adoptable road footprints and controlled re-engineering of selected materials in layers to approximately 600mm below final road levels (car park & allotments)
- Location and treatment of mine entries
- Provision of a minimum 150mm thick cover layer of 'clean' soils in all garden and landscaped areas

4.3 Site set-up, organisation and safety

4.3.1 Site cabins and welfare facilities are to be established at a location to be agreed with the supervising engineer or Site Manager. All welfare facilities must be established in accordance with the relevant health & safety statutory requirements. Provision should be provided on site for car parking for all site employees.

4.3.2 All site personnel should undergo a site-specific health and safety induction prior to commencement of work on site.

4.3.3 The Site Manager should be informed prior to any proposed entry of a confined space or deep excavation. Entry must be restricted to suitably qualified and equipped personnel.

4.3.4 Access into excavations etc. must be controlled and undertaken in accordance with the CDM Regulations 2015, most notably Regulation 22, to mitigate risk of collapse or asphyxiation.

4.3.5 If at any time during the works personnel begin to feel unwell, they are to inform the Manager, who will determine appropriate action.

4.3.6 During the remediation works, all personnel on site will comply with guidance provided in the Health and Safety Executive (HSE) document "Protection of Workers and the General Public during the Redevelopment of Contaminated Land". In summary, the following should be provided:

- Protective clothing, footwear and gloves. (Personnel should be instructed in why and how they are to be used)
- Hand-washing and boot-washing facilities
- Designated smoking areas

4.3.7 All visitors to site must enter and register at the main Site Office.

4.4 Contractor's responsibilities

4.4.1 Prior to the commencement of any works the Contractor, in agreement with the Site Manager, should:

- Comply with any requirements of Kirklees Council's contract documentation
- Establish the boundaries of the site and the working areas
- Undertake a dilapidation survey of site boundaries, adjacent properties and highways, via dated photographs or video footage
- Liaise with the Local Authority regarding working hours, noise/dust/odour control, and protected trees
- Liaise with the Local Water Company regarding any proposed discharge to sewer
- Complete a full services search and liaise with all relevant utility companies regarding work in close proximity to their apparatus
- Prepare a detailed Method Statement outlining how the objectives of this Remediation Strategy will be achieved (and obtain approvals)
- Inform the Supervising Engineer or Site Manager of any risk, identified and assessed, which could impact upon site activities
- Prepare the necessary COSHH statements and Health & Safety Plan in accordance with CDM regulations

4.4.2 The Contractor should satisfy the Health & Safety Executive with regard to all matters concerning the health, safety and welfare of persons on the site.

4.4.3 The Contractor should ensure that:

- Personnel, plant, materials and other equipment related to the contract are confined within the boundaries of the site.
- Any live services lying within the site boundary are marked and protected, or appropriate arrangements made to truncate them.
- Good practices relating to personal hygiene are adopted.
- Suitable precautions are implemented at all times to prevent off-site migration of contaminants via airborne dust and vapours.
- Suitable precautions are taken to prevent the spread of mud and debris on public highways.
- Refuelling of mobile plant is undertaken in a designated area. Above ground oil storage tanks should comply with the requirements of Pollution Prevention Guideline PPG2. A spill kit should be kept on site, adjacent to the designated refuelling area. (Lithos are aware that some of the EA PPG documents have been withdrawn from the gov.uk website. However, PPGs provided a summary of current UK guidance; the principles are still relevant and provide a useful, concise overview).

4.4.4 It should be noted that utilities crossing this site include overhead electricity pylons and an underground regional high pressure gas utility and early liaison with the relevant utility providers (notably Northern Gas and National Grid) to discuss the required easements, safe working practices etc is strongly advised.

4.5 Materials Management Plan

4.5.1 Subject to final levels and the earthworks modelling (balance of cut vs. fill materials) this project will involve the re-use of both natural and made ground soils on site, and possibly the import of natural soils from another development site(s). Therefore, the Contractor should consider the need to prepare a Materials Management Plan (MMP) in accordance with the CL:AIRE Code of Practice (v2, March 2011).

4.5.2 The MMP will document how all of the materials to be excavated during the proposed site preparatory and remediation earthworks are to be dealt with. In summary the MMP should provide:

- Details of the parties that will be involved with the implementation of the MMP
- A description of the materials in terms of potential use and relative quantities of each category
- The specification for use of materials against which proposed materials will be assessed, underpinned by an appropriate risk assessment related to the place where they are to be used
- Details of where and, if appropriate, how these materials will be stored
- Details of the intended final destination and use of these materials
- Details of how these materials are to be tracked
- Contingency arrangements that must be put in place prior to movement of these materials
- Verification Plan

4.5.3 The MMP should include consideration of the following factors:

- Any risks posed by the excavated materials to both human health and the environment
- Suitability for use
- Certainty of use
- Anticipated quantities of materials

4.5.4 The MMP should also detail how materials will be tracked throughout the earthworks in order that the subsequent Verification Report can provide an auditable trail. The tracking system must include:

- Annotated plans of the site(s) identifying different excavation areas, stockpile locations, treatment areas (if applicable) and placement locations
- Inspection procedures
- Registered waste carrier and non-waste haulier
- Tracking form / control sheets
- Treatment results (if applicable)
- Delivery tickets for non-waste materials (if moving from one site to another)
- Acceptance procedures for non-waste materials

4.5.5 Finally, the MMP will have to set out a Verification Plan that identifies how the placement of materials is to be recorded and the quantities of material to be used. It will contain a statement on how the use of the materials relate to the remediation or design objectives.

4.5.6 Once completed, the MMP will need to be reviewed by a Qualified Person (QP), who will submit an online Declaration to CL:AIRE and send a copy to Kirklees Council. It should be noted that in accordance with the Code of Practice, Lithos cannot act as the Qualified Person because we have undertaken the site investigation and prepared this Remediation Strategy.

4.6 Engineering supervision and verification

4.6.1 Site works should be supervised throughout by a suitably qualified Site Manager, who will report to a Project Manager, supported as\where necessary by a suitably qualified geoenvironmental engineer. Engineering supervision may be part-time for certain activities, but must be full-time during the removal of any grossly contaminated soil/fill and any placement of fill to an engineering specification.

4.6.2 The Site Manager will ensure that the requirements of this Remediation Strategy are complied with in a safe and orderly manner.

4.6.3 The responsibilities of the Site Manager should include, but not be limited to, the following:

- Ensuring that all site personnel are suitably qualified and given an appropriate induction at the beginning of their first day
- Supervision of the remediation and ground preparatory works
- Provision of advice on the correct handling of materials and conditions encountered
- Provision of guidance on the appropriate protective clothing and safety equipment that is to be made available and used
- Ensuring that personal hygiene arrangements are adequate
- Retrieval of soil and water samples and the subsequent scheduling of appropriate laboratory analysis to enable verification of various aspects of the works, and to advise the Project Manager of progress
- Liaison with statutory authorities as required

4.6.4 The Site Manager will maintain records of the works to include the following:

- Daily record sheets to include a summary of the day's activities
- Date and weather conditions
- Plant, personnel and visitors present
- Aspects relating to Health and Safety, Environmental Control, or non-compliance with either this Remediation Strategy or the Contractor's Method Statement
- Site surveys as necessary to record the locations of demolition, excavation and filling activity
- Test results

4.6.5 On satisfactory completion of all the works the Site Manager, with input from the geoenvironmental engineer as necessary, will prepare a Verification Report, in accordance with the Environment Agency's online guidance "Land Contamination Risk Management" which replaced CLR11 in October 2020. Copies of the Verification Report will be issued to the Kirklees Council, the Local Authority and NHBC.

4.6.6 The Verification Report will stand as certification that the remediation and ground preparatory works have been carried out in accordance with this Remediation Strategy.

4.6.7 The Verification Report will include:

- A summary of the preparatory & remediation works undertaken, including any works associated with unforeseen ground conditions
- Verification test results associated with "hot-spot" treatment, including plans showing sample locations & levels, and the extent of any "hot-spot" excavations
- Details of the fate of any arisings excavated from "hot-spot"
- Verification test results associated with proposed source materials for clean cover
- Moisture content and plate bearing test results associated with ground improvement beneath proposed highways and dwellings
- Copies of any correspondence with Regulators relating to specific aspects of the remediation works
- Reference to the MMP and associated tracking system, including alterations made and why.
- Signed delivery tickets (if applicable)
- Record of quantity of materials used

4.6.8 The Verification Report will also provide recommendations with respect to:

- Foundation Solution(s)
- Gas Measures
- Placement of Soil Cover
- Handling of Contaminated Soils

4.6.9 The above recommendations will take account of the actual remediation works undertaken, and may differ significantly from recommendations originally presented in the site investigation report.

5 REMEDIATION STRATEGY (specific objectives)

5.1 Contingency for unknowns

5.1.1 Even after an appropriate preliminary investigation and ground investigation, with exploratory holes on a closely spaced grid (say trial pits at 30m centres), a geoenvironmental appraisal is typically based on inspection of the ground underlying less than 0.5% of the total site area (and much less at depths in excess of about 3.5m). Consequently, there is always a possibility that unanticipated ground conditions will be encountered during the remediation works.

5.1.2 If unanticipated ground is encountered during the remediation works, the Contractor should immediately seek further advice from the Engineer.

5.1.3 In order to assess the nature of any unanticipated grossly contaminated soil/fill, and (if necessary) allow revision of this Strategy document, it should be placed in temporary stockpiles on hardstand or Visqueen, suitably covered and bunded.

5.1.4 Analysis of at least 6 samples, for an appropriate range of determinands should be undertaken. On receipt of the results, the Engineer will liaise with the Contractor regarding the most appropriate remediation option.

5.2 Decommissioning of boreholes

5.2.1 Monitoring wells should be decommissioned in order to prevent the possibility of gas migration into sub-floor voids. Decommissioning could be achieved by filling the well with bentonite/cement grout. The headworks (raised helmet or stop-cock type cover) should then be removed and the surface made good.

5.2.2 Ideally the upper length of HDPE well pipe should be back-screwed and removed from the borehole, with the resultant 'hole' to be filled with bentonite pellets (to be wetted after placement).

5.2.3 Account should be taken of proposed changes in ground level that will result from the anticipated earthworks (see Section 5.6).

5.3 Site clearance

5.3.1 Any trees currently under a preservation order should be identified and agreed with relevant authorities prior to the commencement of the works. All trees subject to a TPO should be clearly identified and protected by fencing in accordance with BS5837: 2012.

5.3.2 The site should then be cleared of all residual debris, any vegetation, shrubs, bushes and unprotected trees as instructed by Kirklees Council.

5.3.3 Topsoil, typically 300mm thick, is present across the greenfield areas of the site and testing suggests that this material is chemically suitable for re-use. the topsoil at this site generally complies to the standards set out in BS3882. In terms of textural classification the Topsoil generally falls into the loam/clay loam class.

5.3.4 However, Topsoil recovered from the Allotment Gardens is not considered suitable for re-use and should be stripped and stockpiled separately from Topsoil recovered from the wider site.

5.3.5 Analysis (pH, metals, asbestos ID and speciated PAH) of further samples from the topsoil stockpile in order to confirm its suitability for re-use.

5.4 Asbestos

5.4.1 An asbestos ID (screen) was scheduled on 44 samples of Made Ground and Topsoil, however the only samples which returned positive asbestos IDs were recovered from the area of landfill beneath Lady Wood Extension which is not being given to development.

5.4.2 Localised fragments of asbestos cement sheeting may be encountered during the site remediation and preparatory works, most notably across the car-park and allotments. All suspected asbestos-containing material should be recovered by hand and placed in double sealed bags, within a sealed skip for off-site disposal at a suitably licensed landfill site. Personnel involved in this activity should be equipped with appropriate personal protective equipment, including dust masks (minimum FFP3).

5.5 Supplementary ground investigation

5.5.1 To date ground investigation works have been predominantly undertaken in line with a scope of works which was set out by Kirklees Council.

5.5.2 Further supplementary works are required to reduce uncertainty which remains, most notably in relation to:

- the risk posed by hazardous gas,
- shallow mineworkings in the south,
- ground conditions beneath the car park & allotments and
- the suitability of Topsoil from the allotments for re-use.

5.5.3 The investigation will be undertaken in general accordance with current UK guidance (most notably BS10175:2011+A2:2017). The soils encountered during this investigation will be logged in general accordance with BS5930:2015.

5.5.4 At this stage it is envisaged that the supplementary ground investigation would comprise:

- Additional rotary probeholes
- Rotary cored boreholes to determine whether any packed workings are present and to assess bedrock in any proposed areas of significant earthworks cut
- Further trial pits to locate the former sandstone quarry in the centre
- Post-vacation trial pits across the area of the allotments and car-park
- Bioaccessibility testing for arsenic in topsoil from the main development area
- Further monitoring for hazardous ground gas (as a minimum, twice monthly for a further 3 months)

5.5.5 Representative soil/fill samples will be taken by the Engineer. The number of samples taken will be reflective of the fill/geological complexity actually encountered. However, in general about 3 samples will be taken from most pits.

5.5.6 Selected samples will be sent to a suitably accredited laboratory and scheduled for appropriate chemical analysis (likely to comprise speciated PAH and speciated TPH). Analysis for other determinands may be appropriate and will be requested by the Engineer as necessary.

5.5.7 Consideration could be given to further topsoil stripping in order to locate Shaft -027, but this would require liaison with Northern Gas Networks. In any case, given the presence of the gas main (and the area already searched), this shaft likely lies well beyond the footprint of any proposed dwellings.

5.5.8 Consideration could also be given to a geophysical survey to check for the presence of unrecorded mine entries. Follow-up intrusive investigation (pitting) would be recommended to determine the cause of any anomalies identified by the geophysics.

5.5.9 If a detention basin is proposed, water table levels should be taken from borehole monitoring wells over 4 consecutive seasons, for at least 3 points in the basin area.

5.6 Earthworks regrade & compaction specification

5.6.1 Within the area of proposed development, land falls to the north at a typical gradient of 1v:12h; maximum about 1v:6h. It is envisaged that significant cut and fill earthworks will be undertaken to create development terraces.

5.6.2 Any digital terrain modelling undertaken, or commissioned, by Kirklees Council should consider implications for slope stability, retaining walls, foundations, highway gradients and drainage. Digital terrain modelling, should:

- Achieve a materials balance (thereby avoiding the need for any significant import or export of soils)
- Confirm final levels, including Plot FFLs
- Result in acceptable highway and drive gradients
- Minimise foundation abnormals

5.6.3 Regrade to create development terraces could result in a reduction of the depth of competent cover above mineworkings and consideration should be given to this during any earthworks modelling. Furthermore, consideration should be given to groundwater control in the event that flooded mineworkings (or unrecorded adits) are encountered in areas of more significant cut.

5.6.4 Any areas of deeper cut (say >3m) are likely to expose bedrock. Approximate depths to bedrock are shown on Drawing 3901/12 and the approximate distribution of bedrock types is shown on Drawing 3901/13. It is understood that some sections of the proposed new spine road might require cuttings in excess of 6m depth; further ground investigation (rotary cored boreholes) would be prudent in such areas.

5.6.5 Acceptability of both the weathered Coal Measures and Glacial Deposits for use in the proposed controlled earthworks will need detailed appraisal by the Earthworks Designer in light of the required performance characteristics.

5.6.6 Following the anticipated earthworks, placed fill materials should not contain obstructions and be relatively stable with little overbreak. At this stage, it is assumed that fill will be placed with nominal compaction only; reinforced footings on engineered fill are not currently anticipated.

5.6.7 Natural ground underlying this site is often clayey, therefore consideration should be given to the implication of undertaking earthworks in poor/wet weather when the ground surface is likely to become difficult to cross with heavy machinery.

5.6.8 An Earthworks Compaction Specification should be prepared.

5.7 Coal Extraction

5.7.1 Subject to agreement with the Engineer and Kirklees Council, the Contractor might extract coal at/close to outcrop beneath made ground.

5.7.2 If the Contractor intends to recover any coal he will be responsible for obtaining the necessary Incidental Coal Agreement, and the coal preparation permit, and providing Kirklees Council with copies of the approvals/consents. In addition to the requirements of this Remediation Strategy, the Contractor must satisfy all requirements/conditions of the planning permission and Incidental Coal Agreement.

5.7.3 On removal of coal, the depth and extent of each panel shall be recorded by survey. Where the base of the excavation is sloping the sub-grade shall be benched, with the maximum vertical height of each bench not exceeding 300mm, and the minimum width not being less than 3.0m.

5.7.4 On completion of coal extraction, each panel will be backfilled in accordance with an Earthworks Specification (to be prepared).

5.8 General excavation

5.8.1 Excavation of made ground should be undertaken in a controlled manner, working from a line agreed with the Site Manager in linear panels.

5.8.2 Excavated material should be removed from each panel and screened to remove oversize (> 200mm) and other unsuitable (e.g. anthropogenic or biodegradable materials), prior to replacement.

5.8.3 Each panel should be inspected by the Site Manager, and have its depth and extent recorded by survey, prior to backfilling (see Section 5.17).

5.8.4 Any excavated and screened material that needs to be stockpiled temporarily should be placed in areas designated by the Site Manager. Any stockpile of made ground should be assumed to contain elevated concentrations of inorganic contaminants, and it should be ensured that such materials are not allowed to cross-contaminate any clean soils or controlled waters.

5.9 Excavation of contaminated soil

Topsoil (Allotments)

5.9.1 Topsoil recovered from the Allotments is not considered suitable for re-use and should be stockpiled separately from all other site-won Topsoil.

5.9.2 This material should be stockpiled until either; further testing and assessment has been caried out to determine its suitability for re-use; or, it can be placed in garden areas and/or POS, immediately beneath a 600mm cover of "clean" soil, but that it is overlain by no more than 1m of soil.

Made ground

5.9.3 Made Ground soils excavated from the area of the Allotments and car-park should be stockpiled separately from any natural soil arisings until they can be isolated beneath areas of hardstand or in proposed gardens or landscaped areas where it would need to be isolated beneath at least 600mm of clean cover comprising 450mm of 'clean' subsoil and at least 150mm of Topsoil.

5.10 Control of water

5.10.1 Groundwater should be controlled in accordance with CIRIA report 113 "Control of Groundwater for Temporary Works".

5.10.2 Arrangements should be made to prevent ponding in any excavation "hollows"; the Contractor should ensure that ground levels are of sufficient gradient to enable the collection of surface water run-off in sumps or grips.

5.10.3 Pumping from over-excavated sumps may be required to maintain satisfactory working conditions.

5.10.4 The Contractor should make all necessary arrangements to prevent off-site migration of contaminated sediment via surface water run-off. This might necessitate the installation of surface water grips.

5.10.5 A Silt Management Plan should be prepared by the Contractor, describing the mitigation measures that will be put in place to intercept direct run-off from any disturbed areas, stockpiles etc, thereby preventing any potential impact of adjacent land and nearby watercourses. Surface water run-off will probably require treatment (as a minimum to allow settlement of fines) prior to consented discharge.

5.10.6 It is quite likely that perched waters will be encountered during the remediation earthworks; most commonly associated with redundant drains and buried structures.

5.11 Removal of below ground obstructions

5.11.1 Any foundations associated with existing buildings and other relict structures (unlikely to be encountered other than in the nursery car park) should be chased out and grubbed-up, in order to remove potential obstructions to new foundations and infrastructure.

5.12 Crushing

5.12.1 Production of a selected granular fill should be possible if suitable materials (generated by grubbing-up of hardstand and any buried obstructions) are crushed.

5.12.2 The crushed product should be screened to remove any unsuitable elements and stockpiled for re-use during the subsequent construction works. Generation of a Class 6 material as defined in the Highways Agency Specification (Series 600) may well be possible.

5.12.3 Tarmac could be recycled and crushed to yield a 6F3 selected granular material, provided the recovered bitumen content is less than 10% (determined in accordance with BS598-1:2011). Alternatively, crushed tarmac could also be blended with crushed concrete etc to generate 6F2 graded material. 6F2 can contain up to 50% recycled tarmac/asphalt (provided it does not pose a contamination risk to controlled waters and, if the proportion of asphalt is greater than 20% & the recovered bitumen content is less than 2%).

5.12.4 The Engineer should check the suitability of crushed product for re-use, instruct the removal of any unsuitable material and schedule appropriate confirmatory geotechnical or chemical testing.

5.12.5 A minimum of 3 samples (or 1 sample per 500m^3, whichever is the greater) should be taken from any stockpile of specific crushed product and sent to a UKAS accredited laboratory for analysis to assess whether the material conforms to requirements as defined in of the Highways Agency Specification for Highway Works; Series 600 (if 6F2 is anticipated), or Series 800 (if Type 1).

5.12.6 A minimum of 3 samples (or 1 sample per 500m^3, whichever is the greater) should be taken from any stockpile of specific crushed product and sent to a UKAS accredited laboratory for asbestos analysis.

5.13 Backfill of excavations

5.13.1 Excavated soils should be placed as necessary to achieve the desired levels, with suitable materials and compacted:-

- In accordance with an Earthworks Compaction Specification (to be prepared) - where thicknesses of fill are anticipated to exceed 2.0m.
- In accordance with Lithos' Protocol for the placement of non-engineered fill (copy included in Appendix D) - where final thicknesses of fill are anticipated to be less than about 1.5m. However, where an excavation conflicts with the footprint of a proposed highway, compaction in accordance with the Specification for Highway Works will be required (see Section 5.14).

5.13.2 The site surface should be initially left 150mm below proposed finished garden levels to allow for placement of the cover (600mm where Made Ground remains in-place, 450mm where bedrock is exposed following earthworks regrade). In areas of highways the ground surface will be left approximately 600mm below finished road level.

5.13.3 Geotechnical testing of site won, or imported, materials being engineered in beneath highway footprints will be required to inform construction methodology.

5.13.4 Excavated arisings should be inspected by the Site Manager, and any suspicious material or material yielding evidence of significant contamination (based on visual\olfactory observations), placed in temporary stockpiles from which an adequate number of samples will be taken (typically a minimum of 6 samples). The samples should be scheduled for an appropriate suite of contaminant testing in order to characterise the material and decide its fate.

5.13.5 Any material considered unsuitable for use as backfill should be exported from site (see Section 5.14).

5.14 Highways

5.14.1 The Contractor should consult the adopting authority regarding preparation of the ground beneath new highways (as outlined below, or in any proposed alternative specification) in advance of the works. The Contractor should also agree acceptable performance criteria, with the Engineer and the adopting authority.

5.14.2 However, it is considered that the following options would be suitable to enable the construction of the highways.

5.14.3 Made ground should be excavated from beneath new highway footprints to its full thickness or a maximum of depth of 2.0m (whichever is less) - from existing ground level or proposed highway formation, whichever is the lower. Highways should then be raised to formation level, either with:

- Suitable aggregate placed & compacted in accordance with The Highways Agency Specification for Highway Works (SHW) Series 600, or
- Suitable screened & selected site-won material, placed & compacted in accordance with SHW Series 600. Unsuitable materials include any soft or wet materials, biodegradables including topsoil, wood, scrap metal, frozen & oversize material.

5.14.4 Some refinement of the above advice might be possible after highways design (with consideration of the proposed formation level cf existing ground level), and via inspection (and usually CBR testing) of the proposed formation during site preparatory groundworks.

5.14.5 Any residual made ground materials in the base of the excavation (i.e. in areas where the thickness of made ground exceeds 2m) should be inspected and (where necessary) any soft spots removed and replaced with suitable engineered fill.

5.14.6 In the footprint of proposed highways, the contractor, under supervision, must ensure that relict obstructions are removed to a minimum of 500mm below deepest sewer invert. The resultant sub-formation should then be proof rolled, in accordance with the Specification for Highway Works.

5.14.7 Crushing of hardstand/foundations will generate aggregate, which (subject to confirmatory testing) should be suitable for use as unbound pavement materials within the highways.

5.14.8 The suitability of site-won material for placement as engineered fill should be confirmed by field trials and geotechnical laboratory testing, which will yield the following information:

- Number of passes with the compaction plant (to be used during subsequent earthworks)
- Maximum layer thickness (plant dependent)
- Acceptance criteria: minimum dry density & moisture content range

5.14.9 The engineered fill should achieve at least 95% maximum dry density, with air voids comprising less than 10%, as determined by 2.5kg laboratory compaction tests.

5.14.10 Where made ground is re-engineered in line with the above specification, it is considered that a CBR value of 5% should be achievable; this should be verified by field trials.

5.14.11 The Contractor should ensure that only suitable granular fill is placed within 450mm of estate road formation in order to protect cohesive sub-grade materials (including natural cohesive soils). Such fill should be placed in accordance with the Specification for Highway Works.

5.14.12 The Contractor will arrange for the necessary compliance testing to be undertaken at formation level on road alignments, as required by the adopting authority and Engineer. As a minimum this should comprise plate load tests, carried out to determine the CBR at formation level, at approximate 25m intervals. Test locations should be staggered across the width of the highway to ensure the whole highway area is assessed.

5.15 Export to landfill

5.15.1 Excavation arisings that are unsuitable for retention and re-use on site should be placed in temporary stockpiles on hardstand or polythene sheeting and be suitably covered to minimise the potential for dust/odour nuisance, and prevent surface water run-off.

5.15.2 Any material exported from site to landfill should be hauled by a registered waste carrier in accordance with the requirements of the Waste Regulations 2011 and the Landfill (England & Wales) Regulations 2002.

5.15.3 A transfer note should be completed, signed and retained by the parties involved. The transfer note should include the volume of waste, the nature of the material and a statement of its chemical composition, details of the source and destination sites, and details of the haulier.

5.15.4 In order to protect the general public from dust and vapour emissions, wagons that are to be used for the haulage of the contaminated material from the site must be sheeted. In addition, the Contractor must ensure that no fluids seep from the wagons.

5.15.5 In order to provide the landfill facility with information regarding chemical composition of the waste, further analysis of any material that requires removal from site may be required.

Waste classification

5.15.6 Characterisation of stockpiled materials generated during the site preparatory works is likely to be required if off-site disposal is proposed.

5.15.7 It should be noted that the classification and assessment of waste soils under the Environment Agency's Technical Guidance WM3[2], is a complex process.

5.15.8 It is critical if material is to be exported from site that this is allocated an appropriate waste code, following the steps within WM3. Waste carriers transporting, and sites accepting, this material should have a corresponding code within their permits. It is the responsibility of those generating the waste (i.e. the site), to ensure that the waste is handled and disposed of appropriately.

5.15.9 With respect to asbestos, waste soils will be classed hazardous if the soil mass contains more than 0.1% asbestos fibres that are free and dispersed. However, WM3 states that where the waste contains identifiable pieces of asbestos (i.e. any particle of a size that can be identified as potentially being asbestos by a competent person if examined by the naked eye), then the waste is hazardous if the concentration of asbestos in the pieces alone is 0.1%. If a stockpile of soil contained rare fragments of broken asbestos-cement sheeting, the whole stockpile would be classed as hazardous unless all the fragments could be picked-out (even though the concentration of asbestos in the soil mass might be orders of magnitude less than 0.1%).

5.15.10 Tarmac hardstand is present across the area of the car park.

5.15.11 This tarmac could be recycled and crushed to yield a 6F3 selected granular material, provided the recovered bitumen content is less than 10% (determined in accordance with BS598-1:2011). Crushed tarmac could also be blended with crushed concrete etc to generate 6F2 graded material. 6F2 can contain up to 50% recycled tarmac/asphalt (provided it does not pose a contamination risk to controlled waters and, if the proportion of asphalt is greater than 20%, the recovered bitumen content is less than 2%).

5.15.12 However, if off-site disposal is anticipated, tarmac assessment is based on the amount of coal tar present, this will vary depending on the age of the tarmac. The assessment is based on the amount of benzo(a)pyrene, and has a concertation limit of 50mg/kg.

5.15.13 Following excavation and stockpiling, sampling will be required prior to disposal.

5.15.14 Tarmac is likely to fall within waste code 17 03 02:

- 17 - Construction and Demolition wastes,
- 03 – bituminous mixtures, coal tar and tarred products
- 02 – bituminous mixtures other than those mentioned in 17 03 01

5.15.15 17 03 02 is a mirror non-hazardous entry (17 03 01 is the corresponding mirror hazardous entry). This code along with this supporting report, in particular the laboratory results, should be used to complete a paper trail documenting disposal routes for tarmac.

5.15.16 Contractors exporting waste from the site should review the site investigation data and make their own assessment. Alternatively, Lithos could undertake this assessment once exported waste streams have been identified.

[2] Technical Guidance WM3 – Guidance on the classification and assessment of waste. Environment Agency 2015

5.16 Boundary issues

5.16.1 Kirklees Council's Designer should ensure that proposed levels tie in with the surrounding infrastructure, and ground levels of adjacent properties (after allowance for the placement of any required soil cover). Advice should be sought from the Engineer if mobile contamination or redundant drains/utilities are encountered close to the site's boundaries.

5.17 Surveying

5.17.1 The Contractor should arrange for the following survey work as directed by the Site Manager:

- All setting out necessary to allow the works to proceed
- Recording of the depth and lateral extent of excavations to remove obstructions, contaminated soils etc
- Recording of the positions of any relict obstructions (i.e. piles) left in-situ
- Recording the depth & extent of each excavation panel during turnover of made ground, prior to backfilling
- Recording of natural ground levels, where natural ground encountered during the earthworks
- Recording the locations and volumes of all stockpiles of suitable materials left on site for use during the development works
- As-built survey of the finished surface on completion of the remediation contract

5.17.2 The Contractor should supply the results of this survey work (disc & hard copy) to the Site Manager for inclusion in the Verification Report.

5.18 Placement of soil cover

5.18.1 Where made ground recovered from the area of the Allotments and car-park remains below areas of POS or gardens (but not beneath floor slabs or hardstand) it should be isolated beneath a cover of clean inert soil comprising at least 450mm of subsoil and at least 150mm of Topsoil.

5.18.2 Where no made ground remains beneath gardens and areas of POS a nominal 300mm of soil cover comprising at least 150mm of Topsoil should be placed. It should be noted that this is expected to be the case for the vast majority of plots at this site.

5.18.3 If any garden is directly underlain by bedrock (exposed following earthworks regrade), placement of 450mm of subsoil/topsoil will be required (in accordance with NHBC Standards, Chapter 10.2).

5.18.4 Subsoil suitable for use as cover material may be sourced on site, subject to the Engineer's approval. The Engineer will assess accessibility, suitability, the conceptual site model (most notably the creation of new pathways by which mobile contaminants could impact controlled waters), and engineering implications (for example, increased foundation depth) before allowing any excavation of in-situ natural soils for re-use as clean cover.

5.18.5 Any material imported for use as cover should be validated in accordance with Lithos' Protocol for Soil Importation, copied in Appendix B. This Protocol includes chemical assessment criteria which should not be exceeded.

5.18.6 This work may be undertaken as part of the contract for the preparatory & remediation works, in which case imported soils should be stockpiled in a location agreed with the Engineer. Alternatively, the developer may choose to import soil at a later stage in the development.

5.19 Shallow coal in garden areas

5.19.1 It is likely that much (possibly) all shallow coal will be removed during the anticipated preparatory earthworks (see Section 5.6) and any shallow coal exposed during the earthworks regrade will have been recorded by survey (lateral extent and if possible approximate residual thickness). However, if any residual coal does remain, the advice below would apply.

5.19.2 Whilst there is no explicit guidance in NHBC Standards, liaison with NHBC suggests their stance is essentially the same as that they would apply to potentially combustible fills (such as Ash & Clinker). So where significant coal is present at very shallow depth in garden areas (uppermost 1m), it should either be removed, or covered with inert subsoil/topsoil so that it lies at greater than 1m depth.

5.19.3 In theory this could be an issue for about 20% of the total site area. The approximate area where coal lies very close to surface & could be encountered in shallow excavations is shown on Drawing 3901/13.

5.19.4 The most pragmatic way of dealing with shallow coal in gardens will be to inspect foundation excavations, and where coal is recorded within the uppermost 1m or so then excavate an inspection pit in the rear garden. Further advice should be sought from Lithos during the construction phase.

5.19.5 As with foundation arisings, the Developer will need to contact the Coal Authority to dig or carry away excavated (incidental) coal.

5.20 Hazardous gas protection

5.20.1 Further monitoring (as a minimum, twice monthly for a further 3 months) is required and consideration should also be given to:

- the installation of shallow 1m piezometers to ensure shallow groundwater does not impair ground gas movement, and
- the possible presence of dissolved carbon dioxide in groundwater; it is recommended that some groundwater samples be collected and analysed for dissolved gases.

5.20.2 A full gas risk assessment cannot be undertaken with the limited data available. However, at this stage, it is likely that parts of the site will fall within **Amber 1** or **Amber 2** classification.

5.20.3 Both Amber classifications require a ventilated subfloor void and gas resistant membrane, and both classifications require independent verification. A higher score is required for Amber 2 sites and this is usually achieved through independent installation and verification of gas measures.

5.20.4 Requirements for Amber 1 & 2 are shown in the table below.

Traffic light classificn and "score" req'd by BS8485#	Floor slab (BS8485 "score")	Protective measures	
		Sub-floor ventilation (BS8485 "score")	Membrane Type (BS8485 "score")
Amber 1 **3.5***	*Select one from:* i. Block & Beam – **(0)**. ii. Reinforced ground bearing slab – **(0.5)**. iii. Reinforced, cast in-situ suspended slab (with minimal and suitably sealed service penetrations & joints) – **(1.5)**. iv. Reinforced ground bearing raft (with limited service penetrations cast into slab). Note: the venting area through any downstand beam should be 3 times greater than that provided by the side ventilation (air bricks) – (**1.5**).	*Select one from:* Passive sub-floor ventilation; venting layer could be: i. A min. 150mm clear void (**2.5**), or ii. A proprietary void former providing an equivalent clear void depth of 60mm; see Section B7 in BS8485 (**2.5**), or iii. Min. 300mm thick blanket of min. 20mm single size gravel (**1.0**). Min. ventilation = 1,500 mm²/m run of external wall (via air bricks on each of 2 opposite sides), with 100mm pipes at 1.75m centres or honeycombing of any sub-floor sleeper walls.	Gas resistant membrane meeting all of the following criteria: • sufficiently impervious to gases with a methane gas transmission rate <40.0 ml/day/m²/atm (average) for sheet and joints (tested in accordance with BS ISO 15105-1 manometric method); • sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions; • sufficiently strong to withstand in-service stresses; • sufficiently strong to withstand the installation process and following trades until covered (e.g. penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, dropping tools, etc); • capable, after installation, of providing a complete barrier to the entry of the relevant gas; and • a minimum 0.4 mm thickness (1600g polyethylene) reinforced membrane (virgin polymer • verified in accordance with CIRIA C735∞ **(2.0)**
Amber 2 **4.5***	*Select one from:* i. Block & Beam – **(0)**. ii. Reinforced ground bearing slab – **(0.5)**. iii. Reinforced, cast in-situ suspended slab (with minimal and suitably sealed service penetrations & joints) – **(1.5)**. iv. Reinforced ground bearing raft (with limited service penetrations cast into slab). Note: the venting area through any downstand beam should be 3 times greater than that provided by the side ventilation (air bricks) – (**1.5**).	*Select one from:* Passive sub-floor ventilation; venting layer could be: i. A min. 150mm clear void (**2.5**), or ii. A proprietary void former providing an equivalent clear void depth of 60mm; see Section B7 in BS8485 (**2.5**). Min. ventilation = 2,000 mm²/m run of external wall (via air bricks on each of 2 opposite sides), with 100mm pipes at 1.3m centres or honeycombing of any sub-floor sleeper walls.	Gas resistant membrane meeting all of the following criteria: • sufficiently impervious to the gases with a methane gas transmission rate <40.0 ml/day/m²/atm (average) for sheet and joints (tested in accordance with BS ISO 15105-1 manometric method); • sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions; • sufficiently strong to withstand in-service stresses (e.g. settlement if placed below a floor slab); • sufficiently strong to withstand the installation process and following trades until covered (e.g. penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, tearing due to working above it, dropping tools, etc); • capable, after installation, of providing a complete barrier to the entry of the relevant gas; • a minimum 0.4 mm thickness (1600g polyethylene) reinforced membrane (virgin polymer)and • verified in accordance with CIRIA C735∞ **(2.0)**

∞ In accordance with CIRIA C735, a Verification Plan should be prepared which outlines the activities (inspection and testing), the relevant personnel, and the type of records to be collected. Gas membranes need to be visually inspected to establish possible damage. For Amber 2 sites inspection & verification should be carried out by an independent third party. However, whilst conflicts of interest in verification should be avoided, the Developer's staff on site could undertake inspection & verification on Amber 1 sites. In all circumstances, the verifier should be competent, experienced and suitably trained.

Note NHBC guidance only requires membranes to be fitted by a specialist contractor, and be fully certified, on Amber 2 sites. However, BS8485 is considered to 'outrank' NHBC guidance, and it would be prudent to comply with this Standard and CIRIA C735. Furthermore, (YALPAG) local authorities have issued guidance requiring a detailed verification method statement in advance of the construction phase. This should address how gas measures will be installed and what verification information will be provided to demonstrate that installation has been carried out in accordance with the appropriate guidance.

1. A combination of two or more of the three types of protection measures (slab, ventilation & membrane) should be used to achieve the BS8485 score.
2. The membrane should always be lapped and sealed in accordance with BRE\Environment Agency Report BR 414 (2001) – "*Protective Measures for housing on gas-contaminated land*". The membrane should be **continuous** across internal walls & the cavity, and there should be a **cavity tray** in external walls.
3. In all cases there should be minimum penetration of floor slab by **services**; any penetrations should be suitably sealed.
4. Integral **garages** with occupied rooms above, or direct access through a doorway from the garage to the house, should be provided with the same protective measures as the rest of the dwelling. Buildings with basement car parks (with ventilation in accordance with Building Regulations) may not require gas resistant membranes.

5.20.5 **Verification** is required for all Amber (1 & 2) sites. In accordance with recent YALPAG guidance[3], a detailed verification method statement should be issued to Kirklees Council in advance of the construction phase. 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 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.
- 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.

5.20.6 Where Amber 2 protective measures are required independent certification that the protective gas measures have been installed correctly will be required to enable finalling of plots under the CML initiative (Certification is a Red item). Lithos' Protocol for the Inspection of Gas Measures is copied in Appendix E.

5.20.7 In order to ensure the effectiveness of gas protective measures, workmanship should be carried out by appropriately trained and qualified personnel.

5.20.8 In accordance with recent YALPAG guidance, a detailed verification method statement should be issued to Kirklees Council in advance of the construction phase. 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 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.

[3] *Verification Requirements for Gas Protection Systems - Technical Guidance for Developers, Landowners and Consultants. Yorkshire and Lincolnshire Pollution Advisory Group, December 2016.*

- Details of how any non-conformance will be dealt with.
- Details of the number of plots to be validated.
- 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.

5.20.9 BRE/Environment Agency Report BR 414 (2001) – "Protective Measures for housing on gas-contaminated land" provides a practical guide to good practice for the detailing and construction of passive soil gas protection measures for new residential development. Of particular relevance are a list of 'Watchpoints', which offer practical information for installation and buildability.

5.20.10 Designers\Architects should be made aware of the importance of gas protection measures, and their house designs should take account of potential constraints associated with Building Regulations (most notably those relating to access thresholds, noise and insulation), flood mitigation measures, and utility providers (external meter boxes may have to be located away from air bricks) etc.

5.20.11 Requirements with respect radon measures are set out in Building Regulations Approved Document C. Probability bandings (based on the proportion of properties in a given area that exceed the Action Level; currently 200 $Bq.m^{-3}$) are used to determine whether a property requires no, basic or full measures.

5.20.12 At present Approved Document C advocates basic measures for the probability banding 3% to 10% (full measures if >10%). However, Public Health England would like to see all new build include basic measures.

5.20.13 The Public Health England UK radon map and the Landmark report indicate that the site is in an area where **between 1% and 3%** of homes are estimated to be above the action level.

5.20.14 Consequently, basic radon protection measures are not required. However, in light of Public Health England advice, the Developer might consider providing all new dwellings with basic radon protection measures.

6 TREATMENT OF MINEWORKINGS & MINE ENTRIES

6.1 Mine entries

6.1.1 There are 40 known mine entries within, or close to, the site's boundary. However, the majority of mine entries are located in Lady Wood and Lady Wood Extension, and only those listed in the table below are anticipated to lie within the area of proposed development; see also Drawing 3901/8.

Shaft Ref.	Source	Approx. location	Remarks	Treatment
422419-027	-	Centre-west.	Not yet located due to constraints associated with a gas utility. At this stage given the presence of the gas main, this shaft will likely lie well beyond the footprint of any proposed dwellings.	Bedrock should lie within 3m of ground level. Consequently, these shafts should be capped at or below rockhead.
423419-005	Abandonment plan	Centre-northeast.	A third party has been commissioned by Kirklees Council to locate these two known mine entries. At this stage it is expected that these shafts will lie within a "new" area of allotments.	
423419-006				
-	Anecdotal	Centre	An unrecorded adit; not yet located.	The current tenant farmer believes there was a 'walk-in' mine which included rail tracks. The mine entry was formerly marked by a valley. However, years of ploughing has levelled the area off. The metal rail tracks are anecdotally suggested to still remain buried within nearby hedgerows.

6.1.2 Once located, each shaft should be accurately surveyed-in and its size, shape, orientation and fill material recorded. Each shaft should then be treated.

6.1.3 Given the relatively shallow depth to rockhead (<3m), a 8m sterile, 'no-build' zone around this shaft should be more than adequate. Given the absence of significant thicknesses of made ground and superficial soils, a cap at rockhead should be feasible. The shaft cap is likely to be around 2m in diameter.

6.1.4 A shaft cap should be designed by a competent structural engineer, following the principles detailed below.

6.1.5 The reinforced concrete cap should be constructed at or below rockhead of sufficient bearing capacity for the expected loading.

6.1.6 The width of the cap should be a least twice the internal diameter of the shaft. The structural engineer should specify cap thickness and reinforcement.

6.1.7 A vent pipe will be required where the cap is constructed over shaft backfill.

6.1.8 Following treatment, no construction should take place within an agreed exclusion zone around the shaft; typically a safety zone, the dimensions of which may be subtended by an angle of 45° to the surface from the point where the sides of the shaft intersect rockhead.

6.1.9 It should be noted that further unrecorded/forgotten mine entries may be present across the area being developed. Any such entries should be found during the anticipated earthworks regrade.

6.1.10 If found, the unrecorded adit should be made safe by treatment in accordance with an appropriate Specification (Lithos can prepare this) and a Coal Authority Permit to Enter or Disturb Coal Authority Mining Interests.

6.1.11 At this stage, it is expected that treatment would involve .

6.1.12 excavation until there is at least 3.0m of competent cover above the adit roof. A 300mm thick wall shall then be constructed to seal the adit and the excavated area backfilled with clean inert fill. The adit should then be grouted during treatment of the workings.

6.2 Shallow mineworkings

6.2.1 Shallow mineworkings which could affect surface stability are present beneath the north of the site. The approximate area likely to be underlain by shallow mineworkings is shown on Drawing 3901/15.

6.2.2 Shallow mineworkings may also be present across the north of the site and further probeholes and some cored boreholes are required to reduce uncertainty in relation to risks posed to the proposed development.

6.2.3 Mitigation of the risks posed by the shallow mineworkings will be required, and this could be achieved in one of two ways:

- Consolidation, via drilling & grouting
- Extraction of the remaining coal

6.2.4 If drilling & grouting is the preferred solution, Lithos could prepare a detailed Specification for treatment of the workings and liaise with the relevant regulatory authorities (Local Authority, Coal Authority & NHBC).

6.2.5 However, at this stage, it is considered that the necessary consolidation (grouting) would require drilling holes on a 3.0m grid. A viscous grout composed of appropriate proportions of OPC, PFA, sand or pea gravel would then be injected into the workings via these holes.

6.2.6 The grid should extend beyond dwellings etc by a 15° (to the vertical) angle of repose down to the seam. Further holes will be required in areas of high grout take (to confirm filling of void space), and in areas where several adjacent holes encountered solid coal (to confirm that the local area is underlain by no workings, rather than pillars). In addition, a perimeter grout curtain may be required.

6.2.7 If coal extraction is the preferred solution, Lithos could prepare a detailed Specification, including backfill requirements, and liaise with the relevant regulatory authorities (Local Authority, Coal Authority & NHBC).

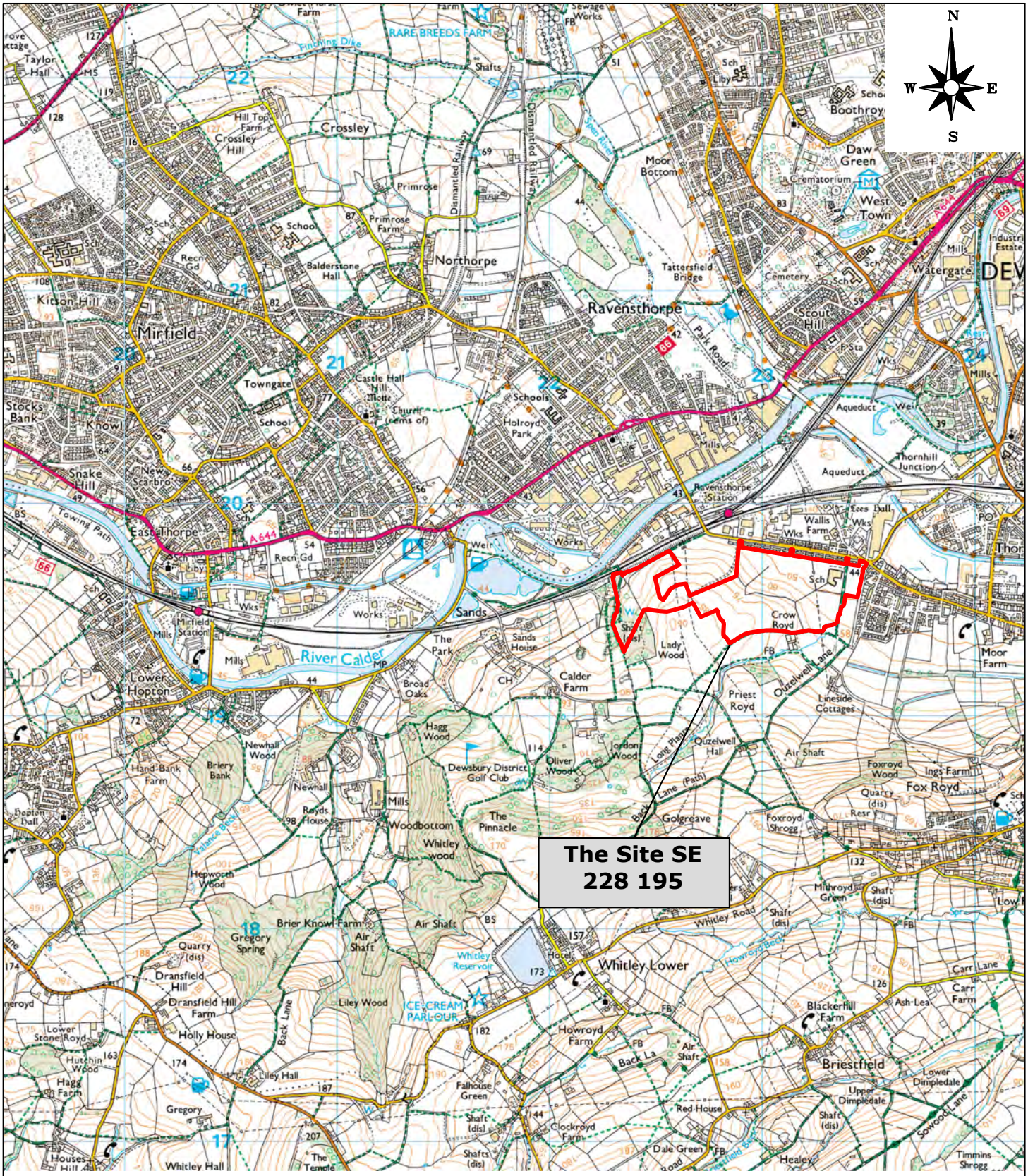
7 MANAGEMENT OF UNKNOWNS

7.1.1 Whilst extensive ground investigation has been undertaken across the site some uncertainties remain.

7.1.2 Uncertainties include:

- The presence of shallow mineworking beneath land in the south
- The exact location of mine entries and the potential for further unrecorded mine entries
- The suitability of Topsoil recovered from the Allotments for re-use (further testing & assessment required)
- Foundation solutions following design and completion of any cut & fill earthworks (most notably where fill is greater than 2.5m thickness)
- The hazardous gas regime at the site & protective measures required for new buildings

APPENDIX A
DRAWINGS



LITHOS CONSULTING
info@lithos.co.uk
www.lithos.co.uk
Tel 01937 545330

CLIENT	KIRKLEES COUNCIL
JOB TITLE	DEWSBURY RIVERSIDE CENTRAL GATEWAY
DRAWING TITLE	SITE LOCATION PLAN
DRAWN	GLM
DATE	25/11/2020
CHECKED	REG
DATE	25/11/2020
STATUS	FOR COMMENT ☐ DRAFT ☐ FOR APPROVAL ☐ FINAL ☑
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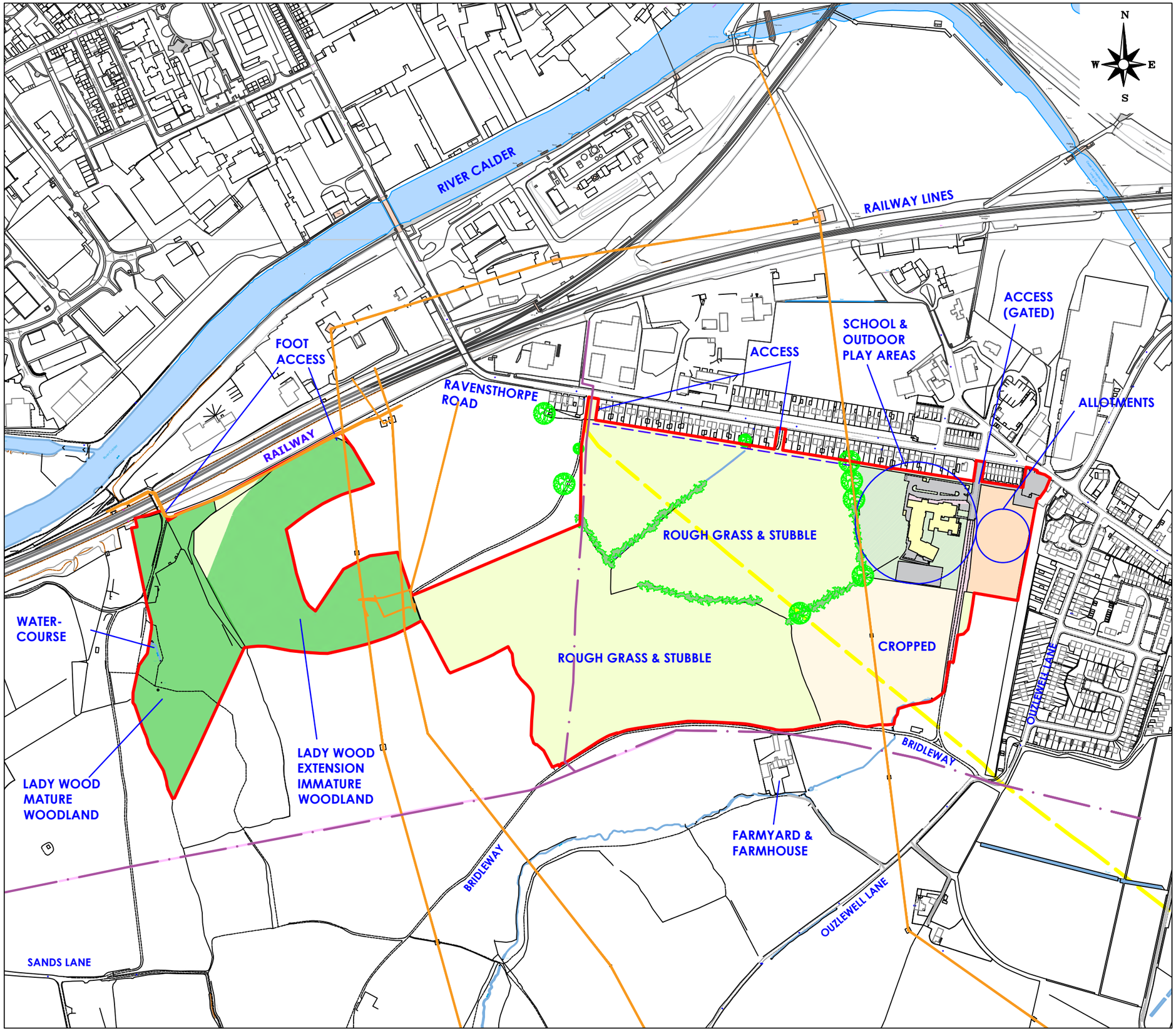
SHEET	A4
DRAWING NO.	3901/1
REVISION	



NOTES

- GRASS/ROUGH STUBBLE
- CROPPED LAND
- MACADAM HARDSTAND
- BUILDING
- ALLOTMENT GARDENS
- HARDCORE/TRACK
- WOODLAND
- WATERCOURSE/SURFACE WATER
- OVERHEAD ELECTRICAL UTILITY
- HIGH PRESSURE GAS UTILITY
- REDUNDANT COLLIERY GAS UTILITY
- STORM DRAINAGE UTILITY
- APPROXIMATE SITE BOUNDARY

REV.	DESCRIPTION	DATE

LITHOS CONSULTING

info@lithos.co.uk
www.lithos.co.uk

Tel 01937 545330

CLIENT

KIRKLEES COUNCIL

JOB TITLE

DEWSBURY RIVERSIDE CENTRAL GATEWAY

DRAWING TITLE

SITE FEATURES

DRAWN	DATE	STATUS
GLM	07/12/2020	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
REG	07/12/2020	DRAFT ☐
		FINAL ☑

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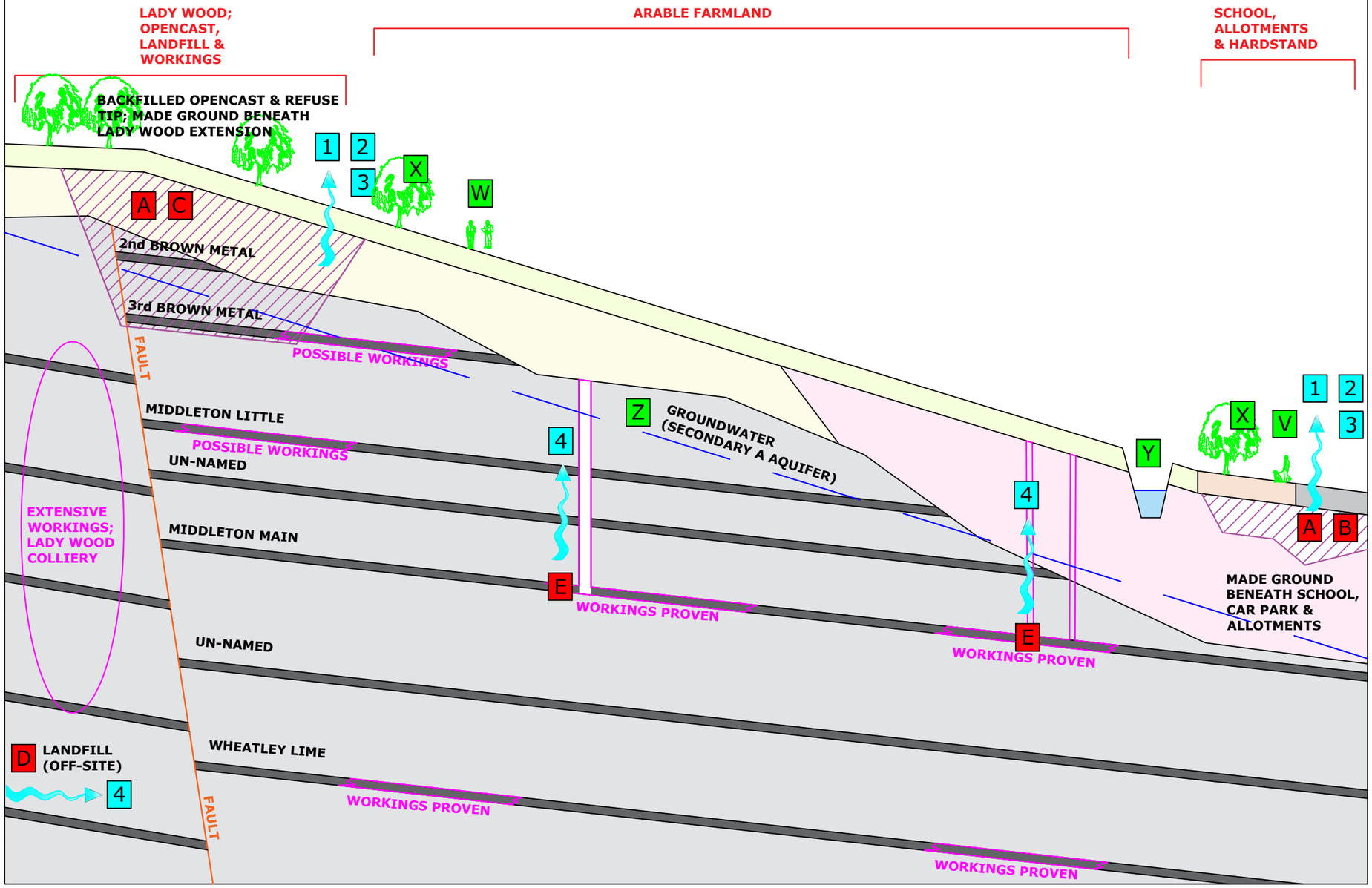

KEY
MADE GROUND
TOPSOIL
GLACIAL DEPOSITS
RESIDUAL SOIL
LOWER COAL MEASURES
COAL

SOURCES
A MADE GROUND (INORGANICS)
B MADE GROUND (ORGANICS)
C MADE GROUND (ASBESTOS)
D LANDFILL
E MINEWORKINGS

PATHWAYS
1 DERMAL CONTACT
2 INGESTION/INHALATION
3 UPTAKE BY PLANTS
4 MIGRATION OF GAS

RECEPTORS
V END USERS (RESIDENTS)
W SITE WORKERS
X VEGETATION
Y SURFACE WATERS
Z GROUNDWATER

NOTES

REV.	DESCRIPTION	DATE

LITHOS CONSULTING
info@lithos.co.uk
www.lithos.co.uk
Tel 01937 545330

CLIENT: KIRKLEES COUNCIL

JOB TITLE: DEWSBURY RIVERSIDE CENTRAL GATEWAY

DRAWING TITLE: REVISED CONCEPTUAL SITE MODEL

DRAWN	DATE	STATUS
GLM	16/02/2021	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
REG	16/02/2021	DRAFT ☐
		FINAL ☑

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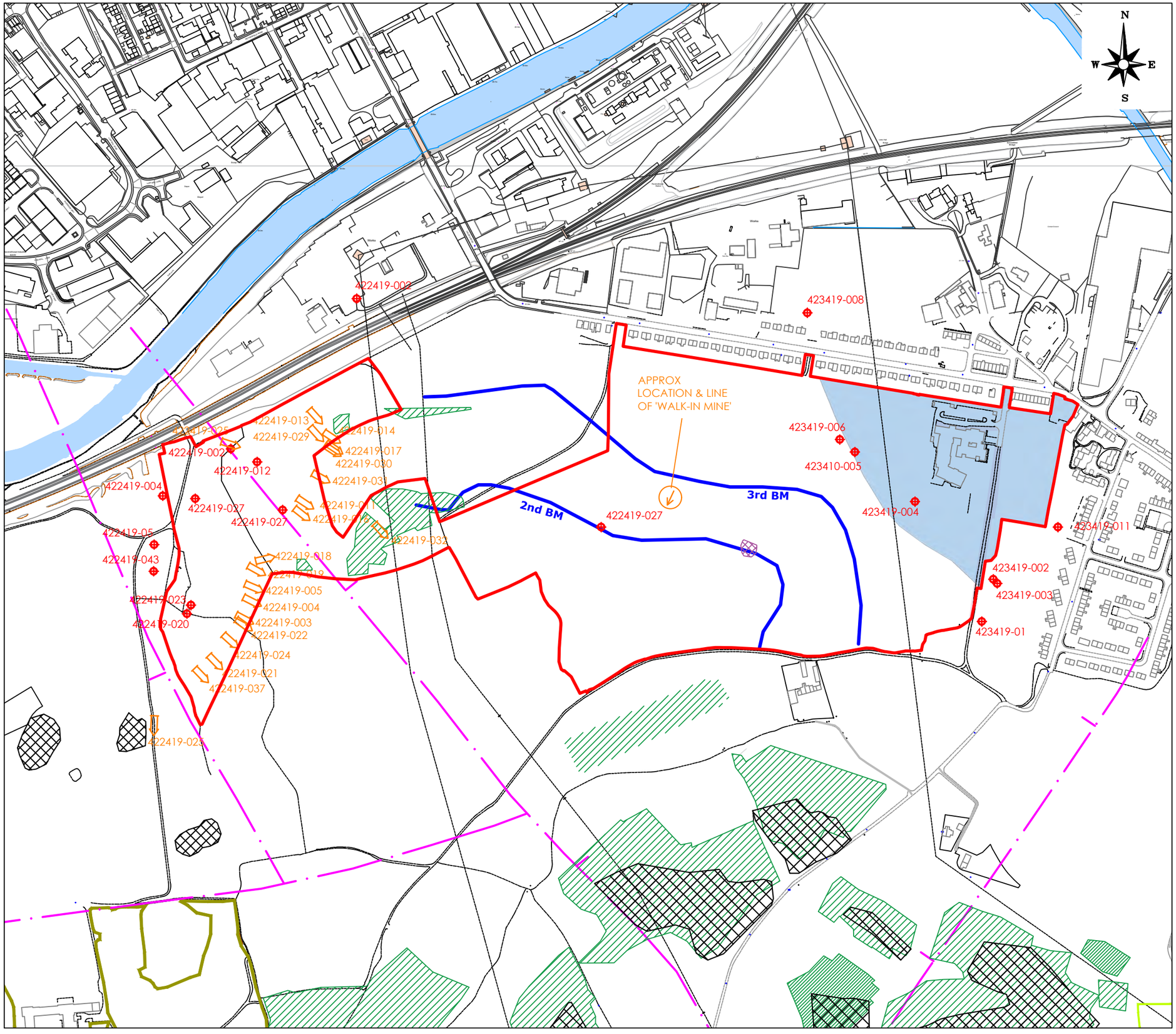

NOTES

- GLACIOFLUVIAL DEPOSITS (BASED ON BGS MAPPING)
- FORMER SANDSTONE QUARRY (BASED ON HISTORICAL OS MAPPING)
- AREA OF OPENCAST EXTRACTION (BASED ON CA REPORT)
- AREA OF OPENCAST EXTRACTION/SPOIL HEAP (BASED ON BGS MAPPING)
- COAL SEAM OUTCROP & NAME (BASED ON NCB DRAWING)
- KNOWN SHAFT LOCATION
- KNOWN ADIT LOCATION
- APPROXIMATE LINE OF GEOLOGICAL FAULT
- APPROXIMATE SITE BOUNDARY

REV.	DESCRIPTION	DATE

LITHOS CONSULTING

info@lithos.co.uk
www.lithos.co.uk

Tel 01937 545330

CLIENT

KIRKLEES COUNCIL

JOB TITLE

DEWSBURY RIVERSIDE CENTRAL GATEWAY

DRAWING TITLE

COAL MINING & GEOLOGICAL FEATURES

DRAWN	DATE	STATUS
GLM	09/12/2020	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
REG	09/12/2020	DRAFT ☐
		FINAL ☑

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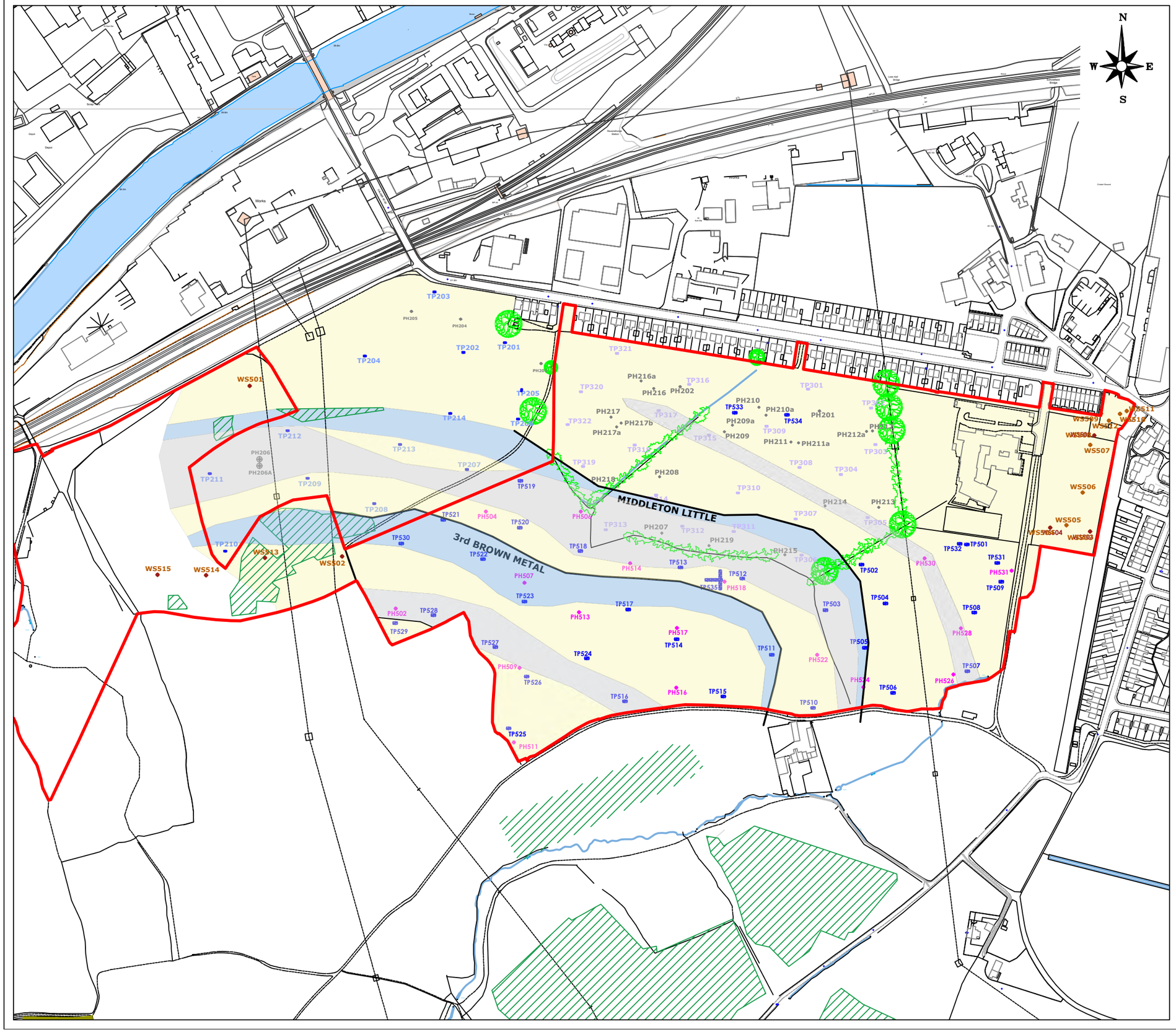

NOTES

- CA AREA OF OPENCAST; LIKELY DEEP MADE GROUND
- SANDSTONE
- MUDSTONE/SILTSTONE
- COAL EXPECTED IN EXCAVATIONS
- COAL SEAM OUTCROP & NAME (BASED ON LITHOS PHs)
- APPROXIMATE SITE BOUNDARY

REV.	DESCRIPTION	DATE

LITHOS CONSULTING

info@lithos.co.uk
www.lithos.co.uk

Tel 01937 545330

CLIENT

KIRKLEES COUNCIL

JOB TITLE

DEWSBURY RIVERSIDE CENTRAL GATEWAY

DRAWING TITLE

BEDROCK COMPOSITION

DRAWN	DATE	STATUS
GLM	24/02/2021	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
REG	24/02/2021	DRAFT ☐
		FINAL ☑

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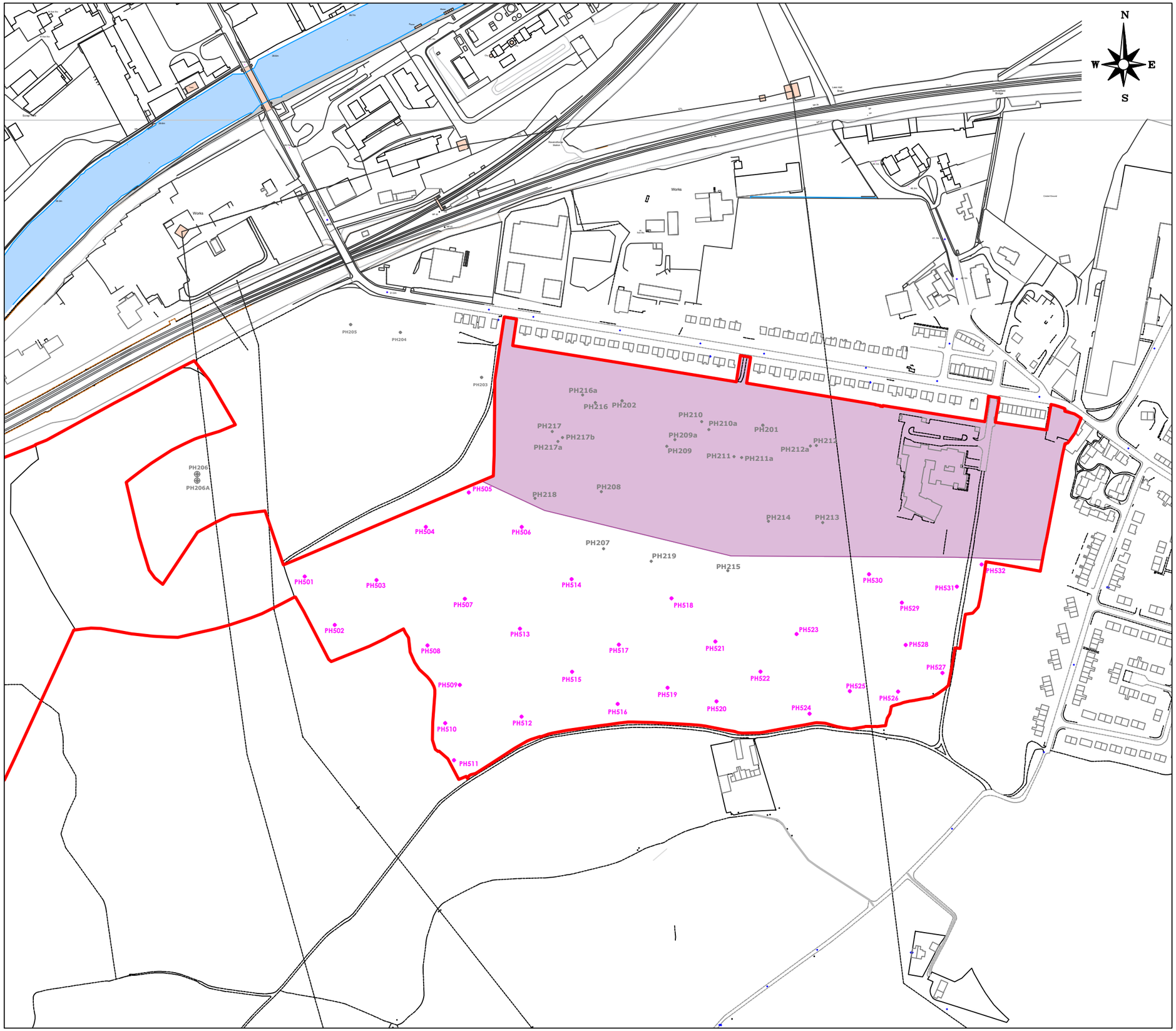

NOTES

- APPROXIMATE AREA OF MIDDLETON MAIN COAL SEAM REQUIRING CONSOLIDATION
- PROBEHOLE LOCATION (JAN 2021)
- PROBEHOLE LOCATION (PREVIOUS INVESTIGATION)
- APPROXIMATE SITE BOUNDARY

REV.	DESCRIPTION	DATE

LITHOS CONSULTING

info@lithos.co.uk
www.lithos.co.uk

Tel 01937 545330

CLIENT

KIRKLEES COUNCIL

JOB TITLE

DEWSBURY RIVERSIDE CENTRAL GATEWAY

DRAWING TITLE

EXTENT OF MIDDLETON MAIN COAL REQUIRING CONSOLIDATION

DRAWN	DATE	STATUS
GLM	04/03/2021	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
REG	04/03/2021	DRAFT ☐
		FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
1:4,000	A3	3901/15	

APPENDIX B

LITHOS PROTOCOL FOR IMPORTATION & USE OF SOIL COVER (CAPPING)

1 INTRODUCTION

1.1 Isolation of made ground in garden and landscaped areas beneath a cover of "clean" subsoil, and topsoil is often recommended on residential developments; most notably when the made ground contains inorganic (and non-volatile organic) contaminants at concentrations above guidance threshold values. A cover solution is not appropriate for volatile or semi-volatile organic contaminants (fuels, solvents etc); removal or treatment will usually be required.

1.2 The thickness of cover is dependent on the nature and degree of contamination (and sometimes the Local Authority whose area the site lies within), but typically between 600mm and 1,000mm is required. Where contamination is more significant a granular hard-dig layer or geotextile marker membrane may also be required at the base of the cover.

1.3 If the made ground is essentially "clean", but contains materials generally considered undesirable as near-surface material in garden areas (e.g. oversize materials such as construction/demolition rubble) then, in accordance with NHBC Standards Chapter 9.2, a 300mm thick soil cover should be adequate. If the made ground is essentially "clean" and comprises reworked natural soil, the only cover likely to be required is topsoil.

1.4 The "clean" soil cover blocks potential linkages between the contaminated made ground and future residents. Soil cover is not required beneath drives, garages or houses.

1.5 The **CML initiative**, which came into force on 1st April 2003, requires housebuilders to submit to NHBC (or other warranty provider) a validation report confirming the thickness and quality (i.e. contaminant-free) of the placed soil cover. Validation reports should normally be prepared by independent geoenvironmental consultants.

1.6 Failure to submit cover validation reports promptly will delay issue of the cover note by the warranty provider, which will subsequently delay the release of mortgage funds and hence legal completion; i.e. the financial implications are significant. Consequently, it is essential that cover validation is requested at least 2 weeks prior to the anticipated finalling date.

1.7 Soil cover is usually placed many weeks after completion of the preparatory/remediation works, and issue of the associated Verification Report, typically at a relatively late stage in the construction programme.

1.8 Prior to placement of soil cover, the appointed remediation contractor and/or groundworker should ensure that ground levels are low enough to accommodate the required cover thickness, taking account of any boundary issues, and without compromising the DPC and any sub-floor ventilation.

1.9 Ideally soil **quality** should be determined by sampling of the **source** at least 7 working days before importation to the development site. Samples could be obtained from stockpiles on site, which may on occasion comprise surplus natural ground development arisings. Soil samples could be obtained from gardens after placement, but this is not recommended.

1.10 Clearly, if soil cover is imported and placed before confirmation of its suitability, no guarantee can be given that validation work will yield the desired results. It may therefore be necessary to excavate and export the placed soil cover and/or import further "clean" soil.

1.11 Where soils have been tested at source and temporarily stockpiled on site, stockpiles should be fenced-off and marked as containing certified topsoil/subsoil. The soil should be inspected prior to placement to confirm that it is the same material as previously tested, and that it has not been cross-contaminated with miscellaneous arisings generated during the construction works.

1.12 Soil **thickness** can only be checked after placement; this should be done before turfing / landscaping, but ideally after scaffolding has been dismantled.

1.13 ***Sampling Frequency (to check Soil Quality):*** The number of samples tested will be dependent on the nature of the source, and the quantity of material to be imported. However, in accordance with current YALPAG (Yorkshire & Lincolnshire Pollution Advisory Group) guidance[1], the testing frequency should be as follows:

Nature of source	Number of samples (from any single source material)	
	Up to 1,000m³	Per additional 1,000m³
Greenfield	At least 3, with at least 1 sample per 250m³	2
Brownfield	At least 6, with at least 1 sample per 100m³	2
Crushed product	At least 3, with at least 1 sample per 500m³	2

1.14 On a typical development with gardens comprising a total area of 100m² (front and rear), and a soil cover thickness of 600mm including 100mm topsoil, for a brownfield source this testing frequency equates to approximately one topsoil sample per ten plots and one subsoil sample per two plots. Given the requirement to test a minimum number of samples from any one source, the testing frequency effectively increases for sites with only a small number of plots.

1.15 **Inspection Frequency (to check Soil Thickness):** The number of inspection pits excavated to check cover thickness (and collect samples, if testing at source has not been undertaken), should be dependent on the number of plots associated with the given development. The following frequencies are recommended:

No. plots within development	Frequency of inspection pits	Remarks
1 to 5	1 pit per plot	e.g. for 3 plots, dig 3 inspection pits
6 to 20	1 pit per 2 plots	e.g. for 9 plots, dig 5 inspection pits
21 to 30	1 pit per 3 plots	e.g. for 23 plots, dig 8 inspection pits
≥ 30	1 pit per 4 plots	e.g. for 39 plots, dig 10 inspection pits

1.16 Photographs should be taken of each inspection pit to show:

- The thickness of cover material present
- The presence of any geotextile marker or granular hard-dig layer (if required)
- The position of each inspection pit in relation to the plot

1.17 **Soil Material Suitability**: Inspection pits should be excavated through the entire thickness of any proposed in-situ source material, or cover material (if inspection is post-placement). Stockpiles should be assessed from both the surface and by digging into the "core", to ensure the material is reasonably homogenous.

[1] *Verification Requirements for Cover Systems: Technical Guidance for Developers, Landowners & Consultants; Version 3.4, November 2017.*

1.18 The soil material should comply with the following requirements:

- Be clean and free of foreign debris, building waste materials, glass sharps, and contaminants
- Topsoil should not have a gravel content of greater than 30% by dry weight and should generally have a maximum stone size of 50mm in any one direction
- Subsoil should generally have a maximum stone size of 150mm in any one direction
- Not have been sourced from an area within 7m laterally, or 3m vertically, of Japanese Knotweed plants, and not contain any Japanese Knotweed fragments (rhizomes, leaves, stems etc)

1.19 **Laboratory Analysis:** Whether samples are taken at source, from stockpiles on site, or from gardens after placement, they should be forwarded to an analytical laboratory for testing in accordance with one of the Schedules detailed in Table 1.

1.20 Imported topsoil should be subject to such testing, unless it is being sourced from a reputable commercial supplier able to provide robust certification (certificate date less than 2 months prior to import date). In addition, some analysis in accordance with BS3882 may occasionally be appropriate.

Table 1 – Test schedule

Source	Test schedule
Greenfield & Manufactured topsoil	pH, total metals (Cu, Ni, Zn, Cr III, Cr VI, As, Hg, Se, Cd & Pb), water soluble boron. TOC & speciated PAH Asbestos ID
Brownfield & Soil transfer stations	pH, total metals (Cu, Ni, Zn, Cr III, Cr VI, As, Hg, Se, Cd & Pb), water soluble boron. TOC, Speciated PAH & banded TPH* Asbestos ID
Crushed product	pH, total metals (Cu, Ni, Zn, Cr III, Cr VI, As, Hg, Se, Cd & Pb), water soluble boron. TOC & Speciated PAH Asbestos ID

Note: The schedules detailed above have been prepared in accordance with the Secondary Model Procedures. This document states that analysis should be relevant to potential sources and not merely a set list of parameters applied to each site.

* The YALPAG guidance recommends speciated TPH (TPH CWG) analysis for brownfield sources, but this should not be necessary unless the banded TPH analysis fails the assessment criteria detailed in Table 2 below.

Where crushed product is used at least 600mm below finished garden level, only asbestos analysis will be required.

1.21 Additional determinands may be scheduled dependent on the history of the source site, although if this is considered necessary it may suggest the material is unlikely to be suitable for use as clean cover in gardens.

1.22 Chemical assessment (Tier 1) criteria for imported soils are provided in Table 2, these reflect exposure and toxicological amendments proposed within the C4SL report. Where no revised toxicological value has been published the former CLEA value has been adopted.

Table 2 - Chemical assessment criteria for imported soils

Contaminant	Source	Tier 1 assessment criteria (mg/kg)	Comments/notes
pH	CLEA		
As	C4SL	37	
Cd	C4SL	26	
Cr (III)	C4SL	3,000	
Cr (VI)	C4SL	21	
Pb	C4SL	200	
Ni	C4SL	127	Assessment of human health risk only.
Se	C4SL	434	
Hg	C4SL	199	Assumes mercury present as an inorganic compound (cf elemental metal or within organic compound). See Science Report SC050021/Mercury SGV.
B	Lithos	5	Based on phytotoxic risks as plants are the more sensitive receptor (Cu is pH dependent).
Cu	DoE	80 to 200	
Zn	DoE	200	
Benzo(a)pyrene	C4SL	5	
Naphthalene	C4SL	12	
GRO	C4SL	45	Conservative value based on value for aromatic fraction C7 to C8 range, but assuming indoor inhalation pathway still relevant (it shouldn't be).
DRO	C4SL	219	Conservative value based on value for aliphatic fraction C10 to C12 range, but assuming indoor inhalation pathway still relevant (it shouldn't be).
LRO	C4SL	1,000	Calculated value above hazardous waste screen in WM3, there 1,000mg/kg adopted. This may be reviewed on a site specific basis depending on the source and nature of transfer.

2 VALIDATION REPORTS

2.1 The analytical testing will usually be undertaken on a 3 or 5-day turnaround and the Client/Contractor will be notified of the soil's suitability (or otherwise) immediately after receipt of the results.

2.2 Interim plot validation certificates should be issued to warranty providers on a plot by plot (or block by block) basis as development proceeds. Once the full development has been completed these should be pulled together into a final verification report, for submission to the Local Authority to satisfy planning conditions.

APPENDIX C
LITHOS TIER 1 VALUES

Soil screening values used by Lithos

In March 2002 DEFRA and the Environment Agency published a series of technical papers (R&D Publications CLR 7, 8, 9 and 10) outlining the UK approach to the assessment of risk to human health from land contamination. In 2008 CLR 7, 9 and 10 and all corresponding SGV and Tox reports were withdrawn and superseded by new guidance including:

- Guidance on Comparing Soil Contamination Data with a Critical Concentration - CL:AIRE and CIEH, May 2008
- Evaluation of models for predicting plant uptake of chemicals from soil - Science Report – SC050021/SR
- Human health toxicological assessment of contaminants in soil - Science Report: SC050021/SR2
- Updated technical background to the CLEA model - Science Report: SC050021/SR3
- CLEA Software Handbook (Version 1.071), Science report: SC050021/SR4
- Compilation of data for priority organic pollutants for derivation of Soil Guideline Values - Science Report: SC050021/SR7

The approach set out in these documents represents current scientific knowledge and thinking; and includes the Contaminated Land Exposure Model (CLEAv1.06). The Environment Agency are in the process of using this updated approach to regenerate a selection of Soil Guideline Values (SGVs).

CLEA SGVs were derived for standard land use scenarios predominantly in the context of Part IIA, using a conceptual site model (CSM) defined in SR3. Lithos have incorporated amendments to the CSM used to derive SGVs, that more accurately reflect redevelopment within the planning regime; consequently, Lithos have not adopted any published SGV as a screening value.

The CLEA conceptual site model assumes a source located in a sandy loam, with 6% soil organic matter (SOM) - equivalent to 3.5% total organic carbon (TOC). However, where the average TOC value for a particular soil type is significantly lower than the 3.5%, evaluation of Lithos Screening Values should be undertaken and a site specific risk assessment will usually be required. Other CLEA default characteristics adopted by Lithos are:

Sandy Loam characteristics (source)	Default values adopted
Total porosity (fraction)	0.53
Water filled porosity (fraction)	0.33
Air filled porosity (fraction)	0.2

Lithos have derived Screening Values for four different CSMs (scenarios); these are:

A - Residential with gardens, but no cover (or only up to 300mm)

B - Residential with gardens and 600mm 'clean' cover

C - Residential apartments with landscaping (i.e. no home grown produce)

D - Commercial/industrial with landscaping

E – Importation of soil cover

The **exposure** pathways considered for each scenario are detailed in the table below.

Scenario	Land use	Pathways	Justification
A	Residential with garden, but no cover (or only up to 300mm)	• Direct ingestion of soil • Dermal contact • Consumption of vegetables & soil attached to vegetables • Inhalation of indoor vapours and dust • Inhalation of outdoor vapours and dust	Minimal cover – insufficient to break any pathways therefore all exposure pathways are relevant.
B	Residential with garden minimum 600mm cover	• Inhalation of indoor vapours • Inhalation of outdoor vapours	The 600mm cover removes the risk from all pathways other than inhalation.
C	Residential apartments with landscaped areas and minimum 300mm cover	• Direct ingestion of soil • Dermal contact • Inhalation of indoor vapours and dust • Inhalation of outdoor vapours and dust	All pathways applicable due to possible exposure from landscaped areas. However consumption of home grown produce not included as unlikely to be grown in landscaped areas. Where vegetables are to be grown site specific QRA may be required.
D	Commercial/ industrial with landscaped areas no cover	• Direct ingestion of soil • Dermal contact • Inhalation of indoor vapours and dust • Inhalation of outdoor vapours and dust	All pathways applicable due to possible exposure from landscaped areas. Assumed the commercial development consists of offices to provide a conservative assessment.
E	Importation of soil for cover in garden and landscaped areas	• Direct ingestion of soil • Dermal contact • Consumption of vegetables & soil attached to vegetables • Inhalation of outdoor vapours and dust	Material used as cover to break existing pathways therefore all direct and indirect pathways relevant; however cover is **not** placed below plots therefore indoor inhalation is not relevant.

Lithos have assumed the source of contamination is directly below the building foundations; i.e. a depth to source of 0.15m as opposed to the CLEA default of 0.65m. This assumption provides for a more conservative approach than the UK default. This adjustment has been included to account for sites where made ground is re-engineered to enable new buildings to be established on raft foundations. In such situations contamination may lie directly beneath the foundation.

The Soil Screening Values referred to in this document are **not** intended to be used when considering potential risks associated with:

- Existing land uses in the context of Part IIA of the Environment Protection Act 1990;
- End uses such as allotments, sports fields, children's playgrounds, care homes, hospitals etc; and
- Controlled waters

In December 2013 Defra published the results of research project SP1010 – Development of Category 4 Screening Levels (C4SLs) for Assessment of Land Affected by Contamination. The objective of this project was to provide technical guidance in support of Defra's revised Statutory Guidance for Part 2A of the Environmental Protection Act 1990 (Part 2A). The revised Statutory Guidance, published in April 2012, introduced a new four-category system for classifying land under Part 2A where Category 1 includes land where the level of risk is clearly unacceptable, and Category 4 includes land where the level of risk posed is acceptably low. Project SP1010 aimed to deliver:

- A methodology for deriving C4SLs for four generic land-uses comprising residential, commercial, allotments and public open space; and
- Demonstration of the methodology, via derivation of C4SLs for 6 substances – arsenic, cadmium, chromium IV, lead, benzene & benzo(a)pyrene.

The methodology for deriving both the previous Soil Guideline Values and the new Category 4 Screening Levels is based on the Environment Agency's Contaminated Land Exposure Assessment (CLEA) methodology. Development of C4SLs has been achieved by modifying the toxicological and\or exposure parameters used within CLEA (while maintaining current exposure parameters).

The Part 2A Statutory Guidance was developed on the basis that C4SLs could be used under the planning regime. However, policy responsibility for the National Planning Policy Framework falls to the Department for Communities and Local Government. Defra anticipate that, where they exist, C4SLs will be used as generic screening criteria, and Lithos consider C4SLs to be suitable for use as Tier 1 Screening Values. Lithos have discussed this matter with both NHBC and YALPAG (collection of Yorkshire & Lincolnshire local authorities) and received confirmation that they are satisfied with this approach.

With respect to **inorganic** determinands, Lithos derived Tier 1 values for the five Scenarios A to E are presented below:

Inorganic contaminant	Tier 1 assessment criteria (mg/kg) for Scenarios A to E							Comments/notes
	SGV*	C4SL*	A	B	C	D	E	
As	32	37	37	Use (A) in SI Report for initial "screen" If >5 x A, then consider increase of cover to 1,000mm	40	640	37	C4SL adopted
Cd	10	26	26		149	410	26	C4SL adopted
Cr			3,000		3,000	30,000	3,000	Assumes Cr is CrIII
Pb	450	200	200		310	2,330	200	C4SL adopted
Ni	130		127		127	1,700	127	Assessment of health risk only
Se	350		350		595	13,000	434	
Hg	170		169		238	3,640	199	Assumes in an inorganic compound
B			5		5	5	5	Based on phytotoxic risks as plants are the more sensitive receptor (Cu is pH dependant)
Cu			80-200		80-200	80-200	80-200	
Zn			200		200	200	200	

With respect to **organic** determinands, Lithos derived Tier 1 values for the five Scenarios A to E are presented below:

Organic contaminant (all sourced via CLEA)	Tier 1 assessment criteria (mg/kg) for Scenarios A to E							Comments/notes
	SGV*	C4SL*	A	B	C	D	E	
Benzene	0.33	0.87	0.9	0.9	3.3	98	N/A	C4SL adopted
Toluene	610		600	3,000	2,700	5,000	N/A	Calculated value over 10,000
Ethyl Benzene	350		350	932	843	5,000	N/A	
Xylenes	240		246	327	321	5,000	N/A	
Phenol	420		412	2,400	519	5,000	N/A	
PCBs			2	8	2	38	N/A	Based on toxicity of EC7
Benzo(a)pyrene		5	5	25	5.3	76	5	C4SL adopted. Where source is not a coal tar
Naphthalene			8	9	9	1,000	12	
Gasoline Range Organics			30	34	34	5,000	45	See 3-step assessment of TPH below
Diesel Range Organics			151	156	154	5,000	219	
Lubricating Range Org			1,000	5,000	2,000	5,000	1,000	

* *For a residential end use*

The significance of PAHs can be determined by considering indicator compounds. In most cases benzo(a)pyrene (BaP) is adopted as an indicator due to the amount of toxicological data available and has been used by various authoritative bodies to assess the carcinogenic risk of PAHs in food. A surrogate marker approach can be used to estimate the toxicity of a mixture of PAHs in soil using toxicity data for individual indicator compounds within that mixture. Exposure to the surrogate marker is assumed to represent exposure to all PAHs in that matrix. The surrogate marker approach relies on a number of assumptions:

- Surrogate marker (BaP) must be present in all soil samples
- Profile of the different PAH relative to BaP should be similar in all samples
- PAH profile in the soil samples should be similar to that used in the pivotal toxicity study[1]

To assess the PAH profile in a soil sample, the ratio of the seven genotoxic PAHs (benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, chrysene, dibenz[a,h]anthracene and indeno[1,2,3-c,d]pyrene), relative to BaP, should be calculated. The ratio relative to BaP should lie within an order of magnitude above and below the mean ratio to BaP.

Naphthalene should also be considered separately against its generic screen. Whilst classed as a PAH, naphthalene is more volatile and mobile in the environment than most other PAHs. As such the significance of naphthalene cannot be considered within the surrogate marker approach.

Similarly, **TPH** cannot be assessed as a single "total" value, and reference has been made to the Environment Agency's document P5-080/TR3, "The UK approach for evaluating human health risks from petroleum hydrocarbons in soils". This document supports the assumptions and recommendations made by the US Total Petroleum Hydrocarbons Criteria Working Group (TPHCWG). The TPHCWG have broken down "TPH" into representative constituent fractions or "EC Bandings". The TPHCWG have derived a series of physiochemical and toxicological parameters for each of the bandings.

[1] SP1010 Appendix E, Provisional C4SIs for benzo(a)pyrene as a surrogate marker for PAHs, CL:AIRE 2013

The significance of speciated TPH results can be assessed by following the 3 steps outlined in the tables below.

Step	Result	Action
1. Consider indicator compounds: Are BTEX, naphthalene, benzo(a)pyrene above their respective Tier 1 values?	Yes	Remediation or dQRA required
	No	Proceed to Step 2
2. Consider individual TPH fractions: are they above respective screening values?	Yes	Remediation or dQRA required
	No	Proceed to Step 3
3. Assess Cumulative effects: Is the calculated Hazard Index for each source >1	Yes	Remediation or dQRA required
	No	TPH compounds pose no significant risk

Step 1 - Assessing indicator compounds

TPH fraction Indicator compound	End use specific screening value (mg/kg)			
	A: Residential no cover	B: Residential with 600mm cover	C: Residential no gardens	D: Commercial\ industrial
Benzene	0.9	0.9	3.3	98
Toluene	600	3,000	2,700	5,000
Ethyl Benzene	350	932	843	5,000
Xylenes	246	327	321	5,000
Naphthalene	8	9	9	1,000
Benzo(a)pyrene	5	25	5.3	76

Step 2 - Assessing individual TPH fractions

TPH fraction		End use specific screening value (mg/kg)			
		A: Residential no cover	B: Residential with 600mm cover	C: Residential with no gardens	D: Commercial/ industrial
Aliphatic 5-6	GRO	41	41	42	5,000^ per fraction
Aliphatic 6-8	GRO	125	125	125	
Aliphatic 8-10	GRO	31	31	32	
Aliphatic 10-12	DRO	151	156	154	
Aliphatic 12-16	DRO	500^	500^	500^	
Aliphatic 16-21	DRO	1,000^	5,000#	1,000^	
Aliphatic 21-35	LRO	1,000^	5,000#	1,000^	
Aromatic 5-7	GRO	100	123	122	
Aromatic 7-8	GRO	30	34	34	
Aromatic 8-10	GRO	47	50	50	
Aromatic 10-12	DRO	215	287	266	
Aromatic 12-16	DRO	689	1,000*	1,000*	
Aromatic 16-21	DRO	1,000^	5,000#	1,000^	
Aromatic 21-35	LRO	1,000^	5,000#	1,000^	

* Calculated Screening Value exceeded soil saturation limit and could indicate free product, therefore calculated soil saturation limit adopted as a target

^ Calculated Screening Value close to soil saturation limit, screening value selected by Lithos considering visual and olfactory impacts.

Five times the screening value for Scenario A.

Step 3 - Assessing Cumulative Effects

$$HI = \sum_{F_i=1}^{16} HQ\ F_i = \frac{Measured\ concentration\ F_i\ (mg\,kg^{-1})}{SGV\ F_i\ (mg\,kg^{-1})}$$

where HI = Hazard Index
HQ = Hazard Quotient
F_i = Fraction $_i$
SGV = Soil Guideline Value

Other screening values used by Lithos

Tier 1 risk assessment of **hazardous gas** is undertaken through reference to the following documents (and further information is presented in Generic Note No. 5 – Hazardous Gas):

- Approved Document C, Building Regulations 2000
- Boyle & Witherington (2007) – Guidance on evaluation on development proposals on sites where methane and carbon dioxide are present, incorporating "traffic lights". Report Ref. 10627-R01-(02), for NHBC
- CIRIA C665 (2007) – Assessing risks posed by hazardous ground gases to buildings
- BS 8485:2015 – Code of Practice for the characterisation & remediation from ground gas in affected developments

With respect to the assessment of potential **phytotoxic effects** of contaminants, Lithos refer to "The Soil Code" (MAFF, 1998) for copper and zinc. The CLEA SGV is adopted for nickel due to its human health effects.

The potential risk to **building materials** is considered through reference to relevant BRE Digests, with particular emphasis on BRE Special Digest 1, 'Concrete in aggressive ground', 2005.

With respect to the interpretation of the **calorific values**, at present there are no accepted methods to assess whether a sample is combustible and under what circumstances it might smoulder. Some guidance is given in ICRCL Note 61/84 "Notes on the fire hazards of contaminated land" which states that: *"In general ... it seems likely that materials whose CV's exceed 10MJ/kg are almost certainly combustible, while those with values below 2MJ/kg are unlikely to burn".*

Tier 1 **groundwater** risk assessments are undertaken by comparing leachate or groundwater concentrations with the appropriate water quality standard. Tier 1 Screening Values have been discussed with the Environment Agency, and typically those in **bold** below are adopted.

Analyte	Source of Tier 1 Screening Value (µg/l)			
	Surface water (Abstraction for Drinking) 1996	Water Supply Regulations 2000	Water Framework Directive	EA Advice
Arsenic	50	10	**50**	
Selenium	10	**10**		
Cadmium	5	5	**1.5**	
Chromium	50	50	**32**	
Copper	50	2,000	**28**	
Lead	50	10	**7.2**	
Nickel		20	**20**	
Zinc	3,000		**125**	
Boron		**1,000**		
Mercury	1	1	**0.07**	
Petroleum Hydrocarbons				**10**
1,1,1-Trichloroethane			**100**	
1,1 Dichloroethane				**100**
1,2-Dichloroethane		3	**10**	
1,1-Dichloroethene				**100**
Benzene		1	**10**	
Ethylbenzene				**10**
Tetrachloroethene		10	**10**	
Toluene			**50**	
Trichloroethene		10	**10**	
Vinyl Chloride		**0.5**		
Trichloromethane			**2.5**	
Xylenes			**30**	
Chloroethane				**100**

Waste classification & WAC

In the context of waste soils generated by remediation and\or groundworks activities on brownfield sites, the following definitions (from the Landfill Regulations 2002) apply:

- Inert (e.g. uncontaminated 'natural' soil, bricks, concrete, tiles & ceramics)
- Non-Hazardous (e.g. soil excavated from a contaminated site which contains dangerous substances, but at concentrations below prescribed thresholds)
- Hazardous (e.g. soil excavated from a contaminated site which contains dangerous substances at concentrations above prescribed thresholds)

Dangerous substances include compounds containing a variety of determinants commonly found in contaminated soils on brownfield sites, for example arsenic, lead, chromium, benzene etc.

Landfill operators require Waste Acceptance Criteria (WAC) laboratory data, if soil waste is classified as **hazardous**, and such waste must have been subjected to pre-treatment. However, subject to WAC testing it may be possible to classify it as stable, non-reactive hazardous waste, which can be placed within a dedicated cell within the non-hazardous landfill.

Lithos typically only include WAC analysis in site investigation proposals and reports, if significant off-site disposal (of soil classified as hazardous waste) is anticipated, for example where redevelopment proposals include basement construction etc. If off-site disposal of soils classified as hazardous waste during redevelopment is anticipated, then WAC analysis should be scheduled at an early stage in the remediation programme. However, organic compounds (BTEX, TPH, PAH etc) are the most common contaminants that result in soils being classed as hazardous, and these contaminants can often be dealt with by alternative technologies (e.g. by bioremediation or stabilisation) and consequently retention on site is often possible.

It should be noted that **non-hazardous** soil waste can go to a non-hazardous landfill facility; no further testing (e.g. WAC) is required.

APPENDIX D

LITHOS PROTOCOL FOR THE PLACEMENT OF NON-ENGINEERED FILL

1 INTRODUCTION

1.1 This protocol is aimed at providing general guidance to contractors in the placement of general earthworks fill materials in areas of a site that do not require high quality, controlled engineering eg Public Open Space. No guarantee can be made as to the degree of settlement that may occur in such fill masses; however, the protocol should mitigate significant differential settlements.

1.2 General fill will be either inert soil or contaminated soil that is deemed chemically suitable for reuse in certain specific site areas or beneath a specified 'clean' soil cover layer. All soft and compressible soils or existing fill shall, if comprising unsuitable fill be removed from site. Suitable fill materials may be compacted on site.

1.3 Unsuitable fill shall comprise:

- Cohesive soils having a liquid limit in excess of 90% or Plasticity Index in excess of 65%
- Chalk having a fine fraction (<400μm) in excess of 10% at the borrow pit
- Any material containing topsoil, wood, peat or lignite
- Any material containing biodegradables
- Any material containing scrap metal
- Frozen or waterlogged substances
- Material defined as unsuitable by the Engineer because of its type or level of contamination
- Material which, by virtue of its particle size or shape, cannot be properly and effectively compacted (eg oversize material, gravels which are tabular and some slate wastes)
- Expansive steel slag
- Non-inert or contaminated material
- Putresible waste
- Materials containing minerals hostile to the built environment such as pyritic shales, gypsiferous clays, burnt colliery discard, pulverised fuel ash, spent oil shale or incinerator waste

1.4 The base of the area to be filled shall be proof rolled with a dead weight roller and all soft materials removed and replaced with compacted fill. Where unsuitable material has been excavated, the underlying ground shall be compacted to the same specification as adopted for subsequent compaction works.

1.5 Fill shall be placed and compacted in near-horizontal layers of maximum 200mm thicknesses and be brought up at a uniform rate so that all parts of the site or particular sections of the site reach finished (formation) level at the same time. Each layer will be subjected to nominal compaction, comprising at least two passes with a towed vibratory roller of at least 2,900 kg per metre width (or equivalent). If the compacted fill demonstrates excessive rutting, excessive roller 'bow-waving' or other soft behaviour then it shall be deemed unsuitable.

1.6 Cobbles, boulders, rock or waste fragments, the largest dimension of which is greater than two-thirds of the compacted layer thickness (or greater than 250mm in any dimension), shall not be incorporated into the fill.

1.7 When compacting fill in the vicinity of existing trenches, excavations, retaining walls or other structures all work shall be performed in such a way as to ensure that their existing stability is not impaired; this will require careful selection of both compaction plant and compaction method.

1.8 When placing fill against structures the Contractor must only use only the following types of compaction plant for fill within 2m of a structure:

- Vibratory roller, mass per metre width of roll not exceeding 1300 kg and total mass not exceeding 1000 kg
- Vibrating plate compactor, mass not exceeding 1000 kg
- Vibro-tamper, mass not exceeding 75 kg

1.9 If weather conditions are such that the fill is adversely affected, the Contractor shall cease work until such time as the fill can be placed and compacted to meet the protocol requirements. No fill shall be placed and left uncompacted at the end of the working day. Compacted fill shall be graded to falls to ensure free run-off of rainwater without ponding.

1.10 Drainage grips or trenches shall be excavated, as necessary, uphill of the area to be filled to prevent the area becoming flooded. Drainage shall be affected without causing siltation or erosion and water shall be disposed of. The area to be filled shall be graded to falls, and sump pumping or other suitable dewatering facilities shall be provided as necessary by the Contractor to keep the base of the excavation dry at all times.

APPENDIX E
PROTOCOL FOR INSPECTION OF GAS MEASURES

Suggested Protocol for Validation of Gas Protection Measures

Hazardous gases, most notably methane and carbon dioxide can pose a significant risk to houses. Consequently, risks associated with such gases are considered during the site investigation, and where appropriate a programme of gas monitoring is recommended. Typically 50mm diameter wells, installed in boreholes, are monitored over a number of months under a variety of atmospheric conditions.

On completion of the monitoring programme, a gas risk assessment report is issued. Where the proposed development comprises low rise residential housing, the gas regime is characterised in accordance with the Situation B (traffic light) methodology outlined in CIRIA Report C665.

If the site is classified as AMBER 2, independent certification is required to ensure that the gas measures are installed correctly, and enable finalling of plots under the CML initiative (Certification is a RED item).

Details of the necessary validation to be provided by suitably qualified Lithos Engineer are site-specific and dependant on the actual scope of gas protection measures recommended. However, typically there are two key stages during construction:

1. Creation of the sub-floor void.
2. Placement of the gas resistant membrane.

BRE\Environment Agency Report BR 414 (2001) – "*Protective Measures for housing on gas-contaminated land*" provides a practical guide to good practice for the detailing and construction of passive soil gas protection measures for new residential development. Of particular relevance are a list of 'Watchpoints', which offer practical information for installation and buildability.

With respect to the actual flow of information etc between Client and Consultant, the following protocol is recommended.

1. Client's site agent\manager to inform Lithos, by fax, of need for an inspection. The fax should state:
   - which plot(s) require inspection,
   - for which stage of construction (sub-floor void, membrane etc), and
   - when the visit is required (ideally 2 working days' notice is required).
2. The Consultant should confirm by fax (to site & copied to office) that he has visited site and undertaken all necessary validation, within 1 working day of his visit. The fax should state:
   - when the visit was undertaken,
   - which plot(s) were inspected,
   - for which stage(s) of construction, and
   - confirm that the details inspected were satisfactory.

If any details were not satisfactory, the Consultant should inform the Client's agent of the necessary remedial measures on site and then detail these in writing on his subsequent fax (clearly an additional visit will be necessary to inspect the remedial works).

The above protocol is considered important to ensure *all* plots are inspected at *all* relevant stages of construction, in order that Lithos can issue a robust Validation Report.

Validation of Gas Protection Measures

Job No.	
Site Name	
Client	

Plot No.	Inspection dates	Inspected by	Hgt of void space > 200mm	Sleeper walls[1]	Air bricks[2]	DPC[3]	Membrane[4]	Membrane penetrations[5]	Remarks

Notes:

1 – Checked for ventilation allowance ie honeycombed, or with min. 100mm dia. pipes in line with external air vents.

2 – Checked for mm^2 ventilation, obstructions, spacing, alignment, connection to telescopic vents (if required).

3 – Checked for material; integrity; unnecessary creasing.

4 – Checked for material; unnecessary creases; underlying floor slab clear of debris that could cause puncture; damage; overlap & seal with DPC (min. 150mm), using correct double-sided tape; curled edges stuck down.

5 - Checked for top hat suitably sealed, with a sufficient length of pipe to allow fitting of connection collar.

Hazardous gases, most notably methane and carbon dioxide can pose a significant risk to houses. Consequently, risks associated with such gases are considered during the site investigation, and where appropriate a programme of gas monitoring is recommended. Typically 50mm diameter wells, installed in boreholes, are monitored over a number of months under a variety of atmospheric conditions.

On completion of the monitoring programme, a gas risk assessment report is issued. Where the proposed development comprises low rise residential housing, the gas regime is characterised in accordance with the Situation B (traffic light) methodology outlined in CIRIA Report C659.

This site has been classified as Amber 2 and therefore the protective measures outlined in the table below are required in new dwellings. It should be noted that independent certification is required to ensure that the gas measures are installed correctly, and enable finalling of plots under the CML initiative (Certification is a Red item). Dependent upon the nature of floor construction integrity testing may also be required.

Traffic light	**Gas "score" req'd by BS 8485**	**Floor slab (BS8485 "score")**	**Protective measures**	
			Sub-floor ventilation (BS8485 "score")	**Membrane** **Type (BS8485 "score")**
Amber 2	4	*Select one from:* Block & Beam – (0). Reinforced ground bearing slab – (0.5). Reinforced, cast in-situ suspended slab (with minimal service penetrations & water bars around all slab penetrations & at joints) – (1.5). Reinforced ground bearing raft (with limited service penetrations cast into slab). Note: the venting area through any downstand beam should be 3 times greater that provided by the side ventilation (air bricks) – (1.5).	*Select one from:* Passive sub-floor ventilation; venting layer could be: A min. 150mm clear void (2.5), or A proprietary void former (expanded polystyrene shuttering) providing an equivalent clear void depth of 33mm (2.5). Min. ventilation = 2,000 mm^2/m run of external wall (via air bricks on each of 2 opposite sides), with 100mm pipes at 1.5m centres or honeycombing of any sub-floor sleeper walls.	Gas resistant membrane, incorporating aluminium foil (eg Monarflex RAC or Reflex Super; Keytec 400; Alderprufe GRA; Visqueen Gas Barrier; PAG Standard & Super). (1.0) - workmanship must be subject to inspection. Increase to 2.0 if also subject to integrity testing.

Footnotes:

1. The membrane should always be lapped and sealed in accordance with BRE\Environment Agency Report BR414 (2001) – "*Protective Measures for housing on gas-contaminated land*". The membrane should be continuous across cavity walls, and there should be a cavity tray in external walls.
2. In all cases there should be minimum penetration of floor slab by services; any penetrations should be suitably sealed.
3. Integral garages with occupied rooms above, or direct access through a doorway from the garage to the house, should be provided with the same protective measures as the rest of the dwelling. Buildings with basement car parks (with ventilation in accordance with Building Regulations) may not require gas resistant membranes.
4. Check manufacturer's specification if hydrocarbon vapours are present; hydrocarbons will degrade some membrane materials.
5. Protection measures for Amber 2 also constitute full radon measures.

BRE\Environment Agency Report BR414 (2001) – "Protective Measures for housing on gas-contaminated land" provides a practical guide to good practice for the detailing and construction of passive soil gas protection measures for new residential development. Of particular relevance are a list of 'Watchpoints', which offer practical information for installation and buildability.

Designers\Architects should be made aware of the importance of gas protection measures, and their house designs should take account of potential constraints associated with Building Regulations (most notably those relating to access thresholds, noise and insulation), flood mitigation measures, and utility providers (external meter boxes may have to be located away from air bricks) etc.

In general accordance with BR414 verification of protective measures installation will be undertaken by suitably experienced Lithos Engineer. Dependent upon the chosen floor construction verification should be undertaken at two or three key stages during construction as detailed below:

1. Floor construction and creation of the sub-floor void.
    - Check floor construction type
    - Check allowance for ventilation ie sleeper wall honeycombed, or with min. 100mm diameter pipes in line with external air vents
    - Check airbricks for mm^2 ventilation, obstructions, spacing, alignment, connection to telescopic vents (if required)
2. Placement of the gas resistant membrane. The following checks should be made:
    - Manufacturer's specification of membrane is acceptable for Amber 2 measures.
    - General integrity and for unnecessary creasing.
    - That underlying floor slab is clear of debris that could cause puncture to the membrane along with any existing damage.
    - That the membrane extends over external wall cavity and overlaps/seals with damp proof membrane (DPC) by a minimum of 150mm. The correct double-sided tape should be used to seal the membrane and DPC and any curled edges should be stuck down.
    - Top hat suitably sealed, with a sufficient length of pipe to allow fitting of connection collar. If service cables are to be run through duct, the pipe should be sealed using an approved mastic sealant sandwiched between layers of expandable polyurethane foam filler.
3. Integrity testing (optional). Post-installation integrity testing of the membrane and joints may be undertaken (usually by the installer). The integrity testing should be in the form of a pressure test where the underside of the membrane is pressurised with an appropriate tracer gas and then the top surface swept with a suitable gas-detection device. A report on testing results should be provided to Lithos.

Ideally insulation layers or the floor screed should be installed immediately that satisfactory inspection and/or integrity testing has been verified. This will prevent damage and loss of integrity of the membrane.

If at any of the key stages defects are identified these should be recorded and passed to the Client or their agent. On completion of the necessary remedial works a further inspection will be undertaken.

Job no.	
Site name	
Client	

Plot no.	Inspection dates	Inspected by	Height of void space	Sleeper walls[1]	Air bricks[2]	DPC[3]	Membrane[4]	Membrane penetrations[5]	Remarks

Notes:

1 Checked for ventilation allowance ie honeycombed, or with min. 100mm dia. pipes in line with external air vents

2 Checked for mm^2 ventilation, obstructions, spacing, alignment, connection to telescopic vents (if required)

3 Checked for material; integrity; unnecessary creasing

4 Checked for material; unnecessary creases; underlying floor slab clear of debris that could cause puncture; damage; overlap & seal with DPC (min. 150mm), using correct double-sided tape; curled edges stuck down

5 Checked for top hat suitably sealed, with a sufficient length of pipe to allow fitting of connection collar