13. Ground Conditions and Contamination

Introduction

- 13.1 This Chapter reports the outcome of the assessment of likely significant environmental effects arising from the Proposed Scheme in relation to ground conditions and contamination.
- 13.2 The Chapter describes the scope of the assessment and assessment methodology, and a summary of the baseline information that has informed the assessment.
- 13.3 In line with **Chapter 2: Approach to EIA**, the assessment reports on the likely significant environmental effects, the further mitigation measures required to prevent, reduce or offset any significant adverse effects, or further enhance beneficial effects. The conclusions are provided both in terms of the residual effects and whether these are considered to be significant. The assessment of effects takes into consideration both primary and tertiary mitigation (see **Chapter 2: Approach to EIA** for further details) and is informed by the EIA Scoping process (**Appendices 2.1 - 2.4**) and iterative scoping process where applicable.
- 13.4 This Chapter, and its associated **Figure 13.1** and **Appendices 13.1 13.5**, is intended to be read as part of the wider ES with particular reference to the introductory Chapters of this ES (**Chapters 1 5**).
- 13.5 In addition, this Chapter should be read in conjunction with **Chapter 15: Assessment of Cumulative Effects**.

Summary of Consultation

13.6 No additional specific consultation has been undertaken to inform the assessment provided within this Chapter of the ES, over and above that completed during the EIA Scoping process. However, wider consultation with the Coal Authority has been undertaken for the ground investigation works that have been undertaken within Phase 1.

Scope of the Assessment

13.7 An EIA Scoping Report was submitted to WC on 13th July 2022, as presented as Appendix 2.1. The Scoping Opinion was received on 30th August 2022 (Appendix 2.2). This section provides update on the scope of the assessment presented within this Chapter following submission of the EIA Scoping Report.

Effects Not Considered to be Significant

13.8 A number of effects were considered unlikely to be significant as part of the EIA Scoping Report. In the Scoping Opinion, WC requested that these are considered. Based on the completion of further technical analysis and intrusive ground investigation works, further technical evidence to demonstrate that these are not significant is provided for each effect below.

Contamination and risk to human health

- 13.9 The Preliminary Risk Assessments (PRAs) (see **Appendices 13.1** and **13.4**) have identified a moderate to low risk to human health from potential contamination in localised areas associated with historic on-site and off-site use, including from colliery spoil associated with shallow open cast and underground coal mining.
- 13.10 Intrusive ground investigations (see Appendix 13.2) have identified the presence of heavy metals, non-volatile polycylic aromatic hydrocarbons (PAH), Asbestos Containing Materials (ACMs), hydrocarbons, inorganic and organic contaminants and phototoxic contaminants. Similar contaminants are anticipated to be present across the wider EIA Study Area.
- 13.11 Further intrusive ground investigations will be undertaken prior to the commencement of main construction works in line with relevant guidance, including British Standard 5930:2015 Code of Practice for Site Investigationsⁱ and British Standard 10175:2011+A1:2013 Investigation of Potentially Contaminated Sites - Code of Practiceⁱⁱ. This will include further chemical analysis and geotechnical testing to be completed in accordance with DEFRA Land Contamination: Risk Management (LCRM 2021)ⁱⁱⁱ.
- 13.12 Given the contamination identified to date, remediation in line with a Remediation Strategy (RS) will be undertaken, which will mitigate the risk. The RS will be approved by WC. This will likely include the use of clean capping layers and disposal, removal and / or processing of contamination hotspots and the placement of geotechnically suitable materials to achieve the required standards for the proposed land uses as defined by the site specific risk assessment developed in accordance with LCRM 2021. A verification strategy will be prepared that will ensure that the required thresholds / criteria have been achieved through the RS. This will be submitted to WC. This will ensure that the EIA Study Area is not classified as 'contaminated land' under Part 2a of the Environmental Protection Act^{iv}.
- 13.13 Contamination, both historic and newly released pollutants from construction activities, will be managed by adherence with the Construction (Design and Management) Regulations, use of appropriate PPE and RPE, toolbox talks, use of working method statements and compliance with health and safety regulations. Furthermore, appropriate strategies / protocols will be put in place in line with relevant legislation (such as The Control of Asbestos Regulations) and best practice for activities, such as demolition. Relevant dust mitigation measures will also be implemented. These measures will be included within a CEMP.
- 13.14 Once the Proposed Scheme has been completed, the areas of built development (see Figure 4.6) will be covered predominantly with hardstanding and building slabs, which will break the plausible contamination linkages for future site users (such as ingestion and dermal contact) in these areas. In addition, as noted above, contaminants encountered during the construction stage will be remediated in line with the requirements for the proposed end use. Clean cover layers will also be validated for chemical quality prior to re-use / use on-site. This will preclude the release / migration of contamination during operation.
- 13.15 With the implementation of the above, any contamination and risk to human health is unlikely to be significant and will not be considered further within this ES.

Contamination and risk to controlled waters (surface watercourses and Secondary Undifferentiated and Secondary A Aquifers)

- 13.16 The PRAs (see **Appendices 13.1** and **13.4**) have identified a moderate to low risk to controlled waters receptors (multiple surface water courses, including named and unnamed streams and drains; Secondary Undifferentiated and Secondary A Aquifers in the superficial strata and Secondary A Aquifer) from potential contamination in localised areas associated with historic on-site and off-site uses.
- 13.17 The ground investigation (**Appendix 13.2**) has identified the presence of mobile contaminants, including metals, PAHs, hydrocarbons and volatile compounds (within Made Ground). Similar contaminants are anticipated to be present across the wider EIA Study Area.
- 13.18 As contamination has been identified, to reduce the short-term risk to controlled waters receptors, a detailed risk assessment will be undertaken based on further ground investigation(s), to include groundwater monitoring / sampling. Subject to the results of this work, in-situ / ex-situ remediation may be required in consultation with the Environment Agency with associated permit. This will form part of the wider RS that will be prepared and will be submitted and agreed with WC. A verification strategy will be prepared that will ensure that the required thresholds / criteria have been achieved through the RS. This will be submitted to WC.
- 13.19 Construction activities are generally a low risk to moderate risk of generating pollution, notably with fuel spillages. Any pollution incidents that occur during the construction stage can be mitigated using inception points and plant spill kits to limit the migration of contaminants to the receptor. These measures will be included in the CEMP, to include the Pollution Prevention Guidelines (PPG's) to provide a suitable structure for legislative compliance. In addition, all works will be undertaken with such as CIRIA's Control of Water Pollution from Construction Sites^v.
- 13.20 A temporary drainage strategy will also be implemented, which will reduce the risk of mobilisation of contamination into the Honksford Brook, Astley Brook and associated surface water features and underlying groundwater bodies within and in the proximity of the EIA Study Area via overland flow / run-off during construction.
- 13.21 Where piled foundations are used, the method of construction will be carefully selected to ensure that the migration of contamination into sensitive resources is kept to a minimum. Such activities will be undertaken in line with guidance, such as the Environment Agency's Piling and penetrative ground improvement methods on land affected by contamination: guidance on pollution prevention^{vi}. This will be led by the appointed contractor. Where required a piling risk assessment will be completed to understand the risk of piling activities associated with impacted soils and receptors.
- 13.22 During the operational stage of the Proposed Scheme, there is a potential for localised spillages of fuel. Contaminants from fuel spillages are likely to occur on areas of hardstanding (e.g. car parking areas). The Proposed Scheme will incorporate a controlled drainage scheme which will include suitable protections / features to mitigate the potential release of chemical contaminants which may be generated during operational stage to the identified surface watercourses and aquifers, such as culverts, soakaways and surface water drainage with petrol interceptors (in line with Pollution Prevention Guidelines 3: Use and design of oil

separators in surface water drainage systems^{vii} (albeit this has been withdrawn)). This will prevent the release / migration of contamination to controlled waters during operation.

13.23 In conclusion, the contamination risk to controlled waters receptors (surface watercourses and underlying Secondary A and Secondary Undifferentiated Aquifers in the superficial and bedrock) are unlikely to be significant and therefore will not be considered further within this ES.

Migration of hazardous ground gases and risk to human health and buildings

- 13.24 The PRAs (see **Appendices 13.1** and **13.4**) have identified a moderate to high risk from hazardous ground gas associated with localised infilled features including former ponds and clay pits and ground gas associated with worked shallow coal seams, mine shafts, peat and marshy ground.
- 13.25 Gas monitoring has been undertaken as part of the intrusive ground investigation (Appendices 13.2 and 13.3) and the presence of methane, carbon dioxide, volatile contaminants (such as hydrocarbons, solvents and antifreeze) identified. Further ground gas risk assessment will be undertaken using the completion of the full ground gas monitoring regime. Similar volatile / ground gases are anticipated to be present across the wider EIA Study Area.
- 13.26 During construction, the potential risks from ground gases are to be dealt with by the appointed contractor in accordance with health and safety legislation, including the Confined Space Regulations. In addition, the CEMP will contain appropriate measures, such as the use of appropriate PPE, monitoring equipment, safe-entry procedures and use of Respiratory Protective Equipment (RPE) where required, to mitigate the potential risk of exposure to hazardous gas and vapours and / or depleted oxygen levels.
- 13.27 In accordance with current standards and guidance (including British Standard 8485:2015+A1:2019^{viii} and CIRIA's Assessing risks posed by hazardous ground gases to buildings^{ix}), appropriate gas protection measures will be incorporated within the new buildings to in order to mitigate the risk to human health and buildings. Gas protection measures will include, where appropriate, passive gas membranes to prevent gas ingress and sub floor ventilation to provide a dispersal pathway and pressure relief. Details of gas protection measures will be provided to WC prior to the commencement of construction.
- 13.28 With an appropriate risk assessment and the installation of gas protection measures (if required), the risk from ground gas to human health can be mitigated and is unlikely to be significant and therefore will not be considered further within this ES.

Subsidence risk from known shallow or probable shallow historic coal mining

- 13.29 This section refers to the known shallow or probable shallow coal mining only. Risks from mine shafts and unlicensed opencast coal mining are considered in detailed within this Chapter (see **Table 13.1**).
- 13.30 Known and unrecorded (probable) mine workings have been identified within the Rams (Bottom Furnace), Top Furnace, Ashton Great, Ince Yard (Bland, Bin), Bin, Crumbouke (Colonel) and Brassey (Rodger) coal seams and significant areas of known opencast mining within the EIA Study Area. If, and where, these seams are present, it is anticipated that these

workings will represent an increased risk within the EIA Study Area. Further details are provided in **Appendix 13.5**.

- 13.31 Ground investigation works were undertaken in the area of Phase 1 to prove the extent of known and probable unrecorded workings and the results are reported in Appendix 13.2. A series of five rotary boreholes were advanced in accordance with the Coal Authority Permission ref: 25093 to confirm the extent of the workings, the depth of the workings, assess the extent of competent rock cover, risk of future subsidence and requirement for future stabilisation of this feature. The locations of the boreholes are shown on Figure 13.1. These ground investigations identified the potential for shallow workings within boreholes RB101, RB102, RB105. RB106 and RB108, based on evidence for coal traces within fractured bedrock and in RB101 a significant loss of flush.
- 13.32 Within an additional ground investigation was undertaken in accordance with the Coal Authority Permission ref: 25738, the potential for shallow workings has been identified in RB201, RB202, RB203 and RB205, based on evidence of voids, loss of flush and coal traces within fractured bedrock. Multiple intact seams of coal are noted to be shallow depths within RB204, RB206 and RB207. However, the information from the boreholes indicate that the depth of rock cover exceeds any ratio of 10 × seam thickness and therefore grouting may not be required in these areas.
- 13.33 Based on the ground investigations carried out, it is considered probable that the Bulldog (Bin) mine seam, Crumbrouke seam, Ochley seam, brassey seam and Ashclough seam have been worked beneath the EIA Study Area. There is also the known risk of near-surface excavation in association with the known opencast mining. Based on the dip of the strata and seam thickness, it is unlikely that sufficient rock cover (10 x seam thickness) will be present.
- 13.34 Further permits will be obtained from the Coal Authority for any further ground investigation works within the wider EIA Study Area (where required) and mine stabilisation works (post investigation), including detailed designs, construction method statements and validation testing protocols to ensure strict environmental and regulatory control for the works.
- 13.35 With respect to the mine stabilisation works, subject to liaison and agreement with the Coal Authority, these are only required beneath areas of proposed development (i.e. roads and built form) and areas which may influence proposed development. Therefore, works are not anticipated to be required across the majority of the green infrastructure areas shown on **Figure 4.6** or within the Eastern Parcel.
- 13.36 In areas of development or areas which will influence proposed development, a programme of drilling and pressure grouting will be completed to stabilise any abandoned mine workings in accordance with CIRIA guidance Abandoned mine workings manual (C758D)^x. These works will be designed by a suitably qualified engineer and will, as a minimum, include:
 - The appropriate use of specialist plant and equipment as required;
 - Bulk materials stored in a manner that prevents any dust egress or impact upon controlled waters;
 - The use of appropriate specification liquid or semiliquid grouts to be pumped into the mine workings requiring stabilisation;

- Pressure testing of an appropriate number of grout injection locations;
- Materials testing of an appropriate number of grout cubes taken at appropriate intervals; and
- Control measures instigated to ensure no egress of liquid grout from the works boundary.
- 13.37 The mine stabilisation works will be designed in consultation with the Coal Authority and in a manner so as not to create any environmental impact to controlled waters or the adjacent properties and will reduce the risk of subsidence of any buildings or structures developed as part of the Proposed Scheme.
- 13.38 The works will be secured by pre-commencement condition, which ensures all mine workings are investigated and stabilised prior to commencement of the Proposed Scheme (and is defined in the Schedule of Mitigation). Therefore, based on the implementation of the above mitigation, subsidence associated with historic coal mining and risk of subsidence is unlikely to be significant and will not be considered further within this ES.

Effects Considered Likely to be Significant

13.39 **Table 13.1** outlines the effects that were considered likely to be significant and are reported within this Chapter.

Table 13.1: Effects considered likely to be significant

Likely significant effect	Receptors	Applicable stage
Subsidence relating to historical open cast coal mining and mine entries	Proposed buildings and infrastructure such as roads	Construction

Assessment Methodology

Legislative Framework, Policy and Guidance

13.40 There is no relevant legislation or policy for the assessment presented within this Chapter.

- 13.41 The following guidance has informed the assessment of effects within this Chapter:
 - CIRIA guidance Abandoned mine workings manual (C758D)^{xi}.

Defining the Study Area

- 13.42 The study area comprises the EIA Study Area (shown on Figure 1.1).
- 13.43 The Phase I Geoenvironmental Site Assessment (Appendix 13.1) and Phase II Geoenvironmental Site Assessment (Appendix 13.2) and gas addendum (Appendix 13.3) have focussed on Phase 1, within the north-western part of the EIA Study Area. Where considered relevant surrounding land uses have been considered.

13.44 The Desk Based Preliminary Risk Assessment (Phase 1 report) (Appendix 13.4) and Desk Based Coal Mining Risk Assessment (Appendix 13.5) are based on a wider boundary than the EIA Study Area and also considered surrounding land uses to identify pertinent features.

Establishing the Baseline

13.45 **Table 13.2** summarises all studies / surveys / analysis / evaluations undertaken to inform the assessment presented within this Chapter.

Study / survey / analysis / evaluation	Overview	Date of completion
Phase I Geoenvironmental Site Assessment (Appendix 13.1)	Desk based assessment of geological, hydrogeological, contaminated land, coal mining and potential pollution risk.	September 2022
Phase II Geoenvironmental Site Assessment (Appendix 13.2) and ground gas addendum (Appendix 13.3)	The Phase II report included factual information on the work undertaken, including: desk study information, sampling location plans and borehole and trial pit logs. A Conceptual Site Model (CSM) in accordance with Environment Agency, LCRM 2021 ^{xii} and British Standard 10175 (Code of Practice for Investigation of Potentially Contaminated Land) ^{xiii} was undertaken. Interpretative information relating to the ground investigation, included; a Tier 1 (qualitative) risk assessment to inform a revised CSM in accordance with LCRM. The report also included preliminary foundation recommendations, pavement design, concrete durability and drainage characteristics based on the information from the ground investigation works.	December 2022 / January 2023
Desk Based Preliminary Risk Assessment (Phase 1 report) (Appendix 13.4)	A desk-based assessment of the potential risks posed by identified historical contamination sources to the Proposed Scheme and to future users ^a .	March 2019
Desk Based Coal Mining Risk Assessment (Appendix 13.5)	A desk-based assessment of the potential risks posed by identified historical coal mining to the Proposed Scheme and to future users ^b .	March 2019

Table 13.2. Dackground stadies / surveys / evaluations / analysi	Table 13.2:	Background studies /	/ surveys /	evaluations /	/ analysis
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^a The report covers a wider area than the EIA Study Area and only Areas 3, 4, 5, 6, 8, 9, 10, 13, 16, 17, 18 and 19 lie within the EIA Study Area.

^b The report covers a wider area than the EIA Study Area and only Areas 3, 4, 5, 6, 8, 9, 10, 13, 16, 17, 18 and 19 lie within the EIA Study Area.

Assessment Process

- 13.46 A review of the Coal Authority abandonment plans within the Phase I Geoenvironmental Site Assessment (**Appendix 13.1**) has been completed for Phase 1 to define the location of historical open cast mine workings and thus assess the areas where impacts could occur on the Proposed Scheme within this area.
- 13.47 Ground investigation works have been undertaken within Phase 1 to prove the extent of known and probable unrecorded workings (Appendix 13.2). A series of rotary boreholes has been advanced in accordance with the Coal Authority Permission process to confirm the extent of the workings, the depth of the workings, assess the extent of competent rock cover, risk of future subsidence and requirement for future stabilisation of this feature. Applications were made to the Coal Authority prior to any intrusive works for a total of two permits to complete investigation works across two separate ground investigations. In line with the Coal Authority's current requirements the permit was completed by the land specialists who are deemed suitably qualified to supervise the process by the Coal Authority and signed by the Applicant.
- 13.48 The Desk Based Preliminary Risk Assessment (Phase 1 report) (**Appendix 13.4**) and Desk Based Coal Mining Risk Assessment (**Appendix 13.5**) included the EIA Study Area and surrounding areas of land. These included a desk-based review of British Geological Survey mapping, Coal Authority records and historical mapping and development of a Conceptual Site Model. This has allowed the broad location of historical open cast mine workings to be identified and thus assess the areas where impacts could occur on the Proposed Scheme.
- 13.49 The information gathered has been used to undertake a qualitative assessment of effects in line with CIRIA guidance (785D).

Reporting of the Environmental Effect and Significance Criteria

13.50 The assessment of likely significant environmental effects as a result of the Proposed Scheme has taken into account the construction stage. The following sections define the approach adopted within the assessment for the determination of sensitivity, magnitude of change (or impact), the level of effect and significance.

Determining Sensitivity of Receptor

- 13.51 The sensitivity of affected receptors has been considered on a scale of **high**, **medium**, **low** or **negligible**.
- 13.52 The criteria for sensitivity are presented in **Table 13.3**.

Category	Criteria
High	Residential properties, schools and community facilities
Medium	Commercial and industrial properties
Low	Highways infrastructure and publicly accessible open space

Table 13.3: Sensitivity criteria

Negligible Agricultural land

Determining the Magnitude of Change (or Impact)

- 13.53 The magnitude of change has been considered as the potential impact at the sensitive receptor (accounting for severity and likelihood) and has been considered on a scale of **large**, **medium**, **small** or **negligible**.
- 13.54 The criteria for magnitude of change (or impact) are presented in **Table 13.4**.

Table 13.4: Magnitude of change (or impact) criteria

Category	Criteria
Large	Catastrophic damage to buildings, structures and / or land which would prevent use / remove integrity which would be likely in the short-term and almost inevitable over the long-term
Medium	Damage to buildings, structures and / or land which would affect the use / integrity which would not be inevitable but possible in the short-term and likely over the long-term
Small	Limited damage to buildings, structures or land which would not affect the use / integrity which would not be inevitable over a long-term period and is less likely in the short-term
Negligible	Minimal damage to buildings, structures and / or land which would not affect the use / integrity which would be improbable

Determining the Level of Effect

- 13.55 The level of effect has been informed by the magnitude of change due to the Proposed Scheme and the evaluation of the sensitivity of the affected receptor. The level of effect has been determined using professional judgement and **Table 13.5** has been a tool which has assisted with this process.
- 13.56 Whilst **Table 13.5** provides ranges, the level of effect is confirmed as a single level and not a range, informed by professional judgement.

		Sensitivity			
		High	Medium	Low	Negligible
ge (or	Large	Major	Moderate to Major	Minor to Moderate	Negligible
Magnitude of chang impact)	Medium	Moderate to Major	Moderate	Minor	Negligible
	Small	Minor to Moderate	Minor	Negligible to Minor	Negligible
	Negligible	Negligible	Negligible	Negligible	Negligible

 Table 13.5:
 Matrix to support determining the level of effect

- 13.57 The following terms have been used to define the level of the effects identified and these can be 'beneficial' or 'adverse':
 - **Major effect**: Where the Proposed Scheme is likely to cause a considerable change from the baseline conditions and the receptor has limited adaptability, tolerance or recoverability or is of the highest sensitivity;
 - **Moderate effect**: Where the Proposed Scheme is likely to cause either a considerable change from the baseline conditions at a receptor which has a degree of adaptability, tolerance or recoverability or a less than considerable change at a receptor that has limited adaptability, tolerance or recoverability;
 - **Minor effect**: Where the Proposed Scheme is likely to cause a small, but noticeable change from the baseline conditions on a receptor which has limited adaptability, tolerance or recoverability or is of the highest sensitivity; or where the Proposed Scheme is likely to cause a considerable change from the baseline conditions at a receptor which can adapt, is tolerant of the change and / or can recover from the change; and
 - **Negligible**: Where the Proposed Scheme is unlikely to cause a noticeable change at a receptor, despite its level of sensitivity or there is a considerable change at a receptor which is not considered sensitive to a change.
- 13.58 The duration of the effect has been assessed as either 'short-term', 'medium-term' or 'longterm'. Short-term is considered to be up to 1 year, medium-term is considered to be between 1 and 10 years and long-term is considered to be greater than 10 years.

Determining Significance

- 13.59 For each effect, a statement has been made as to whether the level of effect is 'Significant' or 'Not Significant'. This determination has been based on professional judgement and / or relevant guidance where applicable.
- 13.60 Significance has only been concluded for residual effects (i.e. following the identification of secondary mitigation).

Baseline Conditions

Historic Mapping

- 13.61 Historical mapping from 1846 indicates the EIA Study Area predominantly comprised agricultural farmland with individual fields and a number of properties / farmsteads shown. Numerous ponds are noted as present on-site, many of which have been infilled with some remaining to the present day. Trees are shown along many of the field boundaries.
- 13.62 There is evidence of coal mines / workings within the EIA Study area from this edition, with Mathers Field Coal Pit is noted in the Eastern Parcel. In 1907, a historic coal mining shaft was indicated on the to the north of the Northern Application parcel and within the central sector of the Eastern Parcel. The Northern Application parcel and Eastern Parcel are known to have been subject to extensive Open Cast coal mining in the mid 20th century.
- 13.63 The Southern Application parcel has not been the subject of any historical mine workings or significant development, largely remaining agricultural pasture since the mid 19th century.
- 13.64 Former historical on-site features include: Tramway, tanks, sludge beds, embankments, slag heaps, refuse / colliery spoil heaps, old shaft / coal pits, undifferentiated buildings, farmyard, roads, tracks, footpaths, railway lines and sidings, builder's yard, working pastoral farm, pastoral grasslands, smithy, bowling greens, cemetery, tennis court, recreation ground, clay pits and a brick works.

Underlying Geology

- 13.65 Geological mapping^{xiv} indicates that the EIA Study Area is primarily underlain by Till (clays) with a small area of Alluvium / Glaciofluvial Deposits (sands and gravels) along the routes of the existing watercourses. There are areas with no superficial deposits in the Northern Application parcel and Eastern Parcel. Due to previous land uses, Made Ground is anticipated in parts of the EIA Study Area.
- 13.66 The majority of the underlying bedrock geology comprises Pennine Middle Coal Measures bedrock (mudstone, siltstone) with the route of the Guided Busway underlain by the Nob End Rock Sandstone formation.
- 13.67 Within Phase 1, the ground investigation (**Appendix 13.2**) identified natural topsoil within localised deposits to depths between 0.20m below ground level (bgl) and 0.40m bgl. Topsoil typically comprised a brown, slightly gravelly clayey fine to medium sand with gravel of sandstone and mudstone. The topsoil appears natural in origin. However, anthropogenic elements are identified, given the known wholesale reworking of the substratum.
- 13.68 The full depth of Made Ground could not be proven in a significant number of exploratory excavations due to the depth of anthropogenic material and the presence of deep open cast workings in defined areas of the Phase 1 area. The drift deposits are varied, generally comprising a firm to stiff, medium strength, brown, orange-brown mottled clay with gravel of sandstone, mudstone. In areas of Phase 1 that appear to be unaffected by historic open cast coal mining and redistribution of the site strip materials, drift deposits were encountered as shallow as 0.3 m bgl. The clay is locally interbedded with dense, orange-brown, gravelly sand with gravel of sandstone, mudstone and coal.

13.69 The solid bedrock geology was encountered between 1.0m and >14.5m bgl (open cast), becoming considerably deeper in the southern sector of Phase 1. The solid geology comprises grey mudstone which is underlain by bands of siltstone, sandstone and coal. Coal and Solid geology with coal as a Primary constituent was encountered within all rotary boreholes between the depths of 6.60m bgl and 34.00m bgl.

Coal Mining

- 13.70 A review of the Coal Authority Online Viewer^{xv} shows that all of the EIA Study Area lies within a Coal Mining Reporting Area and within a Surface Coal Resource Area.
- 13.71 The recorded coal seams that lie under the EIA Study Area are outlined in **Table 13.6**.

Coal Seam (alternative names)	Thickness (m)	Type of workings
Rams (Bottom Furnace) Coal	0.80 - 2.40	Deep mined and surface mined (open cast)
Top Furnace Coal	0.20 - 0.70	Deep mined
Brassey (Rodger) Coal	0.30 - 1.20	Deep mined
Ashton Great coal	0.00 - 2.20	Deep mined
Crumbouke (Colonel) coal	0.80 - 1.50	Deep mined and surface mined (open cast)
Ince Yard (Bland, Bin) Coal	0.60 - 1.30	Deep mined and surface mined (open cast)

 Table 13.6:
 Summary of recorded coal seams

- 13.72 The majority of the Northern Application parcel and parts of the Eastern Parcel lie within a Development High Risk Area. The mapping also indicates that there is the potential for shallow workings and open cast mining beneath the Northern Application parcel and Eastern Parcel and there are a number of mine shafts located within these areas. There is also known to have been underground coal mining activities.
- 13.73 Based on the above, a high risk of unrecorded coal mining at shallow depth has been identified within the Northern Application parcel and Eastern Parcel. Further details are provided in **Appendix 13.5**.
- 13.74 Based on the ground investigations carried out within the Phase 1 area (**Appendix 13.2**), it is considered probable that the Bulldog (Bin) mine seam, Crumbrouke seam, Ochley seam, brassey seam and Ashclough seam have been worked. There is also the known risk of near-surface excavation in association with the known opencast mining. Based on the dip of the strata and seam thickness, it is unlikely that sufficient rock cover (10 x seam thickness) will be present.

Future Baseline

13.75 In the absence of the Proposed Scheme, there are unlikely to be any significant changes from the existing baseline conditions outlined above.

Primary and Tertiary Mitigation

Construction Stage

- 13.76 The following primary and tertiary mitigation has been evaluated as part of the construction stage assessment:
 - Completion of further ground investigation(s) to confirm all contamination and geotechnical risks. Where required, a RS will be prepared and agreed with WC. A verification report will then be prepared following the completion of remedial works. This will be submitted to WC;
 - Use of clean capping layers;
 - Implementation of a CEMP to include measures to avoid contamination risks to human health and controlled waters. This will ensure adherence to the Construction (Design and Management) Regulations and other health and safety legislation. Appropriate strategies / protocols will be put in place in line with relevant legislation (such as The Control of Asbestos Regulations) and best practice for activities, such as demolition. Further measures to be incorporated into the CEMP, include the use of PPE, RPE, the preparation of method statements and provision of environmental awareness training. Relevant dust mitigation measures will be included with the CEMP informed by IAQM guidance;
 - Design and implementation of temporary and permanent surface water drainage strategy to control / manage surface water run-off. The permanent strategy will contain appropriate pollution prevention features; and
 - Ground gas emissions will be monitored with suitable risk mitigation measures to be incorporated within the Proposed Scheme, in line with the BS8485:2015+A1:2019 and CIRIA's Assessing risks posed by hazardous ground gases to buildings.
- 13.77 Within the Development Zones or areas which will influence the areas of built form outside of Phase 1, ground investigation(s) will be undertaken to prove the extent of known and probable unrecorded workings. This will likely comprise a series of rotary boreholes, rotary probeholes, and spiral rotary probing to confirm the extent of the workings, the location of the mineshafts, depth of the workings, assess the extent of competent rock cover, risk of future subsidence and requirement for future stabilisation of these features.
- 13.78 Applications will be made to the Coal Authority prior to any intrusive works for permits to complete the investigation works. In line with the Coal Authority's current requirements the permit will be completed by the land specialists who are deemed suitably qualified to supervise the process by the Coal Authority.
- 13.79 Within the Development Zones or areas which will influence proposed built development outside of Phase 1, it is expected that a programme of drilling and pressure grouting will be completed to stabilise any abandoned mine workings in accordance with CIRIA guidance Abandoned mine workings manual (C758D). These works will be designed by a suitably qualified engineer and will, as a minimum, include:
 - The appropriate use of specialist plant and equipment as required;

- Bulk materials stored in a manner that prevents any dust egress or impact upon controlled waters;
- The use of appropriate specification liquid or semiliquid grouts to be pumped into the mine workings requiring stabilisation;
- Pressure testing of an appropriate number of grout injection locations;
- Materials testing of an appropriate number of grout cubes taken at appropriate intervals; and
- Control measures instigated to ensure no egress of liquid grout from the works boundary.
- 13.80 The mine stabilisation works will be designed in consultation with the Coal Authority and in a manner so as not to create any environmental impact to controlled waters or the adjacent properties and will reduce the risk of subsidence of any buildings or structures developed as part of the Proposed Scheme.
- 13.81 A stiffened soil platform will be constructed over the Open Cast workings to ensure the settlement is within the design tolerable limits for the design classification. This engineering operation will ensure that residual settlement from historical open-cast workings is addressed.
- 13.82 The works will be secured by pre-commencement condition, which ensures all mine workings are investigated and stabilised prior to commencement of the Proposed Scheme (and is defined in the Schedule of Mitigation).

Assessment of Effects, Secondary Mitigation and Residual Effects

Construction Stage

Subsidence relating to historical open cast coal mining and mine entries (Northern Application, Southern Application and Eastern Parcel)

- 13.83 As outlined above, the EIA Study Area is located within a Coal Mining Reporting Area and there are known mine entries, particularly within the Northern Application parcel and Eastern Parcel. Whilst the Southern Application parcel lies within a Coal Mining Reporting Area and Surface Coal Resource Area, no recorded mine entries are present within this parcel.
- 13.84 The ground investigations within Phase 1 (**Appendix 13.2**) have identified the presence of deep Made Ground within the areas of defined open cast mining, this material is predominantly clay and inert in composition placed as backfill during the open cast operations. There is little evidence of materials with significant anthropogenic influence with only localised deposits of Made Ground within the periphery of the former agricultural buildings and colliery structures above ground. It is anticipated that deep-made ground extends into the across the wider Northern Application parcel and Eastern Parcel within the areas of the recorded open cast collieries (all backfilled). There is no evidence to suggest significant anthropogenic deposition in the Southern Application parcel.

- 13.85 Where there is such material, there is a potential risk of subsidence for the proposed buildings / structures and associated infrastructure (e.g. roads), which could lead to damage / total collapse. As shown on Figure 4.6 and described in Chapter 4: Development Specification, all built form and infrastructure is provided within the Northern Application and Southern Application parcels, with only limited works in the Eastern Parcel, reducing the risk of any subsidence in this area.
- 13.86 As outlined above, ground investigation(s) will be undertaken, where appropriate, within the EIA Study Area to identify the geotechnical properties of the underlying ground and identify the presence and extent of mine workings. Following this, within the Development Zones or areas which will influence proposed built development, a programme of drilling and pressure grouting will be completed to stabilise any abandoned mine workings in accordance with CIRIA guidance Abandoned mine workings manual (C758D). In addition, ground engineering works will be completed within the area of the former open Cast Collieries to construct a stiffened soil platform that will mitigate the risk of subsidence to proposed structures and infrastructure. With this mitigation in place, the magnitude of change is considered to be medium.
- 13.87 The sensitivity of the proposed buildings and infrastructure such as roads is considered to range from low to high. The magnitude of change is considered to be medium. Therefore, there is likely to be a direct, permanent, long-term, adverse effect which, by applying professional judgement, is considered to be minor.

Secondary mitigation or enhancement

13.88 Upon completion of the works to consolidate abandoned mine workings and constructed a development platform, specialist geotechnical monitoring will be completed to demonstrate the absence of any ongoing or future subsidence risk. This will comprise maintained zone load testing and specialist instrumentation prior to the commencement of construction.

Residual effect

13.89 The sensitivity of the proposed buildings and infrastructure such as roads is considered to range from low to high. The magnitude of change, following secondary mitigation, is considered to be negligible as the monitoring will ensure that the impact is controlled / managed. Therefore, there is likely to be a direct, permanent, long-term, residual effect which is considered to be negligible.

<u>Significance</u>

13.90 This effect is considered to be **Not Significant**.

Summary

- 13.91 **Table 13.7** provides a summary of the effects, receptors, residual effects and conclusions of significance considered within the Chapter.
- 13.92 The table only provides a summary of the residual effects identified within the assessment and details of all primary, secondary and tertiary mitigation that has been taken into account is set out in detail within the Chapter and summarised within the Schedule of Mitigation included within **Chapter 16: Summary of ES and Schedule of Mitigation**.

Table 13.7: Summary of residual and significant effects

Effect	Receptor	Residual effect	Is the effect significant?
Construction stage			
Subsidence relating to historical open cast coal mining and mine entries (Northern Application, Southern Application and Eastern Parcel)	Proposed buildings and infrastructure such as roads	Negligible	NO

References

^{iv} Environmental Protection Act 1990 c. 43.

^{vi} Environment Agency (2001) Piling and penetrative ground improvement methods on land affected by contamination: Guidance on pollution prevention.

^{vii} https://www.netregs.org.uk/media/1671/ppg-3.pdf.

^{viii} British Standard 8485:2015+A1:2019 (2019) Code of Practice for the Design of Protective Measures for Methane and Carbon Dioxide Ground Gases for New Buildings.

^{ix} CIRIA (2007) Assessing risks posed by hazardous ground gases to buildings (C665).

* CIRIA (2019) Abandoned mine workings manual (C758D) (Errantum 2020).

^{xi} CIRIA (2019) Abandoned mine workings manual (C758D) (Errantum 2020).

^{xii} Environment Agency (2021) LCRM Available at:

https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm ^{xiii} British Standard (2017) 10175:2011+A2:2017 Code of Practice for Investigation of Potentially Contaminated Land.

xiv https://www.bgs.ac.uk/map-viewers/bgs-geology-viewer/

** https://mapapps2.bgs.ac.uk/coalauthority/home.html

ⁱ British Standard 5930:2015 Code of Practice for Site Investigations.

ⁱⁱ British Standard 10175:2011+A1:2013 Investigation of Potentially Contaminated Sites - Code of Practice.

ⁱⁱⁱ https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm

^v CIRIA (2001) Control of Water Pollution from Construction Sites. Guidance for consultants and contractors (C532).