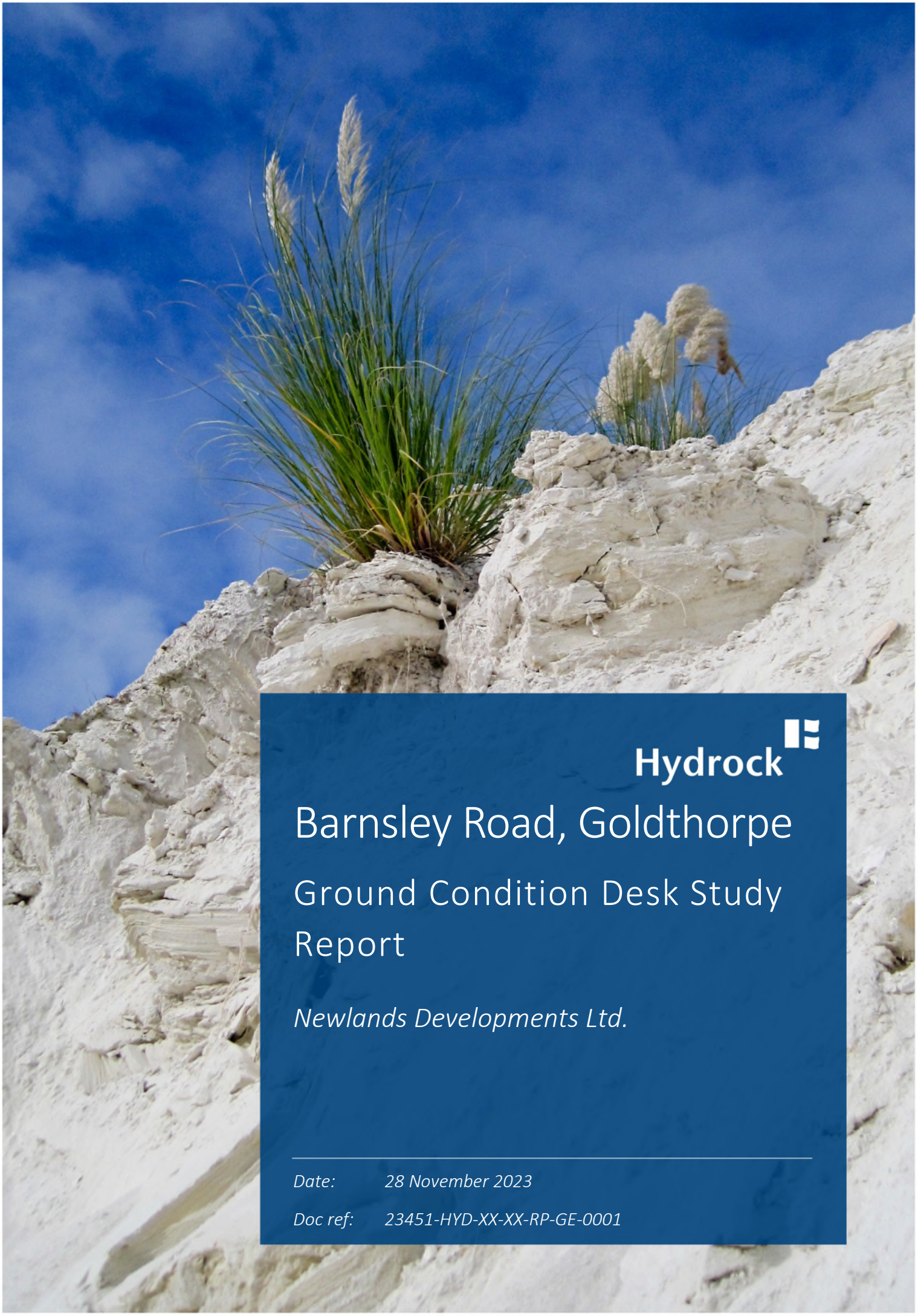

Hydrock

Barnsley Road, Goldthorpe

Ground Condition Desk Study Report

Newlands Developments Ltd.

Date: *28 November 2023*

Doc ref: *23451-HYD-XX-XX-RP-GE-0001*

DOCUMENT CONTROL SHEET

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EXECUTIVE SUMMARY

SITE INFORMATION AND SETTING	
Objectives	Ground condition desk study report.
Client	Newlands Developments Ltd.
Site name and location	Land south of Dearne Valley Parkway, Billingley, Bolton upon Dearne, Barnsley, Yorkshire, S72 0JE.
Proposed development	The site development proposals are understood to comprise a high-quality employment-led development comprising of general industrial, light industrial and warehousing and distribution units, along with associated office space, car parks, roads, soft landscaping and infrastructure.
PHASE 1 (DESK STUDY AND SITE RECONNIASANCE)	
Ground Model	The site comprises open fields with a watercourse, Carr Dike flowing through the centre, from the north to the south-west. The site is approximately 100 ha in area, site levels range between approximately 21m and 45m Above Ordnance Datum (AOD). The land slopes down from the north-west and south to Carr Dike in the centre of the site, which has the lowest elevations. Review of historical Ordnance Survey mapping indicates: • From 1850 the site is mainly occupied by open fields, however in the north-eastern corner there is a bindstone quarry (assumed to be backfilled by 1890). Further quarries are present surrounding the site. • In the 1960s several drains are created in the north of the site. • From the historical mapping the northern half of the site is marked as a quarry (Opencast coal mine) from 2001 and 2010. No significant changes are shown to present day. • A historical landfill is shown in the north of the site, registered as accepting domestic refuse, although the landfill is not shown on historical mapping. A non-specialist UXO assessment indicates a low risk of encountering UXO. Geological mapping indicates that the entire area of the former opencast site comprises Infilled Deposits (northern half of the site). The superficial geology at the site consists of Alluvium across a large area north of Carr Dike, with superficial deposits shown to be absent in the south of the site. The bedrock geology comprises the Pennine Middle Coal Measures in the north of the site and Mexborough Rock – Sandstone (the parent unit is the Pennine Middle Coal Measures Formation) in the south. Hydrock have produced a detailed Coal Mining Risk Assessment (CMRA) referenced 23451-HYD-XX-XX-RP-GE-0002 which should be read in conjunction with this report. A fault is located beneath the south-western tip of the site. The Alluvium comprise a Secondary A aquifer and the Pennine Middle Coal Measures and Mexborough Rock are both Secondary A aquifers. The site is not within a Source Protection Zone and there are no groundwater abstractions within 1km of the site.
ASSESSMENT AND CONCLUSIONS	
Preliminary Geotechnical Hazards	The following plausible geotechnical risks are identified. • Opencast site - historical mining features including uncontrolled backfill to opencast workings and opencast buried highwalls with the potential to cause significant and differential settlement of foundations, floor slabs, roads and infrastructure elements. • Shallow Coal Mining – known mine entries and possible underground shallow workings with the potential to collapse and voids to migrate to the surface resulting in shear failure. • Variable Made Ground/Infilled Ground - settlement or differential settlement of foundations, floor slabs, roads and infrastructure elements. • Low strength, compressible ground of opencast backfill and Alluvium – risk of shear failure and excessive settlement of foundations, roads and infrastructure elements.

<table>
<tr><td></td><td>

Attack of buried concrete by aggressive ground conditions – the development site may contain Made Ground/Infilled Ground and potentially sulfate bearing soils.
Shrinkage/swelling of Alluvium – settlement/heave of foundations, especially where located within the influence of trees and vegetation.
Running sands, loose Made Ground/Infilled Ground and shallow groundwater, leading to difficulty with excavation due to trench instability.
Fault which crosses the south-western tip of the site– this could potentially lead to differential settlement of proposed infrastructure.
Potential for obstructions associated with historical mining features and the risk of instability of excavations with the impact on construction staff, vehicles and plant operators.
High groundwater - associated with Carr Dike high groundwater can be expected in the Alluvial soils and Made Ground/Infilled Ground leading to difficulty with excavation due to trench instability.
Potential for unforeseen ground conditions and the risks associated with limited data.

</td></tr>
<tr><td>Preliminary Geo-environmental Conclusions</td><td>
Based on historical land uses and its current operational use, at this stage the overall risk from land contamination at the site is considered to be moderate for the current development, and low to moderate for a redeveloped site, but would need to be confirmed by appropriate intrusive investigation, testing and assessment of the results of the investigation.
It is considered unlikely that the site would be classified as Contaminated Land under Part 2A of the EPA 1990.
The possible pollutant linkages on an un-remediated site determined by desk study and walk-over are summarised below for risk levels of moderate or greater.
<table>
<tr><th>Source(s)</th><th>potential Impact on --►</th><th>Receptor(s)</th></tr>
<tr><td colspan="2">Made Ground/Infilled Ground, associated with the backfilled opencast sites and bindstone quarry, possibly including elevated concentrations of metals, metalloids, polycyclic aromatic hydrocarbons (PAH), petroleum hydrocarbons (PHC), asbestos fibres, and Asbestos Containing Materials (ACM) (S1).</td><td>Site users
Neighbours
Groundwater</td></tr>
<tr><td colspan="2">Historical landfill comprising household waste potentially containing metals, metalloids, asbestos fibres, ACM (S2).</td><td>Site users
Neighbours
Groundwater</td></tr>
<tr><td colspan="2">Ground gases (carbon dioxide and methane) from organic materials in the Made Ground / Infilled Ground / alluvial deposits (S3).</td><td>Site Users
Buildings</td></tr>
<tr><td colspan="2">Ground gases (carbon dioxide and methane) from organic materials in the landfill (S4).</td><td>Site Users
Buildings</td></tr>
<tr><td colspan="2">Mine gases (carbon dioxide, methane, carbon monoxide and hydrogen sulphide) from shallow mine workings (S5).</td><td>Site Users
Buildings</td></tr>
<tr><td colspan="2">Historical Licenced pollutant release site (Part B permit) for the processing of coal and coke (S6).</td><td>Site users
Neighbours
Groundwater</td></tr>
</table>
</td></tr>
<tr><td colspan="2">FUTURE CONSIDERATIONS</td></tr>
<tr><td>Further work</td><td>
In order to confirm the actual risks to receptors and confirm the ground conditions with respect to potential geotechnical and geo-environmental risks, an appropriate intrusive investigation will need to be undertaken. This investigation will need to:

determine the depth and distribution of Made Ground/Infilled Ground and natural strata across the site;
determine the soil strength/density profile beneath the site;
determine the depth/level of groundwater beneath the site;

</td></tr>
</table>

	• assess the distribution and extent of mineworkings and coal seams below the site; • assess the potential for mine entries at the site; • establish the depth and thickness of the buried opencast highwall; • determine the location of the fault zone below the south-western tip of the site, along with the depth to rockhead and nature of the residual soils either side of the fault; • determine the ground gas concentrations beneath the site; • determine CBRs to assist with pavement design; • assess trench stability, over break potential and 'diggability'; • allow soil infiltration rate testing; • allow sampling for chemical and geotechnical laboratory testing; • allow soil classification to allow geotechnical characterisation and determine suitability for reuse of soils within earthworks; • obtain information in terms of Aggressive Chemical Environment for Concrete Class (ACEC Class). Following investigation, assessment will be required to: • update the Ground Model; • update the Geotechnical Risk Register; • provide Geotechnical Design recommendations; • update the Conceptual Site Model (CSM), including identification of plausible pollution linkages; • undertake generic quantitative risk assessment of potential chemical contaminants to establish 'suitability for use' under the current planning regime; • discuss potential environmental liabilities associated with land contamination (soil, water and gas); and • provide outline mitigation recommendations to ensure the site is 'suitable for use'.

This Executive Summary forms part of Hydrock Consultants Limited report number 23451-HYD-XX-XX-RP-GE-0001 and should not be used as a separate document.

1. INTRODUCTION

1.1 Terms of reference

In July 2022, Hydrock Consultants Limited (Hydrock) was commissioned by Newlands Developments Ltd. (the Client), to undertake a Phase 1 Ground Condition Desk Study at Land south of Dearne Valley Parkway, Billingley, Bolton upon Dearne, Barnsley, Yorkshire, S72 0JE.

The site currently consists of agricultural fields, with Carr Dike flowing north to south-west, exiting the site in the west.

Hydrock understands that that the proposed development is to comprise a high-quality employment-led development comprising of general industrial, light industrial and warehousing and distribution units along with associated office space, car parks, roads, soft landscaping and infrastructure (current and former B Use Classes). The schedule of accommodation for the proposed warehouse units are Plot 1: 11,3500 m²; Plot 2: 84,600 m²; Plot 3: 179,200 m²; Plot 4: 32, 62900 m². An Illustrative Masterplan (UMC Architects, drawing 2081 P0520 Rev E) is presented in Appendix A.

A site reconnaissance walkover was undertaken on 2nd August 2022, and a site features plan (drawing 23451-HYD-XX-XX-DR-GE-1002) is presented in Appendix A.

The works have been undertaken in accordance with Hydrock's proposal (document reference 23451-FP-GE-0001, dated 17th March 2022) and the Client's instructions to proceed (email from Warren Cull dated 15th July 2022).

1.2 Objectives

The works have been commissioned to assist in clearing anticipated planning conditions and to assist with the design of the development.

The objective of the Phase 1 Desk Study is to formulate a preliminary Ground Model and an Initial Conceptual Model of the site to identify and make a preliminary assessment of key geo-environmental and geotechnical risks to the proposed development.

1.3 Scope

The scope of the Phase 1 Desk Study comprises:

- a field reconnaissance (walkover) to determine the nature of the site and its surroundings including current and former land uses, topography and hydrology;
- acquisition and review of:
  - historical Ordnance Survey maps, to identify former potentially contaminative uses shown at the site and immediately surrounding it, and an assessment of the associated contamination risks;
  - a third-party environmental data report to identify flooding warning areas, local landfills, pollution incidents, abstractions, environmental permits etc. which may have had the potential to have environmental impact on the site;
  - topographical, geological and hydrogeological maps;
  - British Geological Survey (BGS) archive records;
  - A review of regional UXO mapping and commentary on UXO risk;

- development of a preliminary Ground Model representing ground conditions at the site;
- development of an outline Conceptual Model (oCM), including identification of potential pollution linkages;
- a qualitative assessment of any geo-environmental risks identified; and
- identification of plausible geotechnical hazards.

1.4 Available information

The following have been provided to Hydrock by the Client for use in the preparation of this report:

- JPG, March 2017, Geo environmental desk study report at Broomhill, Goldthorpe, ref. APN/DS/5064.v1.
- Abbeydale, July 2019, Mining risk assessment report at New Roundabout on A635, ref. 151089 MRA.
- Barnsley MBC, September 2021, Goldthorpe Masterplan Framework, version 2.0.
- Newlands Developments Ltd., February 2022, Cut & Fill Contours, Goldthorpe, Barnsley, ref. 12147-CF-1.
- UMC Architects, February 2022, Existing constraints plan – phase 1, ref. 22081 F0002 A.
- JEH Planning, March 2022, Consultants Briefing Note, Land South of Dearne Valley Parkway.
- UMC Architects, November 2023, Parameters Plan, Barnsley Road, Goldthorpe, ref. 2081 P0520 Rev E

The Client has commissioned or obtained assignment of the above documents and Hydrock is entitled to full reliance upon their contents.

1.5 Regulatory context and guidance

The geo-environmental section of this report is written in broad agreement with BS 10175:2011+ A2:2017, 'Land Contamination: Risk Management' (LCRM, 2021 and the AGS (2006) 'Good Practice Guidelines for Site Investigations'. The methods used follow a risk-based approach, with the first stage being a Phase 1 desk study and field reconnaissance (this report), with the potential geo-environmental risk assessed qualitatively in future report(s) using the 'source-pathway-receptor contaminant linkage' concept to assess risk as introduced in the Environmental Protection Act 1990 (EPA, 1990).

The geotechnical section of this report is prepared in general accordance with BS EN 1997 (EC7) and BS 8004:2015 + A1:2020.

Remaining uncertainties and recommendations for further work are listed in Section 5 and Section 6.

Reference to the technical details of the approach and the methodologies adopted are provided in Appendix G.

2. PHASE 1 STUDY (DESK STUDY AND FIELD RECONNAISSANCE)

2.1 Data

A number of desk study sources have been used to assemble the following information. Where available these are presented in Appendix C and Appendix D and include:

- Third-party environmental report (Groundsure report, reference HYD-8919600);
- Historical Ordnance Survey mapping;
- BGS Archive Records;
- BGS Open-loop ground source heat pump viability screening map https://mapapps2.bgs.ac.uk/gshpnational2/app/index.html
- Zetica UXB Risk Maps (https://zeticauxo.com/downloads-and-resources/risk-maps/);
- Coal Authority 'CON29 Consultants Coal Mining Report' (Reference: 51003255641001);
- Coal Authority's Interactive Viewer (http://mapapps2.bgs.ac.uk/coalauthority/home.html);
- Environment Agency river catchment data (https://environment.data.gov.uk/catchment-planning/WaterBody/GB104027057550); and
- Environment Agency flood data (https://flood-map-for-planning.service.gov.uk/).

Previous reporting at the site is limited to desk-based reports and have been reviewed by Hydrock. However, as no intrusive investigations have been undertaken a review of these reports has not been included in this report. Previous reporting includes:

- JPG. March 2017, Ref: APN/DS/5064.v1 (JPG, 2017):
  - a desk study, including a summary review of historical, geological and hydrogeological mapping and review of a third-party environmental report.

The following report was produced for the proposed new roundabout on the A635 (off site), adjacent to the site northern boundary:

- Abbeydale Building Environment Consultants (Abbeydale). July 2019, Ref: 151089 MRA (Abbeydale, 2019);
  - The Abbeydale report is a coal mining risk assessment report, including a review of historical, geological and hydrogeological mapping, geotechnical considerations and a risk assessment of mining and quarrying at the site.

2.2 Site referencing

The site is referenced in Table 2.1 and the location is indicated in Figure 2.1 and Figure 2.2.

Table 2.1: Site referencing information

Item	Brief Description
Site name	Land south of Dearne Valley Parkway.
Site address	Billingley, Bolton upon Dearne, Barnsley, Yorkshire, S72 0JE.
Site location and grid reference	The site is located directly south of the A635, 800m east of the A619 and 400m west of Goldthorpe Industrial Estate. The National Grid Reference of the approximate centre of the site is 444093E, 403622N.

Figure 2.1: Site location
(Reproduced with permission from Groundsure)

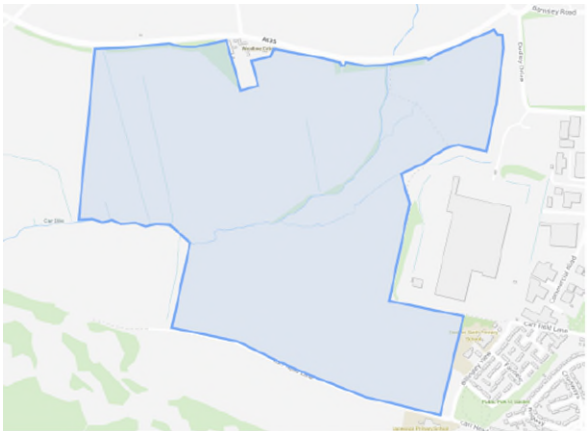

Figure 2.2: Extract from the Ordnance Survey Map
(Reproduced with permission from Groundsure)

A site location plan (Hydrock Drawing 23451-HYD-XX-XX-DR-GE-1001) is presented in Appendix A.

2.3 Site description and field reconnaissance survey

A field reconnaissance survey was undertaken on 2nd August 2022 to visually assess potential geotechnical hazards, contaminant sources and receptors. The weather during the field reconnaissance survey was overcast, dry and warm, and there had been a period of high temperatures prior to the survey.

A basic site description is presented in Table 2.2 and selected photographs are presented in Figure 2.3 to Figure 2.6. Additional photographs are presented in Appendix B.

Table 2.2: Site description

Item	Brief Description
Site zoning	For the purposes of the site description the site can be zoned into seven separate areas (named Area 1 – 7), typically following field boundaries, as shown on the site features plan (ref. 23451-HYD-XX-XX-DR-GE-1002) provided in Appendix A.
Site access	The site is accessed from six locations in total. There are two access points in the north, the first is via a farmer's field entrance (where vegetation has recently been cleared) into Area 3 off Barnsley Road (A635), approximately 300m east of Woodbine Cottage. The second northern access point is via a farmer's field entrance into Area 1 off the A635, approximately 420m west of Woodbine Cottage. The access point in the south is via Carr Head Lane, primarily used as a farmers track to access the fields along the southern boundary. There are three access points to the southern fields off Carr Head Lane.
Site area	The site is irregular in shape and has an area of approximately 85.3 ha.
Elevation, topography and any geomorphic features	Elevations generally fall toward Carr Dike in the centre of the site which flows from the north-east to the west. Ground level on the banks of Carr Dike vary between approximately 25m AOD in the north-east falling to 21m AOD in the west. Carr Head Lane Track in the south is much higher than the rest of the site at approximately 45m AOD in the south east falling to 39m AOD in the south west. Along the A635 road, elevations are higher near the north-west and north-east corner of the site (between 34 – 35m AOD) and falls toward Carr Dike (between 22 – 24m AOD). Desiccation cracks in the soil primarily to the north of Carr Dike were noticeable at surface level during the site walkover. The site walkover was undertaken during a period of high

Item	Brief Description
	temperatures, and the areas of desiccation were generally seen where Alluvium underlies the site. Rockhead was found behind a vegetated boundary in the north eastern corner of the site during the walkover, the rock is a weathered grey mudstone with ironstone partings. Both Carr Dike and its tributaries are located on site. Carr Dike enters the site in the north beneath the A635 in a culvert, flowing in a south west orientation toward the western boundary. A small tributary is located with its spring, to the east of Carr Dike, and a secondary tributary located in the north-west corner of the Aldi depot.
Present land use	Area 1: consists of two large agricultural fields used for crop farming separated by hedgerow boundaries, with two drainage ditches running in a north south orientation toward Carr Dike which bounds the fields on the south. High voltage electricity pylons on wooden poles are present in the north and east. Area 2: consists of two agricultural fields used for crop farming separated by hedgerow boundaries. Area 3: consists of one large field used for crop farming and one smaller rectangular shaped former woodland area at the northern boundary, which has been recently cleared of vegetation. High voltage electricity pylons on wooden poles are present in the centre of the field at an east to west orientation. Carr Dike bounds this area in the east and south. Area 4: consists of one field used for crop farming. Carr Dike constitutes the western boundary. High voltage electricity pylons on wooden poles are present in the south at an east west orientation. A public footpath is present, running parallel approximately 10m east of Carr Dike then crosses into Area 5. Three small piles of fly tipped material are present in the north along the treeline, the piles comprised building waste including concrete, brick and soil. Area 5: consists of one large field used for crop farming. Carr Dike bound this area in the west and a tributary of Carr Dike bounds the south. High voltage electricity pylons on wooden poles are present in the centre of the field at an east to west orientation. A manhole cover is present in the north of the site understood to be associated with a sewer. The public footpath crosses this area at a north-west south-east orientation, exiting the site at the boundary to the Aldi depot. Possible evidence of badger setts is present along the eastern boundary in the form of established burrowed holes. Area 6: consists of one large field used for crop farming. Carr Dike bounds this area in the north. Area 7: consists of one large field used for crop farming. A tributary of Carr Dike bounds this area in the north. There are no buildings present on site.
Vegetation	Semi-mature and mature trees line the sites northern boundary, and an area of woodland is present in the north of Area 1. An area of woodland was also present in the north of Area 3, however this has recently been cleared. Dense semi-mature and mature trees are also present along Carr Dike. Some scattered semi-mature trees are present along the southern boundary with Carr Head Lane.
General site sensitivity	The site is agricultural land within a semi-rural setting, however the site is situated on the edge of an industrial/logistics area to the east which comprises Goldthorpe industrial estate where the Aldi depot is located, and there is also the residential area of Bolton upon Dearne located to the east. Lacewood Primary School is present at the sites south eastern boundary. The site located within four Site of Special Scientific Interest (SSSI) Impact Risk Zone. For the full list of the types of development requiring consultation refer to the environmental data report (Appendix D). Dearne Valley Wetlands SSSI is located approximately 70m to the south-west of the site.

Item	Brief Description
Site boundaries and surrounding land	The site boundary is generally unfenced, and are lined by hedgerows. However, a section of mesh fencing surrounds the Aldi depot along the eastern boundary of the site. The site is bounded to the north by the A635 Barnsley Road and to the west by agricultural fields 6195. The site is bounded to the east by Dudley Drive, an Aldi depot, and several buildings along Billingley View, including a Community Centre, some horse pens and a new housing development adjacent to the south east corner. The site is bounded to the south by a farmers track which is a continuation of Carr Head Lane. Lacewood Primary School is present at the sites south eastern boundary.

A site features plan (Hydrock Drawing 23451-HYD-XX-XX-DR-GE-1002) is presented in Appendix A.

Figure 2.3: Soil desiccation at surface level north of Carr Dike

Figure 2.4: Carr Dike and culvert at entry point to the site

Figure 2.5: Pile of fly-tipped material in Area 4

Figure 2.6: Rockhead found in the north-east corner of Area 5

2.4 Site history

A study of historical Ordnance Survey maps (Appendix C) has been undertaken to identify any former land uses at the site and surrounding areas which may have geotechnical or geo-environmental implications for the proposed development. The key findings are summarised in Table 2.3.

Table 2.3: Site history review

Reference	Key features on site	Key features off-site
OS Map 1850-1854 1:10,560	The site comprises fields and some trees, with Carr Dike flowing north to south-west, exiting the site in the west. A bindstone quarry is shown in the north-east corner of the site. Salters Brook is shown parallel to the eastern half of the northern site boundary.	Fields are present surrounding the site. Bindstone and sandstone quarries are shown beyond the north-east and north-west corners of the site, 300m south of the western edge of the site, and 650m south-east. Billingley is shown 500m north of the site and Bolton upon Dearne is shown 430m south-east of the site. A public house is shown beyond the centre of the northern site boundary. A railway line (London Midland & Scottish Railway) is shown 900m south-west of the site in a north-west to south-east orientation.
OS Map 1890 1:10,560 and 1892 1:2,500	Salters Brook is no longer shown. The quarry is no longer shown (assumed to be backfilled).	The public house and surrounding buildings are now shown as cottages. The quarries to the north-east, north-west and south-west are no longer shown (assumed to be backfilled).
OS Map 1893 and 1901-1904 1:10,560	No significant changes.	Goldthorpe Brick Works is now shown beyond the north-east site boundary. Railway lines are now shown 80m south-east of the site in a north-east to south-west orientation and 760m north-east in a north-west to south-east orientation.
OS Map 1929 1:10,560	The field in the west of the site are now shown as rough pasture.	Goldthorpe Brick Works is now shown as disused. A tank is shown 350m north-east of the site associated with an unspecified building (Holly Grove). Sewage works are now shown 680m north-west of the site. Wath Main Brick Works and allotment gardens are now shown 180m south of the south-east corner of the site.
OS Map 1948 1:10,560	Some buildings and an associated path are now shown on the western site boundary, with the path leading into the site.	No significant changes.
OS Map 1966 – 1967 1:10,560	Several drains are labelled in the northern half of the site.	Bolton upon Dearne has expanded up to the south-west railway line, and includes an unspecified Works 295m to the south-east. The quarry to the south-east appears to have been backfilled. The south-west railway line is now labelled as dismantled.
OS Map 1976 – 1977 1:10,000	No significant changes.	A refuse or slag heap is now shown 240m south of the site, extending over a former marsh. The dismantled railway line is now longer shown and Bolton upon Dearne has expanded to beyond the south-east site boundary, and includes Poultry Houses 560m to the south-east.
OS Map 1988 1:10,000	No significant changes.	An electricity substation is now shown 400m east of the site.
OS Map 2001 1:10,000	The northern half of the site is now labelled as a quarry.	The Poultry Houses to the south-east are no longer shown.

Reference	Key features on site	Key features off-site
OS Map 2010 1:10,000	The northern half of the site is no longer labelled as a quarry.	The unspecified Works to the south-east are no longer shown.
OS Map 2022 1:10,000	No significant changes.	The Aldi distribution centre is now shown beyond the eastern site boundary.

2.5 Geology

The general geology of the site area is shown on the 1:10,000 British Geological Survey (BGS) map extract reproduced as part of the Groundsure report and is summarised in Table 2.4. Extracts from the map are shown in Figure 2.7 and Figure 2.8.

Table 2.4: Geology

Ref. for Figures	Location	Stratigraphic Name	Description
Artificial and Made Ground			
1	On site	Made Ground (Infilled Ground)	Artificial deposits in the north of the site associated with the infilling of the opencast sites.
Superficial Deposits (Figure 2.7)			
1	On site	Alluvium	Alluvium predominantly north of Carr Dike comprising clay, silt, sand and gravel.
Solid Geology (Figure 2.8)			
2 and 4	On site.	Pennine Middle Coal Measures	In the north of the site comprising mudstone, siltstone, sandstone and coal seams.
8	On site.	Mexborough Rock	In the south of the site comprising sandstone.

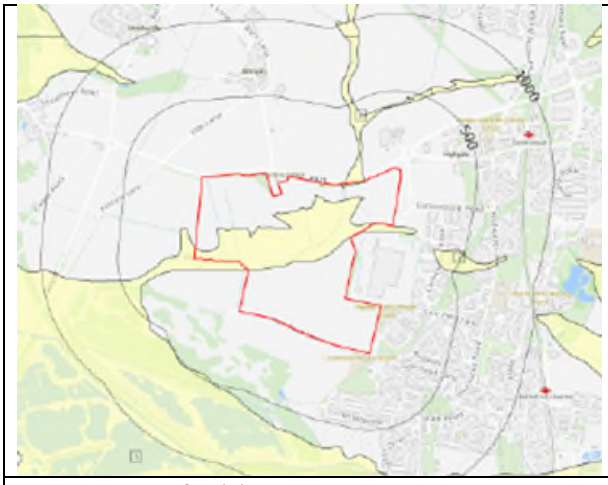

Figure 2.7: Superficial deposits.
(Reproduced with permission from Groundsure)

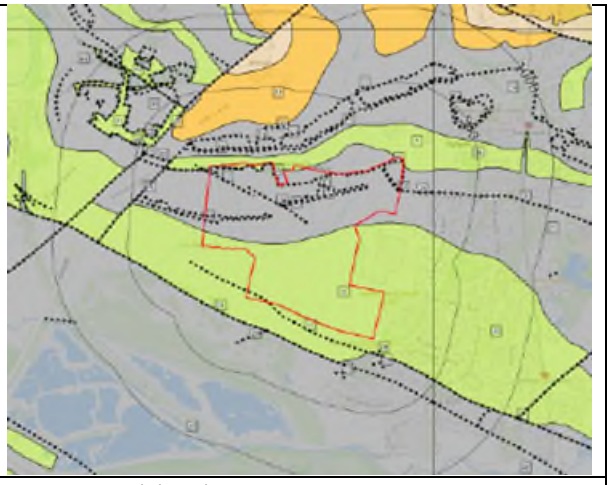

Figure 2.8: Solid geology.
(Reproduced with permission from Groundsure)

The Shafton Coal (0.2 – 2.3m thick) is inferred to outcrop in the north of the site, associated with the Pennine Middle Coal Measures present underlying the northern half of the site.

The Darfield Fault is indicated to underlie the south-western tip in a NW-SE orientation with a downthrow to the NE.

As the site is within a Development High Risk Area, Hydrock have produced a detailed Coal Mining Risk Assessment (CMRA) referenced 23451-HYD-XX-XX-RP-GE-0002. This CMRA will need to be submitted to the Planning Authority as part of any planning application and should be read in conjunction with this report. Coal mining is addressed in this report in section 2.8.

A number of borehole logs from the BGS archive have been reviewed. Selected records are summarised below:

- SE40SW33, located on site (NGR 444594E, 403998N), drilled to a depth of 31.39m and recorded:
  - No recovery between ground level and 0.08m below ground level (bgl);
  - Grey mudstone with ironstone, mussels, pyritised plant debris and ostracods between 0.08m and 0.23m bgl; over
  - Carbonaceous shale with coal streaks between 0.23m and 0.26m bgl; over
  - Grey mudstone-seatearth between 0.26m and 0.36m bgl; over
  - Pale grey sandstone between 0.36m and 0.51m bgl; over
  - Grey siltstone with finely comminuted plant debris and bands of silty mudstone between 0.51m and 1.27m bgl; over
  - Grey silty mudstone between 1.27m and 4.62m bgl; over
  - Grey mudstone between 4.62m and 6.28m bgl; over
  - Interbedded coal/inferior coal, carbonaceous (mudstone) seatearth and pyrites between 6.28m and 31.39m bgl.
- SE40SW440, located 12m east of the site at Bolton on Dearne Junior and Infants School (NGR 444680E, 403210N), drilled to a depth of 2.50m and recorded:
  - Topsoil between ground level and 0.30m bgl; over
  - Sandy clay between 0.30m and 0.40m bgl; over
  - Friable highly weathered sandstone between 0.40m and 2.50m bgl.
  - No groundwater encountered.
- SE40SW86, located 67m north of the site at Billingley Green (NGR 443503E, 404149N), drilled to a depth of 32.31m and recorded:
  - Soil between ground level and 0.30m bgl; over
  - Clay between 0.30m and 0.90m bgl; over
  - Interbedded sandstone and grey bind between 0.90m and 29.87m bgl; over
  - Coal between 29.87m and 31.39m bgl; over
  - Grey bind between 31.39m and 32.31m bgl.
  - No groundwater encountered.

2.5.1 *Ground source heat pump (GSHP) viability*

The BGS ground source heat pump viability screening map indicates that the site in in an area that is favourable for open-loop ground source heat pumps.

This report does not constitute a Thermogeological Assessment (TGA). For site specific GSHP viability a full TGA to characterise the geological and thermogeological properties beneath the site is required.

2.6 Hydrogeology

2.6.1 *Aquifer designations*

Based on the inferred geological sequence presented in Section 2.5 and the Environment Agency's interactive aquifer designation map, the aquifer system presented in Table 2.5 applies.

Table 2.5: Aquifer system

Stratum	Aquifer Designation	Comments
Infilled Made Ground (Imported Fill)	Unclassified/unproductive	Infilled ground not included in the classification system. Likely to be moderate to high porosity because of unconsolidated nature, but permeability is likely to be constrained to low, or low to moderate because of poor sorting and potentially high clay content.
Superficial Deposits		
Alluvium	Secondary A Aquifer	Intergranular permeability. Dominated by moderate to high permeability layers of sand and gravel, interbedded with very low to low permeability clays and silts. Groundwater flow is likely to be variable and discontinuous as water migrates around low permeability areas.
Solid Geology		
Pennine Middle Coal Measures	Secondary A Aquifer	Other than in respect of worked coal seams, likely to be Generally characterised by low permeability and isotropic. Potentially faulted and fractured, with high secondary permeability. Coal workings are likely to have created a significant secondary porosity and permeability and large volumes of groundwater can be present in abandoned workings, with associated potentially high rates of flow.
Mexborough Rock	Secondary A Aquifer	Dominated by fracture flow type with moderate to high intergranular permeability.

2.6.2 *Groundwater abstraction*

There are no active licensed groundwater abstractions within 1km of the site.

2.6.3 *Groundwater source protection zones and groundwater vulnerability*

The site is not within a groundwater Source Protection Zone (SPZ).

2.6.4 Groundwater levels, recharge, and flow

Shallow groundwater is likely to be present within the Alluvium / Made Ground, with a deeper groundwater body in the Pennine Middle Coal Measures / Mexborough Rock. The groundwater bodies may be hydraulically connected where fractures are present in the bedrock or where higher permeability sandstones underlie the superficial deposits. The shallow groundwater is likely to be in hydraulic continuity with Carr Dike.

Recharge to the Alluvium and Made Ground would be expected to take place locally with recharge to the Pennine Middle Coal Measures and Mexborough Rock also taking place locally in outcrop areas in the north and south of the site, respectively. In addition to recharge from outcrop areas to the west of the site, parts of the Pennine Middle Coal Measures (and Mexborough Rock, although limited) is in direct contact with the superficial deposits or Made Ground which is a potentially significant contamination issue because it provides a means by which leachate can reach the aquifer.

Groundwater was not encountered in available BGS borehole data.

2.6.5 Groundwater quality

The groundwater body beneath the site (Don & Rother Millstone grit & Coal Measures) is currently (2019 Cycle 2) classified under the Water Framework Directive as ‘poor’.

The water body is currently given a 'poor' status due to 'chemical dependant surface water body' and ‘general chemical test’ conditions. The objective is for chemical dependant surface water body status to be ‘good’ by 2027.

2.6.6 Groundwater flooding

The environmental data report indicates a negligible risk of groundwater flooding across site.

2.7 Hydrology

2.7.1 Surface water system and drainage

The surface water features in the vicinity of the site are listed in Table 2.6.

Table 2.6: Surface water features

Feature	Location Relative to Site
Carr Dike	On site
Drains	On site
Lakes	From 670m south-west
River Dearne	930m south

2.7.2 Surface water abstractions and discharges

There are no active or historical licensed surface water abstractions recorded within 1km of the site.

There are two active licensed surface water discharges within 1km of the site. They are listed in Table 2.7.

Table 2.7: Active surface water discharges

Location Relative to Site	Purpose of Abstraction
190m north	Billingley Green Farmhouse. Effluent type: sewage. Discharges: final/treated effluent. Receiving waters: land adjacent to the farmhouse.
209m east	Highgate Industrial Estate SPS. Effluent type: sewage. Discharges: pumping station. Receiving water: tributary of Carr Dyke.

The active surface water discharge 209m east at Highgate Industrial Estate has the potential to impact the site. This is on the basis the tributary of Carr Dike receiving the discharge (sewage) flows through the site, and the tributary is also downstream of the discharge meaning that the sewage discharged into the tributary would flow through the site.

There are two historical licensed surface water discharges within 1km of the site. They are listed in Table 2.8.

Table 2.8: Historical surface water discharges

Location Relative to Site	Purpose of Abstraction
On site	Woodbine. Effluent type: trade discharges. Receiving water: Carr Dyke.
On site	The Black Swan Public House. Effluent type: sewage. Discharges: final/treated effluent. Receiving water: unnamed of Trenholme Stell.

The above discharges are not anticipated to pose a risk to the site due to their historical status.

2.7.3 Surface water quality

Reference to the Environment Agency web site shows the site is located within the catchment of the Dearne, with the specific river water body being the Ings/Carr/Thurnscoe Dikes from Source to Dearne. The current (2019 cycle 2) overall status under the Water Framework Directive is 'moderate'.

The water body is currently 'moderate' status due to invertebrate and phosphate levels and Mitigation Measures Assessment, as well as failed mercury and its compounds levels, perfluorooctane sulphonate (PFOS) levels and Polybrominated diphenyl ethers (PBDE) levels. The objective is for the water body to be 'good' by 2027.

2.7.4 *Surface water flooding*

Risk of flooding from rivers and the sea [1]

The desk study information indicates an area of Medium risk in the north of the site and along Carr Dike. A low risk area is present in the west of the site, and a High risk area is present beyond the south-west site boundary. The remainder of the site does not have a flood risk category, showing that the risk in these parts are lower than Very Low.

Flood zones [2]

The desk study information indicates the north of the site and along Carr Dike are in Flood Zone 3 (with a high probability of flooding from rivers or the sea). A Flood Zone 2 (with a moderate probability of flooding from rivers or the sea) is present in the west of the site.

Rainfall flooding

The desk study information indicates that parts of the northern half of the site has a risk of surface water flooding from rainfall events. The highest risk in this area is a flood with depth greater than 1.0m from a 1 in 30-year return period. More information can be found in the Groundsure report provided in Appendix D.

No further consideration of flood risk is undertaken in this report. Specialist flood risk advice should be sought with regard to drainage and flooding.

2.8 Coal Mining and mineral extraction

Geological mapping shows the Shafton Coal (between 0.2m and 2.3m in thickness) is shown to outcrop along the southern boundary of the opencast area, along A635 Barnsley Road. This coal seam is shown to dip by 2 degrees to 5 degrees to the north in the local area.

The Highgate Coal is shown to outcrop near the north western corner of the site, parallel to the Shafton Coal seam. This coal seam is shown to be between 0m and 0.7m in thickness.

The northern half of the site is within an area defined by the Coal Authority (CA) as a Development High Risk Area, with a historical unlicenced opencast site present in the north of the site, and past Shallow Coal Mine Workings Recorded. Two mine entries are recorded in the north of the site, the mine entry further to the west is referenced 44403-008, and the mine entry further east is referenced 444403-007. One mine entry is present off site but is within the 20m zone of influence outside of the site boundary.

As the site is within a Development High Risk Area, Hydrock have produced a detailed Coal Mining Risk Assessment (CMRA) referenced 23451-HYD-XX-XX-RP-GE-0002. This CMRA will need to be submitted to the Planning Authority as part of any planning application and should be read in conjunction with this report.

As there are known past mine workings being present in coal seams beneath the site, a 'CON29, Consultants Coal Mining Report' was obtained from The Coal Authority and is included in Appendix D.

[1] These relate to the chance of flooding from rivers and/or the sea in any given year as modelled by the Environment Agency, taking into account flood defences. Very low (less than 1 in 1000 chance in any given year), Low (less than 1 in 100 but greater than or equal to 1 in 1000 chance), Medium (less than 1 in 30 but greater, than or equal to 1 in 100 chance) or High (greater than or equal to 1 in 30 chance).

[2] These are defined as areas of land at risk of flooding, when the presence of flood defences are ignored. A Flood Zone 3 covers land with a 1 in 100 (1%) or greater chance of flooding each year from rivers. A Flood Zone 2 covers land between Flood Zone 3 and the extent of the flooding from rivers or the sea with a 1 in 1000 (0.1%) chance of flooding each year. A Flood Zone 1 covers land with less than 0.1% chance of flooding each year.

Key statements within the report are that:

- the site has been subject to several phases of unlicenced opencast mining;
- the site is in an area where there are extensive past underground mining activities;
- the Coal Authority states there are probable unrecorded shallow workings at the site; and
- there are no recorded remediated sites or reports of coal mining subsidence within 50 metres of the site.
- Geological mapping and the CON29 report indicate that the site has been subject to historical mining activity in only the north of the site. With the south of the site being underlain by the Mexborough Rock formation (Sandstone)

2.9 Natural ground instability

The risks of natural ground subsidence as given by the environmental data report and Hydrock's professional judgement are summarised in Table 2.9 below.

Table 2.9 Summary of natural ground subsidence risks

Risk	Hazard Rating	Geology	Comments
Shrink swell clays	Moderate	Alluvium and Made Ground/Infilled Ground	Trees and hedges are present around the site boundaries and sporadically across the site. Cohesive deposits may be affected by potential for shrink-swell ground movements in clays as a result of changes in moisture content from removal or growth of trees. During the site walkover desiccation cracks at surface level were apparent in areas underlain by Alluvium.
	Negligible	Where superficial deposits are absent in the southern half of the site.	-
Running sands	Moderate	Alluvium	Running sand conditions may be present. Constraints may apply to land uses involving excavation or the addition or removal of water.
	Very low	Made Ground	Running sand conditions unlikely.
	Negligible	Where superficial deposits are absent in the southern half of the site.	-
Compressible deposits	Moderate	Alluvium and Made Ground/Infilled Ground.	Compressibility and uneven settlement hazards are probably present due to the unconsolidated nature of these strata
	Very low	Where superficial deposits are absent in the southern half of the site.	-
Collapsible deposits	Negligible	Alluvium	-
Landslides	Very low	Alluvium and where there are no superficial deposits on the site.	-

Risk	Hazard Rating	Geology	Comments
Ground dissolution of soluble rocks	Negligible	Pennine Middle Coal Measures and Mexborough Rock.	-

In addition to the above, the northern portion of the site has been subject to extensive historical coal mining. This represents a geotechnical risk due to the presence of heterogeneous Made Ground and significant ground instability.

2.10 Waste management

There are no current waste management sites recorded within 250m, and two historical waste management sites recorded within 250m of the site, as listed in Table 2.10.

Table 2.10: Waste management sites

Site Name and Location	Details
Mary Lane, Darfield, S. Yorks (on site).	Status: Closed. Operational dates: Not recorded. Size: Not recorded. Wastes accepted: Domestic refuse. Prohibited wastes: Not recorded.
Wath Colliery, Manvers Central Coal Preparation Plant (70m west – this covers the refuse heap as mentioned in Section 2.4).	Status: Closed. Operational dates: 20/12/1977 – 26/10/1983 Size: Not recorded. Wastes accepted: Liquid sludge. Prohibited wastes: Not recorded.

There are three waste exemption sites recorded within 250m of the site, as listed in Table 2.11.

Table 2.11: Waste management sites

Site Name and Location	Details
New Hall Farm, Back Lane, Billingley, Barnsley, S72 0JF (on site)	Storing waste exemption on a farm – sludge.
Highgate House Farm, Dearne Valley Parkway, Goldthorpe, Rotherham, S63 9EY (130m north-west and 150m north)	Using waste exemption on a farm and agricultural waste – including spreading waste on agricultural land and spreading plant matter. Treating waste exemption on a farm and agricultural waste – waste wood and waste plant matter. Disposing of waste exemption on a farm and agricultural waste – including burning waste and deposit of waste from dredging of inland waters.

2.11 Regulatory consultation

Information in the GroundSure Report (Appendix D), relating to various regulatory controls has been reviewed, with a summary presented below in Table 2.12.

Table 2.12: Regulatory information within 250m of the site

Regulatory Data	Distance from Site	Details	Potential Risk	Comment
Local Authority Pollution Prevention and Controls	On site	Historical Part B permit for the processing of coal and coke.	Yes	Due to the potential historical legacy contamination.
Pollution Incidents	On site	January 2003, other pollutant, Category 3 (air) – minor, Category 4 (land and water) – no impact	No	Due to the Category 3/4 classification of the incident.
	210m east	January 2002, pollutant not identified, Category 3 (water) – minor, Category 4 (land and air) – no impact	No	Due to the Category 3/4 classification of the incident.
Trade Directory Entries	40m north	Electricity sub station	No	Due to its proximity to the site.
	50m south west	Telecommunications mast	No	Due to the small volumes of potential contaminants and its distance from the site.
	50m east	Vehicle garage	No	
	90m east	Chimney	No	
	120m east	Electricity sub station	No	
	140m east	Electricity sub station	No	
	150m east	Gas governor	No	
	170m east	Electricity sub station	No	
	190m east	Sewage pumping station	No	
	200m north east	Water pumping station	No	
Fuel Station Entries	N/A	No fuel station entries were recorded within 250m of the site.	No	-
Control of major accident hazards sites (COMAH)	N/A	No entries on COMAH sites were recorded within 250m of the site.	No	-
Registered radioactive substances	N/A	No entries on registered radioactive substances were recorded within 250m of the site.	No	-
Notification of installations handling hazardous substances	N/A	No entries on notification of installations handling hazardous substances were recorded within 250m of the site.	No	-

2.12 Natural soil chemistry

Information contained within the environmental report (Appendix D) gives indicative (estimated) concentration values for the natural soils at the site for a selection of Contaminants of Potential Concern (CoPC). These have been reproduced in Table 2.13.

Table 2.13: Natural soil chemistry

Element	Arsenic	Cadmium	Chromium	Lead	Nickel
Concentration (mg/kg)	15 -25	1.8	40 – 120	100	15 - 30

The above natural soil concentrations at the site are below GAC screening values for human health (for the 'commercial' CLEA land use scenario) and do not require further consideration.

2.13 Radon

The radon risk is reported in the environmental report. The guidance indicates that the site is in a Radon Affected Area where recorded radon levels in 1-3% of homes are above the action level but no radon protection measures are required for new buildings at this location in line with current guidance. However, consideration should be given to fitting basic protection measures on the 'as low as reasonably practicable' principle in view of advice given to householders and the legal responsibilities of rental landlords and employers with commercial properties (see references in Section 7 for further information).

2.14 Unexploded ordnance (UXO)

In general accordance with CIRIA Report C681 (Stone et al 2009) a non-specialist UXO screening exercise has been undertaken for the purposes of ground investigation and is presented in Table 2.14 .

Table 2.14: Non-specialist UXO screening (for the purposes of ground investigation)

Data	Comment	Further Assessment Required
Site History	There is no indication of former military use from the desk study.	No
Post War Development	The historical OS mapping does not show any indications of bomb damage in the post war mapping.	No
Geology Type	The ground conditions comprise Alluvium. There is the potential that UXO, if present, would remain undetected.	Yes
Surface Cover during WWII	The surface cover during WWII comprised open fields. There is the potential that UXO, if present, would remain undetected.	Yes
Indicator of Aerial Delivered UXO	Screening against the regional bomb risk map (South Yorkshire) Appendix D indicates the site to be in an area where the bomb risk is low.	No

The non-specialist UXO screening exercise has indicated that there is the potential for UXO to remain undetected due to the presence of open fields at the site during WWII and due to the ground conditions comprising alluvium. However, no further assessment is required with regard to UXO in relation to ground investigation as the site is in a low-risk area with no former military use indicated and no evidence of bomb damage on the historical mapping. Further assessment may be considered prudent for construction activities.

3. OUTLINE CONCEPTUAL SITE MODEL

3.1 Introduction

The outline Conceptual Model (oCM) incorporates evidence from the site walkover, the Desk Study and previous investigations carried out at the site. The formulation of an outline Conceptual Model is a key component of the LCRM methodology. The oCM incorporates a ground model of the site physical conditions and an exposure model of the possible contaminant linkages; it forms the basis for Generic Quantitative Risk Assessment (GQRA) in accordance with current guidelines.

3.2 Ground model

The preliminary ground model presented in Section 2 provides an understanding of the ground conditions and is the basis for preparing the preliminary geotechnical hazard assessment (Section 3.3) and the preliminary geo-environmental exposure model (Section 3.4).

3.3 Geotechnical hazard identification

3.3.1 Context

The preliminary geotechnical hazard identification has been undertaken in accordance with the general requirements of ICE/DETR Document 'Managing Geotechnical Risk' and the HE documents HD 41/15 and CD 622.

The following section sets out the identified geotechnical hazards and the development elements potentially affected (see Table E.1 in Appendix E for further information).

3.3.2 Plausible geotechnical hazards

Plausible geotechnical hazards identified at the site are:

- Historical coal mining and mining features.
- Uncontrollable Made Ground and Infilled Ground.
- Soft / loose compressible ground (low strength and high settlement potential).
- Shrinkage / swelling of the clay fraction of soils under the influence of vegetation.
- Variable lateral and vertical changes in ground conditions.
- Obstructions – coal mining features.
- Shallow groundwater.
- Changing groundwater conditions.
- Risk from flooding.
- Running sands and loose Made Ground/Infilled Ground, leading to difficulty with excavation and collapse of side walls.
- Earthworks – poor bearing capacity of new fill.
- Fault below the south-western tip of the site.
- Problematic soils.

3.3.3 *Potential development elements affected*

Development elements potentially affected by geotechnical hazards are:

- Buildings – foundations.
- Buildings – floor Slabs
- Roads and pavements.
- Services.
- General slopes.
- Construction staff, vehicles and plant operators.
- Earthworks control, inability to place and compact fill.

Health and safety risks to site Contractors and maintenance workers have not been assessed during these works and will need to be considered separately during design.

The above plausible geotechnical hazards and development elements affected have been carried forward for investigation and assessment.

3.4 Geo-environmental exposure model

3.4.1 *Context*

The preliminary exposure model is used to identify geo-environmental hazards and to establish potential pollution linkages, based on the source-pathway-receptor (SPR) approach.

A viable pollution linkage requires all the components of an SPR to be present. If only one or two are present, there is no linkage and no further assessment is required.

3.4.2 *Potential contaminants*

For the purpose of this assessment the potential contaminants have been separated according to whether they are likely to have originated from an on-site or off-site source.

3.4.2.1 *Potential on-site sources of contamination*

- Made Ground/Infilled Ground, associated with the backfilled opencast sites and bindstone quarry, possibly including elevated concentrations of metals, metalloids, polycyclic aromatic hydrocarbons (PAH), petroleum hydrocarbons (PHC), asbestos fibres, and Asbestos Containing Materials (ACM) (S1).
- Historical landfill comprising household waste potentially containing metals, metalloids, asbestos fibres, ACM(S2).
- Ground gases (carbon dioxide and methane) from organic materials in the Made Ground / Infilled Ground / alluvial deposits (S3).
- Ground gases (carbon dioxide and methane) from organic materials in the landfill (S4).
- Mine gases (carbon dioxide, methane, carbon monoxide and hydrogen sulphide) from shallow mine workings (S5).
- Historical Licenced pollutant release site (Part B permit) for the processing of coal and coke (S6) resulting in contaminants of concern potentially impacting superficial deposits/bedrock/Infilled Ground and controlled water.

3.4.2.2 Potential off-site sources of contamination

- Quarry backfill, associated with the former brick pit located on the eastern boundary of the site, possibly including PHC and PAH with the potential to migrate onto site (S7).
- Ground gases (carbon dioxide and methane) from organic materials within the quarry backfill (S8).
- Dismantled railway 80m south east possibly containing elevated concentrations of metals, metalloids, PAH and PHC (S9).
- Active surface water discharge of sewage, discharged into the tributary of Carr Dike located 209m east (S10).

3.4.3 Potential receptors

The following potential receptors in relation to the proposed land use have been identified.

- People (neighbours, site end users) (R1).
- Development end use (buildings, utilities and landscaping) (R2).
- Groundwater: Secondary A aquifer status of the Alluvium, Pennine Middle Coal Measures and Mexborough Rock (R3).
- Surface water: on-site Carr Dike (R4).
- Dearne Valley Wetlands SSSI (R5).
- Aquatic life (R6)

3.4.4 Potential pathways

The following potential pathways have been identified.

- Ingestion, skin contact, inhalation of dust and outdoor air by people (P1).
- Methane and carbon dioxide ingress via permeable soils and/or construction gaps (P2).
- Migration of contaminant via leachate migration through the unsaturated zone in the Alluvium (P3).
- Migration of contaminant from the groundwater within the Alluvium to the groundwater within the Mexborough Rock and Pennine Middle Coal Measures aquifer (P4).
- Surface water via overland flow to Carr Dike (P5).
- Surface water via base flow from groundwater within the Alluvium (P6).
- Active discharge to surfaced water (P7)

Health and safety risks to site development contractors and maintenance workers have not been assessed as part of this study and will need to be considered separately.

The above sources, pathways and receptors have been considered as part of the Preliminary Risk Assessment in accordance with LCRM (2021), are considered to be plausible in the context of this site and have been carried forward for investigation and assessment. An assessment of the Source – Pathway – Receptor linkages is presented in Appendix F (Table F.2).

4. DESK STUDY CONCLUSIONS

4.1 Geotechnical conclusions

The following plausible geotechnical risks are identified.

- Opencast site - historical mining features including uncontrolled backfill to opencast workings and opencast buried highwalls with the potential to cause significant and differential settlement of foundations, floor slabs, roads and infrastructure elements.
- Shallow coal mining – known mine entries and possible underground shallow workings with the potential to collapse and voids to migrate to the surface resulting in shear failure.
- Variable Made Ground/Infilled Ground – settlement or differential settlement of foundations, floor slabs, roads and infrastructure elements.
- Low strength, compressible ground of opencast backfill and Alluvium – risk of shear failure and excessive settlement of foundations, roads and infrastructure elements.
- Attack of buried concrete by aggressive ground conditions – the development site may contain Made Ground/Infilled Ground and potentially sulfate bearing soils.
- Shrinkage/swelling of Alluvium – settlement/heave of foundations, especially where located within the influence of trees and vegetation.
- Running sands, loose Made Ground and shallow groundwater, leading to difficulty with excavation due to trench instability.
- Fault which crosses the south-western tip of the site– this could potentially lead to differential settlement of proposed infrastructure.
- Potential for obstructions associated with historical mining features and the risk of instability of excavations with the impact on construction staff, vehicles and plant operators.
- High groundwater - associated with Carr Dike high groundwater can be expected in the Alluvial soils and Made Ground/Infilled Ground leading to difficulty with excavation due to trench instability.
- Potential for unforeseen ground conditions and the risks associated with limited data.

These plausible risks require further investigation and assessment (see Section 6).

4.2 Geo-environmental conclusions

Based on historical and current land uses and in accordance with the processes set out in Appendix G:

- It is considered that it is unlikely that the site would be classified as Contaminated Land under Part 2A of the EPA 1990.
- The overall risk from land contamination at the site is considered to moderate for the current development. Although it is likely that the former opencast areas have been backfilled with colliery spoil and overburden to win the coal, at this stage the nature of the backfill material is unknown hence the contamination risk level of moderate.
- The overall risk for a redeveloped site is assessed to be low to moderate, with a low risk to human health on the basis that the majority of the site is expected to be covered by hardstanding, and with the risk to controlled waters is potentially a moderate risk due to the unknown nature of backfill material at this stage. This would need to be confirmed by appropriate intrusive investigation, testing and assessment of the results of the investigation.

The possible pollutant linkages (for risk levels of moderate or greater) on an unremediated redeveloped site, as determined by the desk study and walk-over, are summarised in Table 4.1:

Table 4.1: Possible Pollutant Linkages (for Risk Levels of Moderate or Greater)

Source(s)	potential Impact on --►	Receptor(s)
Made Ground/Infilled Ground, associated with the backfilled opencast sites and bindstone quarry, possibly including elevated concentrations of metals, metalloids, polycyclic aromatic hydrocarbons (PAH), petroleum hydrocarbons (PHC), asbestos fibres, and Asbestos Containing Materials (ACM) (S1).		Site users Neighbours Groundwater
Historical landfill comprising household waste potentially containing metals, metalloids, asbestos fibres, ACM (S2).		Site users Neighbours Groundwater
Ground gases (carbon dioxide and methane) from organic materials in the Made Ground / alluvial deposits (S3).		Site Users Buildings
Ground gases (carbon dioxide and methane) from organic materials in the landfill (S4).		Site Users Buildings
Mine gases (carbon dioxide, methane, carbon monoxide and hydrogen sulphide) from shallow mine workings (S5).		Site Users Buildings
Historical Licenced pollutant release site (Part B permit) for the processing of coal and coke (S6) resulting in contaminants of concern potentially impacting superficial deposits/bedrock/Infilled Ground and controlled waters.		Site users Neighbours Groundwater

These possible pollutant linkages require further investigation and assessment (see Section 6).

5. UNCERTAINTIES AND LIMITATIONS

5.1 General comments

Hydrock Consultants Limited (Hydrock) has prepared this report in accordance with the instructions of Newlands Developments Ltd. (the Client), by e-mail dated July 2022 under the terms of appointment for Hydrock, for the sole and specific use of the Client and parties commissioned by them to undertake work where reliance is placed on this report. Any third parties who use the information contained herein do so at their own risk. Hydrock shall not be responsible for any use of the report or its contents for any purpose other than that for which it was prepared or for use of the report by any parties not defined in Hydrock's appointment.

This report details the findings of work carried out in August 2022. The report has been prepared by Hydrock on the basis of available information obtained during the study period. Although every reasonable effort has been made to gather all relevant information, not all potential environmental constraints or liabilities associated with the site may have been revealed.

Groundwater data are only representative of the dates on which they were obtained and both levels and quality may vary.

Information provided by third parties has been used in good faith and is taken at face value; however, Hydrock cannot guarantee its accuracy or completeness.

Where the existing report(s) prepared by others have been provided by the Client, it is assumed that these have been either commissioned by the Client, or can be assigned to the Client, and can be relied upon by Hydrock. Should this not be the case Hydrock should be informed immediately as additional work may be required. Hydrock is not responsible for any factual errors or omissions in the supplied data, or for the opinions and recommendations of others. It is possible that the conditions described may have since changed through natural processes or later activities.

The work has been carried out in general accordance with recognised best practice. The various methodologies used are referenced in Appendix G. Unless otherwise stated, no assessment has been made for the presence of radioactive substances or unexploded ordnance. Where the phrase 'suitable for use' is used in this report, it is in keeping with the terminology used in planning control and does not imply any specific warranty or guarantee offered by Hydrock.

The non-specialist UXO screening has been undertaken for the purposes of ground investigation only (i.e. low risk activity in accordance with CIRIA Report C681). Further assessment should be undertaken with regards to other higher risk activities e.g. construction.

Please note that notwithstanding any site observations concerning the presence or otherwise of archaeological sites, asbestos-containing materials or invasive weeds, this report does not constitute a formal survey of these potential constraints and specialist advice should be sought.

Any site boundary line depicted on plans does not imply legal ownership of land.

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6. RECOMMENDATIONS FOR FURTHER WORK

6.1 Ground investigation objectives

In order to confirm the actual risks to receptors and confirm the ground conditions with respect to potential geotechnical and geo-environmental risks, an appropriate intrusive investigation will need to be undertaken. This investigation will need to:

- determine the depth and distribution of Made Ground/infilled ground and natural strata across the site;
- determine the soil strength/density profile beneath the site;
- determine the depth/level of groundwater beneath the site;
- assess the distribution and extent of mineworkings and coal seams below the site;
- assess the potential for mine entries at the site;
- establish the depth and thickness of the buried opencast highwall;
- determine the location of the fault zone below the south-western tip of the site, along with the depth to rockhead and nature of the residual soils either side of the fault;
- determine the ground gas concentrations beneath the site;
- determine CBRs to assist with pavement design;
- assess trench stability, over break potential and 'diggability';
- allow soil infiltration rate testing;
- allow sampling for chemical and geotechnical laboratory testing;
- allow soil classification to allow geotechnical characterisation and determine suitability for reuse of soils within earthworks;
- obtain information in terms of Aggressive Chemical Environment for Concrete Class (ACEC Class).

Following investigation, assessment will be required to:

- update the Ground Model;
- update the Geotechnical Risk Register;
- provide Geotechnical Design recommendations;
- update the Conceptual Site Model (CSM), including identification of plausible pollution linkages;
- undertake generic quantitative risk assessment of potential chemical contaminants to establish 'suitability for use' under the current planning regime;
- discuss potential environmental liabilities associated with land contamination (soil, water and gas); and
- provide outline mitigation recommendations to ensure the site is 'suitable for use'.

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Appendix A

Drawings