



Silica Sand Mold Ltd

Maes-y-Droell Quarry

Phase 1 Desk Study

323530-R01 (01)

RSK GENERAL NOTES

Project No.: 323530

Title: Phase 1 Desk Study: Maes-y-Droell Quarry, Graianrhyd Road (B5430), Llanarmon-yn-Iâl, Mold, CH7 4QR

Client: Silica Sand Mold Ltd

Date: 03 March 2025

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Status: Rev 01

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Revision control sheet				
Revision ref.	Date	Reason for revision	Amended by:	Approved by:
Rev 00	27/02/2025	First issue	n/a	see above
Rev 01	03/03/2025	Address client amendments, previous reports	EGS	See above

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Where field investigations have been carried out, these have been restricted to a level of detail required to achieve the stated objectives of the work.

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1 EXECUTIVE SUMMARY

Commissioning and purpose of assessment	RSK Environment Limited (RSK) was commissioned by Silica Sand Mold Ltd to carry out a Phase 1 Desk Study of the land at Maes-y-Droell Quarry, Graianrhyd Road (B5430), Llanarmon-yn-Iâl, Mold, CH7 4QR, grid reference 321781, 356461. The overall aim of the project is to assess potential land contamination sources which may impact the proposed re-opening of the site as a silica quarry.
DESK-BASED ASSESSMENT	
Site description and proposed development	The site's northern sector comprises a natural landscape including vegetation, shrubs, trees and several ponds traversed by few tracks/footpaths. The southern sector of the site is occupied by the Maes-y-Droell Quarry and features deep, flooded quarry pits in its south, vegetated spoil heaps in its east, hardstanding and redundant buildings in its west and settling ponds and limited woodland in its north. The site occupies an area of c. 22 hectares and is being considered for the re-opening of the site to win and work high-grade silica sand, with proposals including an expansion into the unquarried northern sector.
History of site and surrounding area	The site was formerly agricultural land with few farms dwellings in the southern sector. Sand and gravel pits were present on the site since the earliest available historical plans, which expanded to the current extent of the Maes-y-Dorell quarry, with a significant expansion noted around the 1960s. The quarry paused operation in the c. early 2010s. The northern sector features limited historical activity, apart from the Llanarmon Mine, which worked the Westminster vein for lead in the late 19th and early 20th centuries. A small sand pit was briefly recorded in the northern sector on one historical plan in the 1960s. No potentially contaminative current activities have been identified in the surrounding area.
Previous site investigation (SI) reports	Borehole investigations in 1991/1992, 1998, 2008 and 2010 are described in previous reports. A 2014 investigation was provided with six boreholes logs. Additionally, the Client supplied a summary of 10 boreholes from an investigation in January 2020, though these logs are not detailed and no associated report was provided.
Geology and environmental setting	The site predominantly features no superficial deposits, apart from a localised area of the northern sector where Lacustrine Deposits (clay And silt) are present. The site is underlain by the Cefn-Y-Fedw Sandstone Formation according to published geological data. The borehole records and previous reports indicate a thick weathered profile overlying the bedrock, comprising varying layers of interbedded sand, gravel, clay and silt to a maximum recorded depth of 30 mbgl. There is also likely to be made ground associated with former quarrying throughout the southern sector, and localised made ground associated with the former lead mine and sand pit in the northern sector. The borehole records and previous reports indicate varying thicknesses of made ground in the quarry to depths of between 3 m and 22 mbgl, comprising silty sand described as mineral waste. The site lies outside a Coal Reporting Area and is not considered to be impacted by coal mining.

	The site lies within an area where <1% of properties are above the radon action level. Groundwater levels are reportedly variable across the site and flows to the south-east. The northern sector lies within the Clwydian Range and Dee Valley AONB. Environmental receptors identified comprise: • groundwater within Cefn-Y-Fedw Sandstone Formation classified as a secondary A aquifer • groundwater within the Minera Formation (Limestone), located 58 m west of the site, classified as a principal aquifer • surface water immediately west and east (unnamed tributary streams/inland rivers) and the River Terrig, located 44 m south.
Site reconnaissance findings	Potential sources of contamination identified during the site walkover include on-site made ground associated with the site's lengthy industrial history (quarrying and lead mining), hazardous chemical/oil storage within sheds, an above ground storage tank, a former electrical substation and existing damaged/undamaged structures which may contain asbestos.
Initial conceptual site model (CSM) and preliminary risk assessment (PRA)	Potentially complete contaminant linkages identified with a risk estimate of moderate to low or above include: • moderate risk to future site users (R1) from on-site made ground (S1) via direct ingestion, inhalation or contact (P1) with contaminated soil and/or dust and the inhalation of asbestos fibres (P2) • moderate/low risk to groundwater quality from leachable contamination in on-site made ground (S1) (underlying Secondary A and adjacent Principal aquifers) (R3) via vertical and lateral migration via groundwater (P3) • moderate/low risk to future site users (R1) from on-site storage of oils/chemicals (S2) within existing sheds via direct ingestion, inhalation and/or contact with contaminated soil and/or dust (P1) • moderate/low risk to future site users (R1) from existing shed structures (S3) via asbestos fibre release and subsequent inhalation (P2). Uncertainties and data gaps have been identified in the CSM at desk study stage and should be considered in the design of future intrusive investigation if proposed.
Recommendations including issues for further assessment	The following recommendations are made for further assessment of the site to address the risks identified above and remaining uncertainties: • boreholes to determine the composition of existing made ground, determine on-site groundwater regime and to collect geo-environmental samples to investigate potential contamination • trail pits to determine shallow ground conditions and contamination across the site and around the periphery of the existing structures • shallow soil sampling to investigate the potential contamination of PCBs and/or hydrocarbons associated with the historical substation
<i>The information given in this summary is necessarily incomplete and is provided for initial briefing purposes only. The summary must not be used as a substitute for the full text of the report.</i>	

2 INTRODUCTION

2.1 Commissioning

RSK Environment Limited (RSK) were engaged by Silica Sand Mold Ltd, (Suites 5 And 6 The Printworks Hey Road, Barrow, Clitheroe, Lancashire, BB7 9WA) herein referred to as the 'Client', to carry out a Phase 1 Preliminary Risk Assessment at the land at Maes-y-Droell Quarry Off Graianrhyd Road (B5430), Graianrhyd, CH7 4QR.

The works were undertaken in accordance with RSK proposal 323350TL01(00), dated 8 January 2025, including RSK Standard Terms and Conditions, Issue No. 12, July 2023], which forms the appointment between ourselves and the Client.

References in this report to 'we', 'us', or 'our' shall mean RSK Geosciences as a trading name of RSK Environment Limited (company no.SC115530) at registered address 65 Sussex Street, Glasgow, G41 1DX.

The site location is provided in **Figure 1** and the site layout boundary to which this report refers is presented in **Figure 2**.

The report should be read and used in accordance with the limitations and constraints identified in the report text, and at **Appendix A – Service Constraints**.

2.2 Scope of works

The scope of works has been developed in accordance with relevant British Standards and authoritative technical guidance as referenced through the report. The assessment of the contamination status of the site is in line with the technical approach presented in Land Contamination Risk Management (LCRM) (Environment Agency, 2023) and in general accordance with BS 10175: 2011 + A2 2017 (BSI, 2017). It is also compliant with relevant planning policy and guidance (i.e. National Planning Policy Framework).

The scope of works for the assessment has included the following:

Desk study:

- the history of development and industry on the site, including a study of archival Ordnance Survey mapping and other sources of historical information as appropriate, e.g. local archives, trade directories and planning records
- a study of local geology, hydrogeology and surface water setting
- the identification of potential geological hazards, including radon and coal and non-coal mining
- a review of relevant environmental data held by appropriate statutory authorities, e.g. the local Environmental Health Department and Natural Resources Wales (NRW) Agency, obtained in the form of an environmental database report (Envirocheck Report) and, where appropriate, through direct contact
- a site reconnaissance survey
- a preliminary conceptual model of contamination on the site identifying possible pollutant linkages

- an assessment of the environmental risks and liabilities associated with site ownership
- recommendations for further investigations, if required.

2.3 Existing reports

The following reports detailing previous works at the site were made available for review:

- Environmental Assessment Scoping Report, Ref: 2893/11, Richards, Moorehead & Laing Ltd, November 2009
- Environmental Statement, Ref: 2893/11/Import, Richards, Moorehead & Laing Ltd, March 2011
- Assessment of Sand Reserves, Document No: UK14001-R-01 01, OTB Engineering, 2014
- Quarry Silica Sand Testing and Assessment, Ref: UK221858 (QT-67446/2/AN)/Ref. 1, Lucideon, 15 June 2022.
- Monitoring of Mining and Landfill Sites Report, Denbighshire Country Council, 23 June 2023
- Pre-Application Report, Ref: 15/2023/0813, Denbighshire County Council, 12 March 2024.
- Consent to Investigate a Groundwater Source, Natural Resources Wales, 8 October 2024.

Pertinent information from these reports has been summarised in Section 4.4.

2.4 Limitations

This report is subject to the RSK service constraints given in **Appendix A** and limitations that may be described below and throughout this document.

This report was prepared in accordance with good practice guidance at the time of issue. Consideration should be considered in the light of changes in legislation, statutory requirements, or industry practices subsequent to the date of issue.

The opinions expressed in this report, and the comments and recommendations given, are based on the information obtained from the desk assessment and the site reconnaissance survey. No intrusive investigations have been undertaken to confirm the actual ground conditions and hence the environmental status of the site.

The study aims to principally identify and assess the potential risks and liabilities associated with contamination of the ground, on and in the vicinity of the site. While this includes consideration of current operations and housekeeping on the site, the report does not constitute a comprehensive environmental audit of the site, as covered under ISO 14001.

Although asbestos may not have been encountered as part of these works, asbestos could be present in soil in discrete areas and may be encountered in future ground investigation.

A detailed survey of invasive plant species is outside the scope of this investigation therefore detailed comments with regards to such species have been omitted from this report.

The comments given in this report and the opinions expressed are primarily based on third party data and investigations, while RSK have undertaken a review of the information provided RSK cannot be held liable for the quality of the data provided. There may be conditions pertaining to the site that have not been disclosed by the investigations and therefore could not be taken into account.

3 SITE DETAILS

3.1 Site location

Site location details are presented in Table 1 and a site location plan is provided on **Figure 1**.

Table 1 Site location details

Site name	Maes-y-Droell Quarry
Full site address and Post code	Graianrhyd Road (B5430), Llanarmon-yn-Iâl, Mold, CH7 4QR
National Grid reference (centre of site)	321781, 356461

3.2 Site description

The Site boundary and current site layout are shown on **Figure 2**. The Site covers an area of c. 22 hectares. It is predominantly occupied by a disused quarry in its southern sector. The northern sector of the site is occupied by several ponds, grassland, vegetation and woodland. The easternmost corner of the site is grassland.

The site boundary is irregular, measuring approximately 925 m north-south and 375 m east-west at its maximum. Elevation increases toward the north, to a maximum of c. 360 mAOD, with a minimum elevation recorded in the south of c. 298 mAOD located within a quarry pit. Vegetated spoil heaps lie in the east of the site, with elevations of 343 m and 346 mAOD.

The site is immediately bound by Nercwys Mountain (road) to the east, Graianrhyd Road (B5430) in the south and Eryrys Road to the west. A bridleway, orientated east-west, links Nercwys Mountain and Eryrys Road and separates the northern sector and southern quarried sector of the site. The north is not bound by any distinguishable feature.

RSK understand that quarrying was paused in the early 2010s. Five small ponds are located in the north. Additionally, two settling ponds lie in the centre and two in the south of the quarry. Hardstanding and three redundant buildings (sheds) lies in the central east of the quarry.

The quarried central and southern areas are dissected by internal roadways and tracks associated with silica sand extraction. A track crosses the entire northern area from the central bridleway to the north site boundary. Additionally, two paths are located north from the bridleway across the northern sector and extend beyond the northern site boundary. A third path crosses the southwestern corner of the northern sector.

3.3 Surrounding land uses

The Site is located in Llanarmon-yn-Iâl, within a predominantly agricultural setting. Immediate surrounding land uses are described in Table 2.

Table 2 Surrounding land uses

North	Livestock agricultural and pasture grassland. Nercwys Forest lies c. 800 m north.
East	Arable and livestock agricultural, farm dwellings and pasture grassland. 'Woolly Experiences therapy farm' lies immediately east. Nercwys Mountain (road), orientated north-south, lies immediately east.
South	Residential dwellings and public house (Rose and Crown) lie immediately south within Graianrhyd village, limited farm dwellings, livestock agricultural and pasture grassland. Graianrhyd Road (B5430), oriented east-west, lies immediately south.
West	Livestock agricultural with limited residential and farm dwellings. Eryrys Road lies immediately west. Graig Quarry (limestone) lies c. 925 m west.

3.4 Proposed development plans

The development proposals are to resume the winning and working of high-grade silica sand within the previously operational quarry and extent the quarry into the undeveloped/unquarried northern sector. The phasing plan described the processing of previously worked spoil material as well as virgin material. The proposal includes four phases within the site, starting re-operations in the south then east of the site in existing quarried areas before continuing northward. Biodiversity Net Gain (BNG) areas are proposed in the far east and south of the site. Site access is not proposed to change though new tracks will be required as the phases progress.

The proposed layout and phasing of the site, at the time of preparing this report, is shown in **Appendix B** and referenced below:

- Concept Strategic Phasing, Maes y Droell Quarry. Drawing No. MDQ-SH-ELS-M2-LS-001_CONCEPT_PHASING_v3.dwg. Status: Planning. Draft for information only. Stephenson Halliday. Dated 11/07/2024.

4 DESK-BASED ASSESSMENT

The desk-based assessment was designed to generally meet the objectives of a preliminary or Phase 1 investigation, as defined by BS 10175:2011+A2:2017 (BSI, 2017) and BS 5930:2015, and is set in context of a Tier 1 preliminary risk assessment as defined in LCRM.

The "vicinity" of the site for the purposes of this report is defined as locations situated within an approximate 250 m radius of the site, although certain sources and/ or sensitive targets further than 250 m distance from the site may also have been considered.

4.1 Site history

4.1.1 Historical development record

The development history of the site and surrounding area based upon assessment of historical plans and records is detailed in Table 3 and Table 4 respectively.

The historical maps reviewed are shown within the environmental database report in **Appendix C**.

Table 3 Summary of historical development on site

Date from	Date to	Historical Land Use (on-site)
1871	1890	Southern sector features predominantly agricultural land, with field boundaries shown, tracks and possible farm dwellings. Northern sector shown as reeds/marsh with few tracks. Llandrmon Mine (lead) including a shaft, an old shaft and spoil heap located in the south of the northern sector. Sand pit shown in the south-east. Few dwellings located in the centre and south. A well is shown in the north-west of southern sector. Road orientated east-west splits the northern and southern sectors.
1899	1900	Llandrmon Mine (lead) and structures no longer shown. Shaft is marked as old shaft. Well no longer shown in north-west of the southern sector. Sand pit has expanded in the east of the southern sector. Gravel pit shown in west of southern sector. Quarry marked near the western boundary of the southern sector.
1912	1914	Sand pit shown in west of northern sector. Additional quarried areas marked in west and south of southern sector. Sand pit labelled at 'Pen-y-foel' and extends to the north and south. Two small structures shown by old shafts (previously Llandrmon Mine).
1938	1954	Pen-y-foel sand pit expanding further north.
1962	1971	Southern sector is labelled Maes-y-Droell Quarry (silicate) and the Pen-y-foel sand pit is no longer shown (1963 mapping shows the pit expanded to the north and west).

Date from	Date to	Historical Land Use (on-site)
		Farm dwellings, tracks and agricultural field boundaries no longer shown in the centre of the southern sector. Structures (one large and five small) and three ponds are located in the west of the quarry (not shown in 1963 mapping). Sand pit no longer shown in the northern sector (shown in 1963 mapping).
1975	1976	No significant changes shown.
1994		Ponds and few small structures no longer shown in west of Maes-y-Droell Quarry. Two ponds shown in centre of the northern sector.
2000		No significant changes shown.
2003	2009	Additional pond shown in centre and north-east of the northern sector. Pond shown in central west and south (2009 only) of the southern sector. Tracks shown throughout Maes-y-Droell Quarry and woodland shown in central east.
2013	2016	Central eastern and southern ponds no longer shown. Two additional ponds shown in north-west of Maes-y-Droell Quarry. Additional pond shown in north-east of the northern sector. Two small structures removed in the west of Maes-y-Droell Quarry.
2024	Present	Maes-y-Droell Quarry marked as pit (disused) and large western structure removed. Woodland marked across approximately half of the disused quarry. Ponds shown in the central west and south of disused quarry. Ponds are labelled settling ponds. Silo marked adjacent to structures in west of disused Maes-y-Droell Quarry. Shafts marked as air shafts (previous site of Llandrmon Mine).

Table 4 Summary of historical development in the vicinity of the site

Date from	Date to	Historical Land Use (off-site)
1871	1890	Residential dwellings shown at Cil-y-waen, Pen-y-foel, Graianrhyd and Tabernacle. Moriah Chapel is located immediately west of the site. Road oriented east-west and the Rose & Crown public house lies immediately south. Two old quarries and an old limekiln shown at Maes-y-Droell 200 m west. An old gravel pit is shown 200 m south-east. An old mine (lead) with shafts and old shaft (lead) are shown 225 m west and north-west. An old limekiln is shown 250 m west. Bog Mines (lead) and a shaft lies 500 m west and an unnamed shaft lies 500 m south-east.
1899	1900	Well shown 50m west of the southern sector.
1912	1914	Sand pit shown 250 m north-west. Old shafts (lead) shown between 230 m and 260 m west.

Date from	Date to	Historical Land Use (off-site)
		Quarry feature shown immediately west of the southern sector. Well shown immediately east at Cil-y-waen. A burial ground is now shown adjacent to Moriah chapel
1938	1954	No significant changes shown.
1962	1976	Sewage works shown 244 m south-east. New residential dwellings at Grainanrhyd, 50m-100m south and southwest. Well at Maes-y-Droell no longer shown. Bog Mine no longer shown. Ponds shown immediately east of northern sector and immediately east at Pen-y-foel. Road 50 m south of site labelled 'Allt Bryn Rotty' (B5430). Grainrhyd County Primary School shown 175 m south-east. Pond shown immediately west of southern sector shown with watercourse flowing into it from the north-west.
1994	2016	No significant changes shown.
	2024	Grainrhyd County Primary School no longer shown.

The key potential contaminative land uses identified from the available historical maps include:

Historical lead mining (Llandrmon Mine) in the northern sector which operated from at least 1871 until at least 1899. The mine comprised a few small structures and two shafts located approximately 60 m apart. There are several other lead mines and shafts shown on historical plans but at distances exceeding 250 m from the site.

Historical and recent silica quarrying throughout the southern sector of the site. A sand pit is first shown in maps from 1890, in the south-east of the site. Gravel pits and quarries are first shown by the 1900 mapping throughout the southern sector of the site. The quarrying extent expands significantly from the 1960s with the quarry termed Maes-y-Droell Quarry. The quarrying activity paused in the early 2010s.

4.1.2 Unexploded ordnance

A review of publicly available unexploded ordnance (UXO) risk maps indicates that the site is located in an area with low potential for wartime bombs to be present (Zetica, 2025).

A copy of the UXO risk map for the site is provided in **Appendix D**.

4.2 Information from environmental database report

Relevant environmental permits and incidents detailed within the environmental database report (see **Appendix C**) are summarised below in Table 5.

Table 5 Summary of environmental permits, landfills and incidents

Data type	Entries on-site	Entries <250m from site	Entries >250m from site of relevance	Details
Agency and hydrological				
Environmental permits – incorporating Environmental Permitting Regulations (EPR) and/or Pollution Prevention and Control (PPC) permits; former Integrated Pollution Controls (IPC), Local Authority Pollution Control (LAPC)	1 (revoked)	0	0	On-site (revoked) Name: J Stoddard & Sons Ltd. Ref. DCC/PPC/3.5/029.0 Date 23/04/1993. Description: PG3/9 Sand drying and cooling.
Enforcement and prohibition notices	0	0	0	
Pollution incidents to controlled waters, Prosecutions relating to controlled waters, Substantiated pollution incident register, Water Industry Act referrals	0	1	0	87 m W: No location details. Ref: 2999. Pollutant: Farm effluent/slurry. Date: 29/07/1991. Category 2.
Discharge consents	0	3 (1 revoked)	0	Active Off-site <250 m: 20 m S. Operator: Denbighshire County Council. Location: Graianrhyd C P School. Ref. CM0124001. Date: 06/11/1967. Receiving: Unnamed Trib Of River Terrig. Type: Unknown. 242 m SW. Operator: Dwr Cymru Cyfyngedig. Location: Grainnrhyd STW. Ref. CM0188501. Date: 24/09/2009. Receiving: Unnamed Trib Of River Terrig. Type: Sewage discharges (final/treated effluent). Revoked <250 m:

Data type	Entries on-site	Entries <250m from site	Entries >250m from site of relevance	Details
				53 m SW. Operator: Stoddard J & Sons Ltd. (previous quarry operator) Ref. Cm0022301. Date: 27/04/1964. Revoked: 22/12/1992. Receiving: Unnamed Trib Of River Terrig. Type: Unspecified.
Registered radioactive substances	0	0	0	
Landfill and waste				
Active landfills	0	0	0	
Historic / closed landfills	0	0	1	820 m SW. Holder: A R Whitby & D A Gillbanks. Ref: GL43. Date: 17/05/94. Waste: Hardcore, Brick, Stone, Concrete, Clinker Inert Constr'N/Demol Waste Comprising Road Scalpings/Tarmac For Site Roads, Top/Subsoil, Clay, Sand, Silica.
Other waste management licences	0	0	0	
Potentially in-filled land (pit, quarry, pond, marsh, river, stream, dock etc)	3	1	0	On-site: Unknown filled ground (pit, quarry etc). <250 m off-site: 194 m SE. Unknown filled ground (pit, quarry etc).
Hazardous substances/ industrial land uses				
Control of Major Accident Hazards (COMAH) sites	0	0	0	

Data type	Entries on-site	Entries <250m from site	Entries >250m from site of relevance	Details
Explosives sites, Notification of Installations Handling Hazardous Substances (NIHHS), Planning hazardous substance consents/enforcements	0	0	0	
Contaminated land Part 2A register entries and notices	0	0	0	
Fuel station entries	0	0	0	
<i>Note: Entries have only been included within the table where they are located within a 250m radius of the site or, where they fall outside of this radius but are considered to comprise a significant entry.</i>				

4.2.1 Contemporary trade directory entries

There are no active potentially contaminative land uses identified in the contemporary trade directory and with potential to affect the site.

Inactive potentially contaminative land uses identified in the contemporary trade directory with 250 m of the site includes N Johnson Transport Ltd (224 m W) and two entries >250 m from the site relating to cleaning services and quarrying/plant repair.

4.3 Information from regulatory authorities

4.3.1 Planning records

Planning records held by the Local Authority Planning Department (Denbighshire County Council) pertaining to the site and relevant to the current assessment are summarised in Table 6.

Table 6 Planning information

Valid from	Details and application reference no.
08/02/2007	15/2006/1371 Type: Mineral Application Extension to existing quarry (1.0 hectare). Outcome: refused (07/04/2008)
26/11/2009	15/2009/1554 Type: EIA Scoping a) The continued mineral extraction and processing of Maes-y-Droell b) creating a recycling facility at Maes-y-Droell for the importation of inert construction and demolition waste for recycling c) the importation and the deposition of inert waste for restoration of the quarry

Valid from	Details and application reference no.
22/10/2012	15/2011/0692 Type: Full Planning Importation of inert waste materials for recycling and use in restoration of quarry workings. Outcome: refused (20/02/2013) due to the highways, access and visibility grounds. Appeal withdrawn.

4.3.2 Local Authority environmental health department information

The Environmental Health Department of the local authority (Denbighshire County Council) has been contacted to confirm whether they hold records of contamination in connection with the site. A copy of the response is included in **Appendix E**.

Denbighshire County Council stated that they are aware that the site previously used an oil burning system of approximately 120 litres per minute to dry sand. They advised that the oil was contained within one or two storage tanks on the site, though could not confirm the exact location.

4.3.3 Natural Resources Wales information

Natural Resources Wales (NRW) has been contacted to confirm whether they hold records on the nearby River Terrig, environmental assessments, remedial activities or waste exemptions in connection with or in the vicinity of the site. A copy of the response is included in **Appendix E**.

NRW confirmed there are no remedial activities or waste exemptions registered at this site.

Available water quality data in the vicinity of the site was not deemed representative, as the monitoring station related to upstream treated effluent discharge from the Graianrhyd sewage works.

4.3.4 Site services

Obtaining a full set of service plans was outside the scope of this report. Services identified on-site during the walkover are detailed in Section 5.

Buried utility services and their backfill can represent a constraint to development and act as preferential migration pathways for gas, vapour or groundwater towards a receptor.

4.4 Summary of previous reports

A summary of pertinent information from previous reports pertaining to the site is included below in Table 7.

Relevant information relating to the identified ground and groundwater conditions has not been included within the table below but has been incorporated into the relevant parts of Sections 4.5 - geology and 4.7 – hydrogeology.

Table 7 Summary of previous reports

Report Details	Environmental Assessment Scoping Report, Ref 2893/11, Richards, Moorehead & Laing Ltd, November 2009
Site coverage	Full site.
Summary scope of works	Submitted in preparation for a planning application to Denbighshire Country Council (proposal to import c. 500,000 m ³ of inert waste for landfill to fill the quarry void).
Does the client have reliance upon the report?	Yes.
Key factual findings	It is estimated that 1.5 million tonnes of saleable mineral was present on the site. Previous annual output during operation of the site was between 12,000 and 15,000 tonnes, with proposals expected to produce 25,000 to 35,000 tonnes annually. Future extraction is considered to lie above the natural water table. Worked sandstone beds at the quarry are typically 6 m to 7 m thick and the product is renowned as the most pure deposit in England and Wales. Primary identified issues with the proposal relate to air quality, ecology, landscape/visual impact, traffic and noise pollution.
Report Details	Environmental Statement, Ref 2893/11/Import, Richards, Moorehead & Laing Ltd, March 2011
Site coverage	Full site.
Summary scope of works	Submitted in preparation for a planning application to Denbighshire Country Council (proposal for the importation and recycling of inert materials).
Does the client have reliance upon the report?	Yes.
Key factual findings	The site supports relatively few species, but has the potential to contribute to greater local biodiversity. Short term impacts of the proposal would be minor, with an increase of valuable habitats in the long term. Surface water collects in the quarry and drains into the sandstone bedrock. Surface water discharge via pumping during wetter periods was assessed as a minor impact due to silt settlement within ponds. Mineral workings do not extend below the water table. The volume of silica sandstone remaining in-situ is estimated to be over 1 million m³, although the workable volume is around 0.5 million m³. Borehole investigations took place in 1998 (locations unknown), 2008 and 2010. The report references appended borehole logs, but these were not provided.
Report Details	Assessment of Sand Reserves, Document No: UK14001-R-01 01, Version 2, OTB Engineering, 2014
Site coverage	Southern sector only.

Summary scope of works	Drilling of six rotary open-hole boreholes (between 25 m and 35 mbgl) and a review of previous exploratory drilling at the site.
Does the client have reliance upon the report?	Yes.
Key factual findings	To the west and east of the settling ponds, it has been calculated, there are approximately 960,000 tonnes of recoverable sandstone with an additional 160,000 tonnes underlying the lagoons. A thickness of at least 30 m of sandstone in the northern area (area around the silt ponds). Estimates between 50,000 to 60,000 tonnes of sand present within tip/infill materials. Describes that previous borehole investigation logs (1998, 2008 and 2010) which were not surveyed. Also describes an additional investigation in 1991/1992 but notes no logs or survey data are available.
Report Details	Quarry Silica Sand Testing and Assessment, Ref: UK221858 (QT-67446/2/AN)/Ref. 1, Lucideon, 15 June 2022.
Site coverage	N/a.
Summary scope of works	Four samples of site-won material (termed virgin, waste, pre-filter and washed product) submitted for a laboratory material assessment.
Does the client have reliance upon the report?	Yes.
Key factual findings	Testing analysis comprised: Elemental analysis by X-ray Fluorescence (XRF), mineralogical analysis by X-ray Diffraction (XRD), particle size analysis by sieve and laser diffraction (Malvern Mastersizer), particle morphology (shape etc) by Scanning Electron Microscope (SEM) (Virgin and waste samples only) and soluble salt analysis. The products qualified as silica sands > 95% SiO₂.
Report Details	Monitoring of Mining and Landfill Sites Report, Denbighshire Country Council, 23 June 2023.
Site coverage	Southern sector only.
Summary scope of works	Scheduled monitoring visit and inspection of the site conditions by the Local Authority.
Does the client have reliance upon the report?	Yes.
Key factual findings	Includes a factual description of the site condition, its complex planning history and notes discussions with the Client regarding the potential reworking of material.
Report Details	Pre Application Report, Ref 15/2023/0813, Denbighshire Country Council, 12 March 2024
Site coverage	Full site.
Summary scope of works	Describes the Planning Permission constraints and history of the site.

Does the client have reliance upon the report?	N/a.
Key factual findings	The quarry is of national importance as there are very few sites in the UK that can produce such a high quality silica sand. The County Council have concerns reworking may not be economically viable. The approximate quantity of mineral remaining on site is 1 million m³, although this may not all be recoverable. Annual output is anticipated to be approximately 50,000 tonnes. There are registered Public Footpaths in both the north and south sectors of the site which require careful consideration should the site become operational.
Report Details	Consent to Investigate a Groundwater Source, Natural Resources Wales, 8 October 2024
Site coverage	N/a.
Summary scope of works	N/a.
Does the client have reliance upon the report?	N/a.
Key factual findings	Consent to investigate groundwater from the Millstone Grit Group bedrock aquifer, Cefn-y-Fedw Sandstone Formation. National Grid Reference SJ 21744 56544. Consent to expire 8 May 2025.

4.5 Site geology

4.5.1 Anticipated geological sequence

Published records (British Geological Survey, 1999) for the area and available historical borehole logs indicate the geology of the site to be characterised by the succession recorded in Table 8. The Client provided RSK with a summary of 10 boreholes drilled in January 2020 across the site. Whilst receiving a summary of these boreholes, RSK have not been provided with detailed logs or a report regarding this investigation. Boreholes logs drilled in 2014 were provided in the Assessment of Sand Reserves report, undertaken by OTB Engineering. Logs from the 1998, 2008 and 2010 investigations have not been provided, although they are discussed in the previous reports listed in Section 2.3.

There are two publicly available BGS historical boreholes located on or within 250 m of the site. The BGS logs, 2014 investigation logs and borehole summary from the 2020 investigation are presented in **Appendix D**.

Table 8 Site geology

Strata	Description	Estimated thickness	Permeability
Made Ground	Widespread made ground associated with the Maes-y-Droell Quarry within the southern sector should be anticipated. Limited made ground associated with the previous Llanarmon Mine within the northern sector should be anticipated. Localised made ground associated with the sand pit (c. 1963 mapping) in the west of the northern sector. Made ground was encountered in BH8-BH10 in the centre and south-east of the southern sector. BH9 encountered shallow 'loose made ground' mixed with sand/silt between ground level and 3 mbgl. BH8 and BH10 encountered deep 'loose made ground' between ground level and 16.50 m and 13.50 mbgl respectively. BH10 also encountered 'compacted made ground' between 13.50 m to 17 mbgl. 2014 logs detailed made ground comprising crushed sandstone (silty sand) with iron staining (i.e. mineral waste) in two locations.	Variable across the site. Where encountered, between 3 m and 22 m within the southern sector.	Variable.
Northern Sector only, adjacent to ponds. Lacustrine Deposits - Clay And Silt	Lacustrine deposits were laid down as deltaic, lake bottom and shore sediments in lakes. They include clastic deposits, composed of coarse-grained bedload and suspended fine-grained material brought by streams flowing into the lake. Under arid and semiarid conditions evaporites form an important component of lake sediments. Includes fine-grained sediments (i.e. clay and silt), commonly laminated, and can contain thin layers of organic material or sand.	Unknown	Unproductive strata aquifer designation.
Glacial Till	The 2010 investigation reported deposits comprising sandy, silty, gravelly clays and sand gravel and cobbles interpreted as glacial till	Up to 3.70 m in northern sector. Up to 10.10 m in southern sector	

Strata	Description	Estimated thickness	Permeability
Weathered Cefn-Y-Fedw Sandstone Formation	From provided borehole records, a significant thickness of weathered bedrock material is present across the site. These comprise varying layers of sand, gravel, clay and silts.	Maximum depths of 16.50 m to 30 mbgl	Variable upon granular or cohesive composition.
Cefn-Y-Fedw Sandstone Formation - Sandstone And [Subequal/Subordinate] Argillaceous Rocks, Interbedded	White and pale grey, fine- to medium-grained, planar- and cross-bedded, quartzose sandstones, pebbly sandstones and thin beds of quartz conglomerate; with units of calcareous sandstone, sandy limestone, chert and siliceous mudstones in lower part; locally thick beds of siltstone and mudstone, and thin, impersistent coal seams. Rock is described as friable and moderately to weakly cemented. Encountered sandstone is typically light grey to brownish grey and fine to medium-grained. From provided borehole records, only mudstone bedrock was encountered in the January 2020 investigation within BH4 and BH5 in the northern sector. BH4 encountered mudstone from 16.50 mbgl to a final depth of 21 mbgl. BH5 encountered mudstone interbedded with thin layers of very fine sand/silts from 10.50 mbgl to a final depth of 36 mbgl.	To 585 m Sandstone: up to 22 m thick. Chert bands 0.20 m to 11.8m thick Siltstone/mudstone bands: 0.30 m to 4.10 m thick	Predominantly permeable but variable between interbedded geologies. Sandstones on the site possess little primary porosity or permeability and groundwater storage and movement are mainly dependent on the presence of fractures.
Relevant information sources: BGS Geoindex ☒ BGS borehole logs ☒ Previous investigations ☒			

With reference to the historical data and current site condition, there have clearly been significant industrial quarrying across the southern sector and localised mining activity in the northern sector. Therefore, the presence of widespread made ground is expected throughout the southern sector and locally within the northern sector.

4.5.2 Radon

The environmental database report indicates that the site is located within an area where less than 1% of homes are above the Action Level (termed an 'Affected Area') and indicates that radon protection measures are required. Although the radon data used in production of the ukradon.org indicative atlas comes from measurements in homes, the maps indicate the likely extent of the local radon hazard in all buildings.

The report indicates that the site is within a Radon Affected area whereby <1% of homes are above the radon Action Level of 200 Bq m⁻³.

In Radon Affected areas it is recommended by the Health and Safety Executive that radon protection measures are incorporated into the design of commercial premises to reduce exposure to future site workers and/or visitors. The monitoring of radon is also recommended by HSE to inform occupational exposure risk assessments.

4.6 Mining and quarrying

Evidence has been sought to identify any mining, quarrying, landfilling and land reclamation operations, past and present, which have taken place within 500 m of the site. An initial site appraisal has been carried out based on the information provided on the Mining Remediation Authority Interactive Viewer of the UK Coalfield areas and the commercial environmental databased report for information on non-coal mining.

Use of the Mining Remediation Authority interactive viewer indicates the site lies outside their Coal Mining Reporting Area and therefore no further assessment of coal mining issues is required within this report.

4.6.1 Lead mining

Earliest historical evidence suggests that lead mining in the area dates back to the 13th Century, with mineral licences granted in the area in 1635. Mines in the area are reported to have been impacted by extensive flooding.

The Llanarmon Mine (also referred to as the Westminster Mine) is located in the south of the northern sector and records indicate two shafts are present associated with historical lead mining.

Online searches state that the mine was worked between 1873 to 1913 within the eastern end of the Westminster Vein (lead and silver), which was also worked extensively at the nearby Bog Mine (500m west) and other sites in the vicinity of the site. The shafts are shown on historical plans as old shafts in the 1899-1900 (1:2,500) and 1912 (1:2,500) though the shafts may have been reworked in-between the publication of these maps.

An engine house was reportedly present at the shafts. Online sources suggest no evidence of its remains exist, nor was it identified in the site walkover. The presumed location of the eastern shaft was identified in the walkover as a circular hollow (~2 m diameter) within a wooded area. The western shaft could not be identified.

There is no available information on the depth of the shafts, though a cross-section of the Westminster Vein shows the nearby Bog Mine extending to a maximum depth of approximately 146 mbgl.

Online sources are referenced at the end of this report.

4.6.2 Silica quarrying

The site lies in an area with a known history of quarrying of silica sand/rock within quartzitic sandstone within the Cefn-y-fedw Sandstone Formation.

The Maes-y-Droell quarry has been active since approximately 1880 and previously had planning permission to extract mineral until 2042 (Denbighshire Country Council records). The quarry

paused operation in the early 2010s. The site has not been restored, reclaimed or backfilled. A planning application to import inert waste materials for recycling and use in restoration of quarry workings was rejected in 2013 (Table 6).

4.7 Hydrogeology

A summary of the hydrogeological setting of the site, with respect to the anticipated geological sequence set out in Section 4.5 is presented in Table 9. Borehole records provided, from January 2020, do not feature information on groundwater.

Table 9 Summary of hydrogeological setting

Condition	Description
Aquifer characteristics	On-site <u>Superficial Deposits</u> In the north of the site, Unproductive Strata are associated with the localised Lacustrine Deposits. <u>Bedrock</u> The site is underlain by a Secondary A aquifer associated with the Cefn-y-fedw Sandstone Formation. BGS GeoIndex states that this forms part of the Millstone Grit Group, a moderately productive aquifer. The BGS describe it as a “regionally significant, multi-layered aquifer up to 900 m thick with yields of 5-10 L/s, rarely 50 L/s, with many springs”. The Envirocheck report states the aquifer has dilution of >550 mm per year and is of high vulnerability. Additionally, the Client has provided a consent letter from NRW to investigate the bedrock aquifer with a maximum extraction of 2,000 m³ per day (effective 10/2024 to 05/2025). This investigation will provide site-specific characteristics pertaining to the underlying bedrock aquifer (RSK have not been provided with the results of this investigation). “Good yields are occasionally obtained” and “Outcrop samples from the Cefn-y-fedw Sandstone at Pen-y-foel [SJ 2193 5645] provided porosities of 20% and hydraulic conductivities of 0.4 to 0.7 m/d within the bedrock aquifer” (The physical Properties of Minor Aquifers in England and Wales, Technical report WD/00/04, Environment Agency R&D Publication 68, BGS, 2000). The Cefn-y-Fedw Formation was suggested as a multi-layered aquifer due to varied groundwater depths encountered in the 2010 investigation (Environmental Statement report, 2011). Off-site <u>Superficial Deposits</u> A Secondary Aquifer (Undifferentiated) is located 3 m south-west of the site, associated with Head deposits. A Secondary Aquifer (Undifferentiated) is located 9 m NW of the site, associated with Till Devensian (Diamicton) and Head deposits. <u>Bedrock</u> A Principal Aquifer lies 58 m to the west of the site, within Minera Formation - Limestone and [Subequal/Subordinate] Sandstone, associated with the Clwyd Limestone Group.

Condition	Description
	The Envirocheck report states the aquifer has dilution of >550 mm per year and is of high vulnerability.
Depth to groundwater and flow	The 2010 boreholes encountered variable groundwater resting levels of between 290.50 mAOD and 302 mAOD. Groundwater in the northern sector of the site is estimated between 13 m and 48 mbgl. The groundwater reportedly flows south-east. A mineshaft abstraction from BGS borehole SJ25NW42 indicates a water well depth of 24.40 mbgl within adjacent limestone bedrock (licence number 24/67/8/0032) though no groundwater levels are provided. It is likely that perched water may be present in any made ground deposits present on-site.
Groundwater recharge/attenuation	Most of the site is currently unsurfaced and will likely drain to ground, particularly in quarried depressions.
Historical implications for hydrogeology	Several wells are noted in the immediate area around the site and one recorded in the north of the southern sector. Several ponds are recorded on the site. The ponds within the quarry are typically within deep topographical depressions, which may have an impact on the hydrogeological regime of the site. Ponds are also located off-site to the immediate west. Several shafts, associated with historical lead mining, are located on and adjacent to the site. The depth and current condition (i.e. backfilled/flooded) of these may have implications on the hydrogeological regime.
Licensed groundwater abstractions	The environmental database report indicates that there are no active licenses within a 1 km radius of the site. Previously, J Stoddard and Sons Ltd held three licenced abstractions (licence number 24/67/8/0032) from a mineshaft (associated with an old lead mine) located 173 m north-west of the site, from at least 2005 until an unspecified end date. The abstraction licences were associated with Mineral Products: General Washing/Process Washing.
Source protection zones	Information available in the Envirocheck report indicates that the site does not lie within a currently designated groundwater Source Protection Zone (SPZ).
Ground source potential	As part of RSK's commitment to promote sustainability in all that we do, we have assessed the site to determine the potential for space heating and/or cooling and hot water to be supplied by sustainable ground source heat pumps (GSHP). According to the BGS and EA online open loop GSHP screening tool for England and Wales the aquifer beneath the site is favourable. The geology beneath the site has potential for providing space heating and hot water via closed loop ground source heat pumps. Additionally, recorded mine shafts on the site and in the vicinity may be suitable as alternate sources of heating/cooling. To investigate sustainable heating further, please contact the RSK Geosciences/ Carbon Zero ground heat team who have expertise in providing effective geothermal heating and cooling solutions

4.8 Hydrology

A summary of the hydrology within the site area is summarised in Table 10.

Table 10 Summary of hydrology in site area

Condition	Description
Surface watercourses/features	The nearest off-site watercourse, an inland river, is located 10 m to the west of the site, broadly flowing from north to south. This watercourse is referred to as an River Terrig Stream in Envirocheck records. An additional inland river is located 107 m east from the site, flowing north to south, into the River Terrig. Further tributaries flow into the River Terrig beyond 250 m to the south of the site. The River Terrig is located 44 m south of the site, flowing broadly eastward. A small stream with limited flow traverses south from the largest northern sector ponds. Iron ochre was observed during the site walkover. Nine ponds are located on the site, including five in the northern sector and four in within the existing Maes-y-Droell Quarry. The client provided an Environmental Statement (dated March 2011) stating that the ponds within the quarry freely drain into the underlying sandstone. In the north of the quarry, the ponds are reed-covered settling ponds. Anecdotally, the site representative stated that these settling ponds contain a minimum depth of a few metres of clay/silt. Several ponds lie within approximately 100 m of the site to the north, east and west of the site. The site lies within the catchment of the River Dee and Bala Lake Special Area of Conservation (SAC).
Surface water abstractions	The environmental database report indicates that there are two licensed surface water abstractions within a 1 km radius of the site. These are located 980 m (licence ref: 24/67/8/0085) and 984 m (licence ref: 24/67/8/0084) north-east of the site and related to general farming/domestic stream abstraction, granted in 1979. It is not stated whether these licences are currently active/inactive. Historically, J Stoddard and Sons Ltd (previous operator of Maes-y-Droell quarry) had three licenced abstractions (licence number 24/67/8/0031) from the River Terrig Stream located 26 m north-west of the site, from at least 1967 to an unspecified end date. The abstraction licences were associated with Mineral Products: General Washing/Process Washing.
Site drainage	Surface drainage from the site appears to be discharged into to the south, following the topographic profile. This is evidenced by pond formation in the south of the quarry. The area of hardstanding in the west of the quarry, associated with the existing buildings and site access, may feature subsurface drains/culverts. If present, these may represent potential preferential pathways for the migration of possible contamination beneath the site.
Preliminary flood risk assessment	The site does not lie within a designated floodplain area. The risk of flooding across the site has been assessed by NRW as negligible. However, there are localised areas which have been assessed by NRW as high –i.e. greater than 3.3%, 1 in 30. A flood risk assessment (FRA) is outside the scope of this report. The River Terrig to the immediate south of the site has a high risk of flooding.

4.9 Sensitive land uses

Table 11 provides a summary of any environmentally sensitive areas identified within 250 m of the site based on the environmental database report.

Table 11 Environmentally sensitive areas

Feature	Present within 250m of site?	Details	Likely pathways from site?
International designations – Ramsar wetland, Special Area of Conservation (SAC), Special Protection Area (SPA)	No		
National designations – Site of Special Scientific Interest (SSSI), National Nature Reserve (NNR), ancient woodland, Area of Outstanding Natural Beauty (AONB)	Yes	Northern sector of the site lies within the Clwydian Range and Dee Valley AONB	No, upgradient of potential contamination sources.
Local designations – Local Nature Reserve, Site of Importance for Nature Conservation (SINC)	No		
Nearest high sensitivity development, e.g. residential	Yes	Graianrhyd village, immediately south of the site.	Yes, located adjacent to and downstream/downgradient of the site.

4.10 Climate change

Planning policies place a requirement on developers to mitigate and adapt to future climate change.

LCRM (EA, 2023) requires land contamination assessments to ‘*factor in climate change impacts, including extreme weather events, to ensure site works and any long term remediation is sustainably robust*’, this includes consideration in the CSM and potential contaminant linkages that may be affected and the related uncertainty.

The effects of climate change on the conceptual site model and the potential for climate change effects to improve or exacerbate site conditions with respect to potential contaminant linkages is uncertain. Effects identified in LCRM could include increased rainfall and extreme weather events (i.e. flood and storms), increased seasonal variations in groundwater levels, soil moisture content, and potential for mobilisation of contaminants.

RSK consider that sites that are likely to be more susceptible to climate change effects to be those located on or near to the coast and at risk of coastal flooding, or erosion and those located within the flood plain.

Qualitative consideration of climate change is provided for specific linkages in the qualitative risk assessment and in the assessment of uncertainty.

5 SITE RECONNAISSANCE FINDINGS

A site reconnaissance survey was completed on 30 January 2025 by RSK, accompanied by client representative David Scott.

The key findings from the site reconnaissance survey were as follows:

Northern Sector

- the northern sector features shrubs, gorse, grasses and small trees in the south which open out to moorland grasses in the north with five small ponds present. There is a footpath and track (accessible to off road vehicles) travelling north through this sector
- there was no observed evidence of the historical Llanarmon Mine. The presumed location of the eastern shaft was identified in the walkover as a circular hollow (~2m diameter) within a wooded area which was partially infilled with fly tipped waste. The western shaft could not be identified.

Southern Sector (Maes-y-Droell Quarry)

- the quarry features significant elevation changes with quarried depressions in the south rising to elevated spoil heaps in the north and east of the site. The quarried depressions were flooded at the time of the walkover
- the spoil heaps are vegetated with shrubs and small trees. The rest of the quarry is sparsely vegetated with grasses and small shrubs. Woodland lies on the northern quarry boundary
- access throughout the site is well maintained with tracks suitable for off road vehicles. The track from the central east of the site to the southern quarried depressions is less maintained and muddy
- the sheds in the central west of the quarry feature evidence of hazardous substance use including labels signs on tins/drums in both buildings, a COSHH warning sign on the northern shed, an AST adjacent to the northern shed and evidence of a possible previous AST near the southern shed
- a historical electrical substation lies in an outbuilding immediate north of the northern shed and features redundant electrical infrastructure
- sub-surface services providing electricity are likely beneath the hardstanding associated with the sheds. A protruding pipe was observed to the north-east of the southern shed
- the southern shed had a damaged roof, which may contain asbestos. Asbestos may also be present in the other shed and substation outbuilding
- the settling ponds in the north of the quarry feature reedbeds and reportedly comprise a few metres of clay/silt accumulation
- the quarry and spoil heaps appear stable, with only small slippages noted in the spoil heaps.

A site plan is provided in **Figure 2**. Photographic records are included in **Appendix F** and an associated site walkover photograph location plan is provided as **Figure 3**.

The notes recorded during the reconnaissance survey are provided in **Appendix G**.

6 PRELIMINARY GEOTECHNICAL CONSTRAINTS

6.1 Design class

BS EN 1997-1 defines three different Geotechnical Categories that structures may fall into, which are summarised as follows:

- Category 1: Small and relatively simple structures for which it is possible to ensure that the fundamental requirements will be satisfied on the basis of experience and qualitative geotechnical investigations; with negligible risk
- Category 2: Conventional types of structure and foundation with no exceptional risk or difficult ground or loading conditions
- Category 3: Structures or part of structures, which fall outside limits of Geotechnical Categories 1 and 2. Examples include very large or unusual structures; structures involving abnormal risks, or unusual or exceptionally difficult ground or loading conditions; structures in highly seismic areas; structures in areas of probable site instability or persistent ground movements that require separate investigation or special measures.

Based on the information provided above on the proposed development and in view of the anticipated ground conditions, Geotechnical Category 2 has been assumed for the purposes of designing the geotechnical investigation. This should be reviewed at all stages of the investigation and revised where necessary.

6.2 Preliminary geotechnical hazards assessment

A summary of commonly occurring geotechnical hazards associated with the anticipated geology outlined in Section 4.5 above is given in Table 12, together with an assessment of whether the site may be affected by each of the stated hazards.

Table 12 Summary of preliminary geotechnical risks that may affect site

Hazard category	Hazard status based on desk study findings and proposed development		Engineering considerations if hazard affects site
	Could be present and/or affect site	Unlikely to be present and/or affect site	
Sudden lateral changes in ground conditions	☒	☐	Sudden lateral changes present within the southern sector, i.e. Maes-y-Dorell Quarry.
Shrinkable clay soils	☐	☒	Risk assessed as low to very low. Design to NHBC Standards Chapter 4 or similar.

Hazard category	Hazard status based on desk study findings and proposed development		Engineering considerations if hazard affects site
	Could be present and/or affect site	Unlikely to be present and/or affect site	
Highly compressible and low bearing capacity soils, (including peat and soft clay)	☒	☐	Envirocheck report identifies some areas at moderate risk from compressibility hazards.
Silt-rich soils susceptible to rapid loss of strength in wet conditions	☒	☐	Silt is noted in some borehole records, but no information on susceptibility to loss of strength.
Running sand at and below water table	☐	☒	Low to very low risk, or no risk, identified by Envirocheck data.
Karstic dissolution features	☐	☒	Limestone present geological units. Envirocheck reports states no hazard of dissolution ground instability hazards.
Evaporite dissolution features and/or subsidence	☐	☒	Not expected to be present.
Ground subject to or at risk from landslides	☒	☐	Envirocheck dataset identified the risk as low, but some evidence of minor slippages of spoil heaps. Landslips could occur in spoil heaps present across the southern site area.
Ground subject to peri-glacial valley cambering with gulls possibly present	☐	☒	Not expected to be present.
Ground subject to or at risk from coastal or river erosion	☐	☒	Site is inland. No rivers on-site.
High groundwater table (including waterlogged ground)	☐	☒	High groundwater table possible in some areas due to presence of clay/silt. However, no surface waterlogging evident during site walkover.
Rising groundwater table due to diminishing abstraction in urban area	☐	☒	Not expected to be an issue.
Geological faults, fissures and breaklines	☒	☐	A fault at rockhead is recorded on BGS 1:625,000 data. Several faults are shown in BGS 1:50,000 data transect the site through the centre of the southern sector (broadly east-west) and the northern sector (broadly north-south) through the approximate location of the Llanarmon Mine.

Hazard category	Hazard status based on desk study findings and proposed development		Engineering considerations if hazard affects site
	Could be present and/or affect site	Unlikely to be present and/or affect site	
Underground mining, including shafts and adits (e.g. coal, mineral)	☒	☐	Two shafts recorded in northern sector, associated with the previous Llanarmon Mine (lead). There are number of lead mines in the surrounding area. No impact from coal anticipated based on the underlying geologies.
Effects of extreme temperature (e.g. cold stores or brick kilns/furnaces)	☐	☒	Not expected to be present.
Existing sub-structures (e.g. tunnels, foundations, basements, and adjacent sub-structures)	☒	☐	Unrecorded sub-structures associated with previous quarry activities may be present. A number of slabs have been observed within the southern sector.
Filled and made ground (including embankments, infilled ponds and quarries)	☒	☐	Could be present through the southern sector (Maes-y-Droell Quarry) and locally in the northern sector associated with the previous Llanarmon Mine and sand pit (c. 1960s).
Adverse ground chemistry (including expansive slags and weathering of sulphides to sulphates)	☐	☒	Not expected to be present.
Site topography	☒	☐	Southern site area is made up of old works areas quarried areas and numerous spoil mounds.
Note: Seismicity is not included in the above table as this is not normally a design consideration in the UK.			

7 INITIAL CONCEPTUAL SITE MODEL

In the UK land contamination is assessed using a risk-based approach taking account of the magnitude (severity of the hazard) and likelihood (probability) of occurrence. A 'receptor' is something that could be adversely affected by contamination (e.g. people, an ecological system, property or a water body). A 'pathway' is a route or means by which a receptor is or could be exposed to or affected by a contaminant. A 'contaminant source' is a hazard but it can only pose a risk to a receptor where a pathway is present.

The relationship between sources, pathways and receptors are referred to as a conceptual site model. A risk can only be realised where a contaminant source, pathway and receptor are all in place, referred to as a 'contaminant linkage'.

In line with LCRM (Environment Agency, 2023) and BS 10175: 2011 + A2 2017 (BSI, 2017), RSK has used information in the preceding sections to identify hazards (sources of contaminants), receptors that may be impacted and plausible linking pathways. Where all three are present this is termed a potentially complete contaminant linkage and a qualitative risk estimation is made.

The conceptual site model has been considered in context of the proposed development as understood at the time of writing this report. Should the site development proposals change, the CSM and the associated contaminant linkages identified may need to be revised.

7.1 Potential soil, soil vapour and groundwater linkages

7.1.1 Potential sources of contamination

Potential sources of soil and groundwater contamination identified from current activities and the history of the site and surrounding area are presented in Table 13.

Table 13 Potential sources of soil and groundwater contamination

Potential sources	Contaminants of concern
On-site	
S1. Made ground (associated with industrial quarrying and historical lead mining)	Unknown materials which may potentially include brick, ash and clinker containing toxic and phytotoxic metals, inorganics, polycyclic aromatic hydrocarbons (PAHs), asbestos.
S2. Storage of oils/chemicals on-site	Lube oil, diesel, kerosene, paints, chlorinated solvents, explosive material residue.
S3. Existing structures - Sheds	Asbestos.
S4. Above ground storage tank and associated pipework	Petroleum hydrocarbons (petrol/diesel).
S5. Historical electric substation	Hydrocarbons, polychlorinated biphenyls (PCBs), toxic and phytotoxic metals, asbestos.
Off-site	
No off-site sources	

7.1.2 Sensitive receptors

Sensitive receptors identified at or in the vicinity of the site that could be affected by the potential sources identified above comprise:

- R1: future site users and visitors (quarry workers, plant/vehicle operators)
- R2: adjacent site users (residential, agricultural, commercial workers/visitors, public footpath/bridleway users)
- R3: groundwater in the underlying secondary A aquifer (Cefn-y-fedw Sandstone Formation) and adjacent (58 m west) principal aquifer (Minera Formation)
- R4: surface water courses and ponds to the immediate east and west of the site (unnamed tributaries) and the River Terrig located 44 m south.

7.1.3 Potential contaminant pathways

Exposure pathways to receptors include:

- P1: direct ingestion, inhalation and dermal contact with soil and soil-derived dust
- P2: asbestos fibre release followed by inhalation
- P3: vertical and lateral migration via groundwater
- P4: vertical and lateral migration via surface waters
- P5: vapour migration followed by indoor and/or outdoor inhalation.

Please note that construction workers and future maintenance workers have not been identified in the conceptual model as receptors because risks are considered to be managed through health and safety procedures according to the Health & Safety at Work Act 1974 and associated regulations and guidance.

Where there are potential instances that construction methods may result in short term environmental impacts, these will need to be assessed at design stage, within a construction phase environmental management plan and mitigation measures put in place where required.

7.2 Potential ground gas linkages

7.2.1 Ground gas generation potential

Potential ground gas sources identified for the site and surrounding are shown in Table 14.

Table 14 Potential ground gas sources (excludes mine gas)

Potential sources	Indicative ground gas generation potential (CIEH, 2008)	Additional information
On-site		
Natural soil strata with a low degradable organic content	Very low	

Potential sources	Indicative ground gas generation potential (CIEH, 2008)	Additional information
Made ground with low degradable organic content (e.g. up to 5% organic material and no easily degradable waste).	Very low	Made ground likely to comprise quarry and mining spoil with low degradable organic content.
Off-site		
No off-site sources identified.		

Given the anticipated ground conditions set out above, no significant potential sources of ground gas generation have been identified. As such, the above potential sources ground gas sources are excluded from further consideration.

7.2.2 Potential mine gas sources

The potentially significant sources of mine gas associated with the area of the site are as follows:

1. desorption of gas from bedrock – predominantly methane
2. decomposition (aerobic) of old wood (e.g. pit props) – carbon dioxide
3. acidic mine water drainage reacting with carbonate in underlying limestone – carbon dioxide.

Flooded mine workings typically have a very low generation potential. It is noted in reviewed sources (Section 4.6.1) that lead mines in the area were historically impacted by extensive flooding, though this cannot be determined as the status of the on-site shafts are unknown.

7.2.3 Radon

The site is in an area where the estimated percentage of homes exceeding the action level of 200 Bq m³ is <1% as indicated on available radon potential mapping (UKHSA & BGS, 2022).

In accordance with BRE 211 guidance (2023) and associated building regulations/standards no protection measures are considered to be required in new developments.

7.2.4 Preferential pathways for ground gas migration

Credible preferential pathways potentially connecting the source and receptor through vertical and lateral migration are:

1. permeable geologies of the Cefn-y-fedw Sandstone Formation and deeper underlying Minera Formation (limestone/sandstone) and Cefn Mawr Limestone Formation
2. faults – several faults at rockhead recorded across the site
3. mine shafts
4. mine workings extending laterally.

7.2.5 Preferential pathways for mine gas migration to near surface

Credible preferential pathways potentially connecting mine gas sources at depth and near surface are as follows:

1. unsealed shafts connected to unflooded workings
2. unsealed site investigation boreholes connected to unflooded workings
3. fractured rock above shallow workings
4. fault zones connecting to unflooded workings
5. permeable backfill to surface mines and shafts below backfill
6. permeable geological units.

The geology and mining history within the vicinity of the site suggests that a source of mine gas may be present below the site associated with:

1. geological strata – the permeable Cefn-y-fedw Sandstone Formation, overlies the Minera Formation and Cefn Mawr Limestone Formations at depth
2. faults – several faults at rockhead transect the site
3. known shafts – Two former lead mine shafts are located in the south of the northern sector, associated with the historical Llanarmon Mine. The flooding status of these shafts are unknown, though historical mines in the region were reported impacted by extensive flooding. The connectivity between these shafts and others which worked the Westminster vein are unknown.

Drivers for mine gas migration that may or may not be present are as follows:

1. changes in barometric pressure causes expansion or contraction of gas in mine workings
2. rising groundwater pushing gas out of ground via shafts, faults or fractured rock
3. thermal gradient
4. predicted climate change effects and extreme weather.

7.2.6 Sensitive receptors and ground gas linking pathways

The potential generation of methane and carbon dioxide from the underlying geologies is considered to be low.

Thin, impersistent coal seams within the Cefn-y-fedw Sandstone Formation do not pose a high potential for gas generation, should they be present beneath or adjacent to the site.

Although credible pathways including multiple site-adjacent shafts and faults, the sources of potential gases in the surrounding area are limited.

Given the above considerations and the development proposals to re-operate the site to win and work silica sand, there are not considered to be any sensitive receptors and credible linkage pathways. As such, the risk of ground gas risk is considered a very low and is not included in the CSM.

7.3 Preliminary risk assessment

The preliminary risk assessment findings and potentially complete contaminant linkages are shown in Table 15.

The risk classification is based on the combination of hazard, consequence and probability using a risk matrix from CIRIA C552 (Rudland et al., 2001). The requirement for a preliminary qualitative risk assessment is in accordance with LCRM (Environment Agency, 2023). A summary of the risk assessment process is in **Appendix H**.

The initial conceptual site model is shown schematically in **Figure 4**.

Table 15 Risk estimation for potentially complete contaminant linkages

Potential source	Potential receptor	Possible pathway	Likelihood	Severity	Risk Rating	Justification
S1: Made ground (associated with industrial quarrying and historical lead mining)	R1: Future site users/visitors (quarry workers, plant/vehicle operators)	P1: Direct ingestion, inhalation and dermal contact with soil and soil-derived dust	Likely	Medium	Moderate	The potential for chemical contamination in made ground is possible due to the site's lengthy industrial history. During re-operation of the quarry it is considered likely that a linkage may be present.
		P2: Asbestos fibre release followed by inhalation	Low Likelihood	Medium	Moderate/low	The site's lengthy industrial history makes it likely that asbestos may be present within existing made ground. This may be distributed should quarrying resume which represents a moderate/low linkage.
	R2: Adjacent site users (residential, commercial workers/visitors, public footpath/bridleway users)	P1: Direct ingestion, inhalation and dermal contact with soil and soil-derived dust	Unlikely	Medium	Low	The potential for chemical contamination in made ground is possible due to the site's lengthy industrial history. During re-operation of the quarry it is considered that dust generation is highly likely. However, given the sparsely populated area and dust suppression methods deployed during quarrying, potential pathways will be restricted and linkages unlikely to occur.
	R3: Groundwater (Secondary A and principal aquifers) and site adjacent wells	P3: Vertical and lateral migration via groundwater	Low likelihood	Medium	Moderate/low	The groundwater is considered to be moderately (Secondary A) to highly (Principal) sensitive and provide base-flow to rivers. The site is not in an SPZ and no potable abstractions have been identified within 2 km. The potential for leaching from made ground during quarrying development is considered likely but potential linkages to the off-site principal aquifer are limited. Ponds in the south of the quarry reportedly freely drain into the underlying sandstone, therefore a potential linkage to the Secondary A aquifer is present.

Potential source	Potential receptor	Possible pathway	Likelihood	Severity	Risk Rating	Justification
	R4: Surface water (Unnamed streams, ponds and River Terrig)	P4: Vertical and lateral migration via surface waters	Low likelihood	Mild	Low	Site adjacent surface waters are considered to be of low sensitivity and connectivity to potential contamination sources. Given the permeability of the underlying bedrock and made ground spoil, it is likely that sources would migrate via groundwater prior to intersection with surface waters.
S2: Storage of oils/chemicals on-site	R1: Future site users and visitors (quarry workers, plant/vehicle operators)	P1: Direct ingestion, inhalation and dermal contact with soil and soil-derived dust	Low Likelihood	Medium	Moderate/low	The potential for chemical contamination in made ground is possible due to the site's lengthy industrial history. During re-operation of the quarry it is considered likely that a linkage may be present. Several sources of hazardous chemicals were identified within the on-site sheds, though these sources are likely to be localised.
	R3: Groundwater (Secondary A and principal aquifers) and site adjacent wells	P3: Vertical and lateral migration via groundwater	Low likelihood	Medium	Very low	The identified localised sources are not deemed to pose a high risk to underlying aquifers. Additionally hazardous materials are located within buildings with hardstandings and therefore connectivity is low.
	R4: Surface water (Unnamed streams, ponds and River Terrig)	P4: Vertical and lateral migration via surface waters	Low likelihood	Medium	Very low	Identified sources are not deemed to pose a high risk to adjacent surface waters. Hazardous materials are located within buildings over hardstanding and therefore connectivity is low. Contamination may spread via undetermined site drainage beneath the sheds/hardstanding, though this is considered to remain of low likelihood.
S3: Existing structures - Sheds	R1: Future site users and visitors (quarry workers, plant/vehicle operators)	P2: Asbestos fibre release followed by inhalation	Low likelihood	Medium	Moderate/low	On-site sheds are at risk of containing ACM due to their pre-1990s construction. Previous structures may also have contained ACM. Damage to the southern shed's roof was observed which may be a source of loose asbestos fibres. The COSHH

Potential source	Potential receptor	Possible pathway	Likelihood	Severity	Risk Rating	Justification
						warning sign in the northern shed stored flammable and explosive materials, therefore may contain ACM as a fire protective measure. Most sources, are likely undisturbed, therefore of low risk. However, the damage roof may release loose fibres.
S4: Above ground storage tank(s) and associated pipework	R1: Future site users and visitors (quarry workers, plant/vehicle operators)	P1: Direct ingestion, inhalation and dermal contact with soil and soil-derived dust	Unlikely	Medium	Low	The AST is of unknown decommissioning status. The condition of the AST appeared good during the site walkover. It is therefore considered that any potential contamination is contained within the AST. Spillages may have resulted in the past but no evidence of such was observed during the walkover.
	R3: Groundwater (Secondary A and principal aquifers) and site adjacent wells	P3: Vertical and lateral migration via groundwater	Unlikely	Medium	Low	The condition of the AST appeared good during the site walkover. Additionally, the AST lies upon an area of hardstanding which should restrict the potential percolation to ground and migration via groundwater.
	R4: Surface water (Unnamed streams, ponds and River Terrig)	P4: Vertical and lateral migration via surface waters	Unlikely	Medium	Low	The condition of the AST appeared good during the site walkover. Additionally, the AST lies upon an area of hardstanding which should restrict the potential migration via surface waters.
S5: Historical electric substation	R1: Future site users and visitors (quarry workers, plant/vehicle operators)	P1: Direct ingestion, inhalation and dermal contact with soil and soil-derived dust	Unlikely	Medium	Low	Leaks/spills from substations would be expected to be visible and identified during maintenance and subsequent removal of the infrastructure. If the development was to re-install a substation within the outbuilding, underlying contamination may be present due to limited migration upon the hardstanding/flooring.

Potential source	Potential receptor	Possible pathway	Likelihood	Severity	Risk Rating	Justification
	R3: Groundwater (Secondary A and principal aquifers) and site adjacent wells	P3: Vertical and lateral migration via groundwater	Unlikely	Medium	Low	Leaks/spills from substations would be expected to be visible and identified during maintenance and subsequent removal of the infrastructure. The removed substation lies upon an area of hardstanding, which should restrict linkages to underlying aquifers.
	R4: Surface water (Unnamed streams, ponds and River Terrig)	P4: Vertical and lateral migration via surface waters	Unlikely	Medium	Low	Leaks/spills from substations would be expected to be visible and identified during maintenance and subsequent removal of the infrastructure. The removed substation lies upon an area of hardstanding, though underlying drainage may be present which could allow limited lateral migration.
Off-site sources						
No significant sources identified.						

Risk matrix		Consequences			
		Severe	Medium	Mild	Minor
Probability	Highly likely	Very high	High	Moderate	Moderate/low
	Likely	High	Moderate	Moderate/low	Low
	Low likelihood	Moderate	Moderate/low	Low	Very low
	Unlikely	Moderate/low	Low	Very low	Very low
	Very Unlikely	Low	Very Low	Negligible	Negligible

Potentially complete contaminant linkages with a potential risk of moderate to low or higher comprise:

- moderate risk to future site users (R1) from on-site made ground (S1) via direct ingestion, inhalation or contact (P1) with contaminated soil and/or dust and the inhalation of asbestos fibres (P2)
- moderate/low risk to groundwater quality from leachable contamination in on-site made ground (S1) (underlying Secondary A and adjacent Principal aquifers) (R3) via vertical and lateral migration via groundwater (P3)
- moderate/low risk to future site users (R1) from on-site storage of oils/chemicals (S2) within existing sheds via direct ingestion, inhalation and/or contact with contaminated soil and/or dust (P1)
- moderate/low risk to future site users (R1) from existing shed structures (S3) via asbestos fibre release and subsequent inhalation (P2).

In line with LCRM, these potentially complete contaminant linkages need to be assessed further through an appropriate scope of site investigation and/or mitigation incorporated into the development as may be appropriate.

7.4 Data gaps and uncertainties

Key data gaps and uncertainties identified in the CSM at desk study stage include:

1. on some occasions, information may be missed due to gaps between available historical OS maps. However, for the area of the site for this development, there are few changes to field boundaries between successive map editions, and it is considered unlikely that significant features have been missed
2. decommissioning status of above ground storage tanks not known
3. there are no complete previous investigations available for the site, therefore no information on actual ground conditions and the contamination status of the site at this stage
4. the client provided borehole summaries from January 2020 were generalised and not detailed logs
5. groundwater depth and flow direction are unknown at this stage
6. the precise locations of the lead mine shafts are not known, and as well as the shafts themselves, there is no information on the potential for mining related surface/near surface contamination
7. the condition and flooding status of lead mine shafts on the site are not known
8. potential uncertainties exist relating to climate change impacts, including predicted increases in extreme weather events and/ or predicted long term impacts, for example rising groundwater levels.

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 Geo-environmental assessment

The key findings of the geo-environmental assessment are as follows:

A review of historical maps has found limited development within the northern sector, with the exception of the Llanarmon Mine, comprising two shafts in the south of this area (c. 1873 to 1913) and a small briefly operational sand pit (c. 1963).

The southern sector (Maes-y-Droell Quarry) was historically agricultural land until at least the 1960s whereafter the site was utilised for sand/gravel pits and silica sand quarrying which was active until the early 2010s.

Surrounding land uses comprise predominantly agricultural and undeveloped with occasional farm/residential dwellings. The village of Graianrhyd is located immediately south of the site, which features few businesses (such as the Woolly Experience and the Rose and Crown public house).

Risk of mine gas from the on-site shafts was deemed very low due to the site's geological setting and limited sources.

The most likely risk of contamination is made ground associated with the site's extensive industrial past which may be present at varying depth across the site. Additionally, there is a risk of ACM in the existing structures and from hazardous chemicals/oils stored within these sheds.

8.2 Geotechnical assessment

The key findings of the initial geotechnical assessment are as follows:

- geotechnical Category 2 has been assigned to the site for the purposes of designing the geotechnical investigation (this should be reviewed and revised as the project progresses)
- sudden lateral changes in ground conditions are present within the southern sector associated with quarrying
- highly compressible and low bearing capacity soils (including peat and soft clay) could be present
- silt-rich soils susceptible to rapid loss of strength in wet conditions could be present
- several faults are recorded across the site in north-south and east-west orientations
- two shafts are located in the northern sector associated with the former Llanarmon Mine (lead). There are a number of lead mines in the surrounding area
- infilled or made ground is present throughout the southern sector and may be present locally in the northern sector. Materials include large mounds mainly vegetated quarry spoil which it appears have only been end tipped and possibly profiled but are likely to be made up of loose soils.

8.3 Recommendations

8.3.1 Geo-environmental assessment

The following recommendations are made for further assessment of the site to investigate the risks and potentially complete pollutant linkages identified above:

- boreholes to determine the composition of existing made ground, determine on-site groundwater regime and to collect geo-environmental samples to investigate potential contamination
- trial pits to determine shallow ground conditions and contamination across the site and around the periphery of the existing structures
- shallow soil sampling to investigate the potential contamination of PCBs and/or hydrocarbons associated with the historical substation.

8.3.2 Geotechnical assessment

With respect to issues that could affect geotechnical aspects of the proposed development, additional work is recommended to provide site-specific localised information.

As part of intrusive ground investigation works for the proposed development, geotechnical in situ and laboratory testing should be incorporated. This should include an assessment of soil and bedrock types and depths, with additional focus on areas where the ground will be more heavily loaded, i.e. within proposed processing plant areas. The geotechnical investigation should be developed in consultation with the project design team to ensure that all necessary areas are assessed for the intended end-use.

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