

AtkinsRéalis



Depot Area Geo- Environmental Interpretive Report

Walters Group

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GCRE001-AWJV-00-XX-RP-CLAH-00004

GLOBAL CENTRE OF RAIL EXCELLENCE

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1. Introduction

1.1 Background

AtkinsRéalis UK Limited (AtkinsRéalis) has been commissioned by Walters Group as their designer to undertake the detailed design of proposed earthworks for the redevelopment of the Nant Helen site, near Onllwyn, and Onllwyn Washery area at the Global Centre of Rail Excellence (GCRE), a rolling stock and rail infrastructure testing facility.

This report has been designed to deliver an assessment of potential contamination risks to human health and the environment of the portion of the Onllwyn Washery area where development is intended, this is a subset of the larger plot of land that the GCRE planning permission / development boundary encompasses. During the works completed to date the Onllwyn Washery (the Washery) area has been split into three portions, a zone referred to as the Depot Area where development is intended to occur (formerly comprised of the majority of the areas known as Zone 1A and Zone 2A), the Campus Area (located to the south of the Depot Area) where development will occur at a future point, and a surrounding area that is within the planning footprint, but where land use will not change. The Depot Area is referred to as “the site” within this report, with the plot of land encompassed within the entire GCRE planning permission redline referred to as the “wider site”, and areas within the Washery that do not fall within the Depot Area referred to as the wider Washery. The Washery is located in the south-eastern part of the wider site, and comprises railway land, spoil heaps, stockpiles, lagoons, several buildings, conveyer belts and material sorting facilities used to support the activities in the neighbouring Nant Helen Opencast Coal Mine. Figure 3-1 illustrates the different areas referred to above and Drawing GCRE-WA-62-000-DR-W-SK- 04 Draft (Appendix A) presents a phasing plan for the wider site showing the Depot Area, Campus Area and further phases that are located outside of the Washery.

Planning permission for the wider site is complex with two Local Planning Authorities (LPAs) and four planning permissions. Two permissions relate to “Nant Helen Complimentary Earthworks” (supporting earthworks for structures and track bed within a footprint of land restricted to Nant Helen) and two relate to “the GCRE Development” (construction of the rail infrastructure testing facility and track bed within Nant Helen and the adjoining Washery) due to the respective geographic areas covered by each LPA. Due to the topography of the wider site, geographic areas of the LPAs and the detail of the planning permissions, the relevant permission for the Depot Area this report considers is GCRE Planning Permission P2021/0327.

1.2 Objectives and scope

This report has been designed to deliver an assessment of potential land contamination risks to human health, controlled waters, the environment and property in accordance with Land Contamination Risk Management (LCRM) guidance (EA, 2023 [1]). The scope of work for this report is as follows:

- Review the historical land use and environmental setting of the site, and the immediate surrounding area;
- Summarise and review available ground investigation data from published information to date which includes factual and interpretative reports from three phases of ground investigations;
- Provide a summary of ground conditions;
- Provide a hydrogeological overview;
- Develop a preliminary land contamination risk assessment and initial Conceptual Site Model (CSM);
- Undertake a ground gas risk assessment;
- Undertake a coal mine gas risk assessment;

- Undertake generic quantitative human health and controlled waters risk assessments;
- Ascertain any limitations or information gaps attributed to the available information; and
- Revise the CSM.

A previous Geo-Environmental Interpretive Report (GIR) has been issued focusing solely on the northern portion of the Depot Area which was known as Zone 1A [2].

This report, in conjunction with Arup's previously submitted Desk Study [2] [2] and Ground Investigation Report [3] (GIR) [3], and AtkinsRéalis previous GIR [4], is designed to address the requirements of land contamination planning conditions relating to the Depot Area within the Onllwyn Washery area.

1.3 Proposed scheme

The development proposal for the Global Centre of Rail Excellence (GCRE), is presented in the Masterplan Drawings 264904 003A (Appendix A) with the Masterplan for the portion of the wider site known as the Washery provided in Masterplan Drawing 264904 003B (Appendix A). Please see section 2.0 for a more detailed information on planning conditions and permissions.

The outline GCRE planning permission for the wider Washery comprises the installation of multiple sidings for rolling stock storage and decommissioning, a 'shunter's cabin' and electricity substation, inspection and maintenance sheds, carriage wash facilities, several buildings forming an Innovation Hub, a Depot, as well as further industrial/commercial developments.

GCREs intention is for development within the Washery to occur in three stages:

- Stage 1 – construction of earthworks, limited railway trackbed and sidings, and UKRRIN building (land falling within the Depot Area);
- Stage 2 – construction of additional trackbed and sidings, and a train repair depot building within the earthworks footprint (land falling within the Depot Area);
- Stage 3 – construction of additional buildings (offices, research buildings, engineering), site access roads and soft landscaping outside of the earthworks footprint (land falling within the Campus Area).

The development intended within the site's footprint is Stage 1 of the above and will consist of an earthworks (area of cut and fill intended to produce a level platform), and the construction of sidings and UKRRIN building on top of the earthworks.

The wider GCRE development comprises the construction of earthworks (cuttings and embankments) to support railway infrastructure and development of a rail testing, storage, and maintenance facility at the Nant Helen opencast coal mine currently owned and operated by Celtic Energy.

1.4 Assumptions and limitations

Any geo-environmental considerations based on ground investigation data are subject to inherent limitations of any such study, whereby the nature of the work means that only a small proportion of the sub-surface conditions can be observed / sampled. Ground conditions can vary significantly between exploratory hole locations and groundwater conditions vary seasonally. Therefore, unexpected ground conditions could occur between the sampling points and groundwater conditions may differ from those encountered during the monitoring periods.

Opinions and recommendations presented in this report are based partly upon information provided by third party sources. AtkinsRéalis has not been able to verify independently all third-party information and for the purposes of this assessment has assumed that such information is accurate and complete. Therefore, whilst



this report and the opinions contained herein are accurate to the best of AtkinsRéalis' knowledge and belief, AtkinsRéalis cannot guarantee the completeness or accuracy of any descriptions or conclusions based on supplied third-party information.

This report only relates to geo-environmental risks to human health, controlled waters, the environment and property receptors. Geotechnical and mining risks (outside of coal mine gas) have not been considered as part of the scope within this report, however these will be covered in the final version of a AtkinsRéalis Geotechnical Ground Investigation Report (GIR) and AtkinsRéalis Mine Risk Review (MMR) Report [6] that are in preparation.

This report has been based on the development proposals in place at the time of writing as depicted in the masterplan drawing 003B Issue 02, presented in Appendix A. Should the scheme proposals change as design develops then further assessment may be required.

This report should be read considering the current legislation, statutory requirements and/or industry good practice applicable at the time of the works being undertaken. Any subsequent changes in this legislation, guidance or design may necessitate the findings to be reassessed in the light of these circumstances.



2. Planning status

Celtic Energy is required to restore the Nant Helen site (the wider site) in accordance with regulatory requirements and agreements with Powys County Council (PCC) and Neath Port Talbot Council (NPTC).

The Nant Helen Complementary Earthworks scheme (Planning References 20/0738/FUL and P2020/0362), which includes the creation of 17.5 m wide plateaus on the wider site, has planning approval with several pre-commencement conditions still to be discharged.

Following Welsh Government (WG) discussions with both PCC and NPTC, the local authorities expressed a desire to develop a GCRE earthworks proposal for the wider site, in advance of the detailed rail project. This project is known as the Nant Helen Complementary Earthworks Scheme and an application was submitted for this earthworks scheme, seeking consent for the earthworks for two testing tracks, and the earthworks for a link from the existing railway in the south of the wider site which currently services the Onllwyn Washery to both councils. This earthworks full planning permission was submitted, and approval granted in July 2020. Following on from the Complimentary Earthworks Application a further Application was made for outline permission for the GCRE scheme.

Table 2-1 summarises the planning permissions that are applicable to Nant Helen Complimentary Earthworks Scheme and the GCRE redevelopments, setting out the LPA each relates to and whether they apply to the site.

Table 2-1: Planning Permission Summary Table

Planning Permission Title	Planning Reference	LPA	Applicable to Depot area (the site)
Nant Helen Complimentary Earthworks Scheme	20/0738/FUL	PCC	No
	P2020/0362	NPTC	No
Development of GCRE	21/0559/OUT	PCC	No
	P2021/0327	NPTC	Yes

This outline GCRE permission application was for the “Development of a Global Centre of Rail Excellence”, with proposals comprising two rail tracks on sleepers set in a ballast track foundation, associated Overhead Line Equipment (OLE) and all other required supporting infrastructure. The two test tracks of loop configuration are the outer loop (OL), which is an electrified high speed rolling stock test track and the inner loop (IL), which is an electrified low speed infrastructure test track. A vehicle access track is proposed adjacent to the proposed rail loops.

Planning applications and conditions related to the assessment of land contamination risks are summarised in Table 2-2 below. Those conditions that are applicable to the site are highlighted in red text.

Table 2-2: Planning application and land quality condition summary

Planning Decision:	20/0738/FUL	Local Planning Authority:	Powys County Council (PCC)
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Description:	Earthworks Planning Permission: Construction of complementary restoration earthworks to create two looped landform platforms (part in cutting and part on embankment) with associated drainage infrastructure and areas of landscaping and habitat creation to create a flexible and adaptable area of land that could be used for a variety of uses including agriculture, nature conservation, leisure, tourism and industrial, research and development/business uses (potentially including a proposed rail testing, research and development and storage facility).
Condition and Summary	
15	Condition requires preliminary investigation and assessment of nature and extent of contamination. Requires Desk Study, site reconnaissance, initial CSM and preliminary risk assessment (PRA).
16	Completion of site investigation into nature and extent of contamination, and reporting. To include appraisal of remedial options and identification of appropriate remedial options. Methodology of site investigation to be submitted to and approved in writing by the local planning authority prior to commencement.
17	Preparation of detailed remediation scheme.
18	Implementation of remediation scheme and notification to Local Planning Authority (LPA) that it has commenced.
19	Remediation monitoring and maintenance scheme.
20	Reporting, investigation and remediation of any unidentified contamination.
Planning Decision:	21/0559/OUT Local Planning Authority PCC
Description:	GCRE Planning Permission: Development of a Global Centre of Rail Excellence, comprising of two test tracks of loop configuration being an electrified high speed rolling stock test track of 6.9 km in length and an electrified low speed infrastructure test track of 4.5 km, with overhead line equipment (OLE) and dual platform station test environment; together with operations and control offices (including staff accommodation and welfare), shunter cabins (two), research and development, education and training, rolling stock storage sidings and maintenance / cleaning/ decommissioning facilities; associated, drainage, internal vehicular accesses, branch line rail connection, staff and visitor car parking, lighting, electrical infrastructure (including substations and lineside shore supplies and transformers), fencing (perimeter security, acoustic and stock proof), land reformation and hard and soft landscaping, together with demolition of existing buildings / structures
Condition and Summary	
21	Requirement to complete preliminary investigation and assessment of the nature and extent of contamination in accordance with agreed phasing plan (Phasing Conditions 7). Requires Desk Study, site reconnaissance, initial CSM and PRA.
22	Completion of site investigation into nature and extent of contamination, and reporting in accordance with agreed phasing plan (Phasing Conditions 7). To include appraisal of remedial options and identification of appropriate remediation options and mine gas risk assessment. Methodology of site investigation to be submitted to and approved in writing by the local planning authority prior to commencement.
23	Preparation of detailed remediation scheme.

35	Implementation of remediation scheme and notification to Local Planning Authority (LPA) that it has commenced.
36	Remediation monitoring and maintenance scheme.
37	Reporting, investigation and remediation of any unidentified contamination.
48	No part of development to be brought into beneficial use until declaration by a competent person that remediation/mitigation needed to address risks posed by coal mining activity have been addressed.
Planning Decision:	P2020/0362 Local Planning Authority Neath and Port Talbot Council (NPTC)
Description:	Earthworks Planning Permission: Construction of complementary restoration earthworks to create two looped landform platforms (part in cutting and part on embankment) with associated drainage infrastructure and areas of landscaping and habitat creation to create a flexible and adaptable area of land that could be used for a variety of uses including agriculture, nature conservation, leisure, tourism and industrial, research and development/business uses (potentially including a proposed rail testing, research and development and storage facility).
Condition and Summary	
13	Condition requires preliminary investigation and assessment of nature and extent of contamination. Requires Desk Study, site reconnaissance, initial CSM and PRA.
14	Completion of site investigation into nature and extent of contamination, and reporting. To include appraisal of remedial options and identification of appropriate remedial options. Methodology of site investigation to be submitted to and approved in writing by the local planning authority prior to commencement.
15	Preparation of detailed remediation scheme.
18	Remediation monitoring and maintenance scheme.
19	Reporting, investigation and remediation of any unidentified contamination.
24	Requirement to submit any additional remediation requirements arising from unidentified contamination to the Local Planning Authority (LPA).
Planning Decision:	P2021/0327 Local Planning Authority NPTC
Description:	GCRE Planning Permission: Development of a Global Centre of Rail Excellence, comprising of two test tracks of loop configuration being an electrified high speed rolling stock test track of 6.9 km in length and an electrified low speed infrastructure test track of 4.5 km, with overhead line equipment (OLE) and dual platform station test environment; together with operations and control offices (including staff accommodation and welfare), shunter cabins (two), research and development, education and training, rolling stock storage sidings and maintenance / cleaning / decommissioning facilities; associated, drainage, internal vehicular accesses, branch line rail connection, staff and visitor car parking, lighting, electrical infrastructure (including substations and lineside shore supplies and transformers), fencing (perimeter security, acoustic and stock proof), land reformation and hard and soft landscaping, together with demolition of existing buildings/structures.
Condition and Summary	

21	Requirement to complete preliminary investigation and assessment of the nature and extent of contamination in accordance with agreed phasing plan (Phasing Conditions 7). Requires Desk Study, site reconnaissance, initial CSM and PRA.
22	Completion of site investigation into nature and extent of contamination, and reporting in accordance with agreed phasing plan (Phasing Conditions 7). To include appraisal of remedial options and identification of appropriate remediation options and mine gas risk assessment. Methodology of site investigation to be submitted to and approved in writing by the local planning authority prior to commencement.
23	Preparation of detailed remediation scheme.
38	Implementation of remediation scheme and notification to Local Planning Authority (LPA) that it has commenced.
39	Remediation monitoring and maintenance scheme.
40	Reporting, investigation and remediation of any unidentified contamination.
52	No part of development to be brought into beneficial use until declaration by a competent person that remediation/mitigation needed to address risks posed by coal mining activity have been addressed.

NB: All conditions require submission to the relevant LPA for approval before development/beneficial use can commence.

This report in, conjunction with Arup's previous submissions, is designed to address Condition 22 ("Completion of site investigation into nature and extent of contamination, and reporting") for the NPTC Planning Decision P2021/0327. The location of the Depot Area is shown in drawing GCRE-WA-62-00-DR-W-SK-002_Draft, Appendix A.



3. Site setting

3.1 Site location

The site is located within the Onllwyn Washery, Onllwyn, Neath, SA10 9HN centred on approximate Ordnance Survey (OS) coordinates 284734E, 210533N, with an area of approximately 24 hectares (Ha). The Washery is located between the villages of Coelbryn and Dyffryn and immediately north of the A4109. The site can be accessed from the east via the A4221 and the west from Onllwyn Road.

The wider site is located immediately to the south of Abercraf, approximately 20 km north-west of Swansea, south Wales with an area of approximately 476 Ha. The wider site, as indicated by the orange line in Figure 3-1 comprises two areas: the 'Land at Nant Helen' and 'The Washery'. The focus of this report is solely the zone of the 'The Washery,' referred to within this report as 'the site', unless otherwise stated. The redline area shown in Figure 3-1 shows the location of the land considered within this report with the wider Washery shown by the blue shaded area.

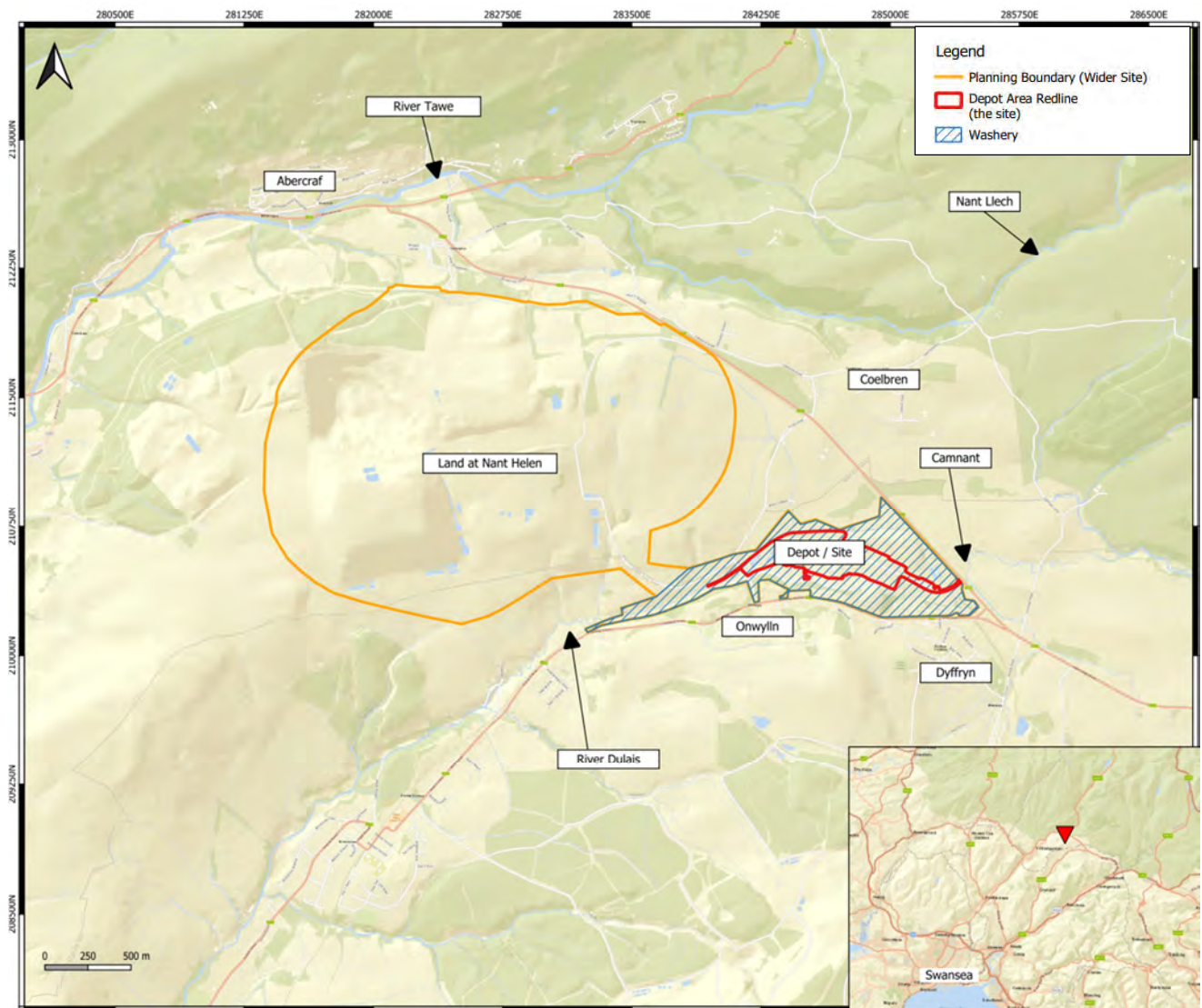


Figure 3-1: Site Location Plan

The 'Land at Nant Helen' refers to portion of the wider site located at the Celtic Energy Nant Helen opencast site and that will contain the proposed rail test track, centred on approximate OS coordinates 282643E, 211288N. The Celtic Energy Nant Helen Extension opencast mine was active until recently but is now in the process of being restored. Other parts of the proposed 'Land at Nant Helen' have been mined through opencast techniques in the past and have since been restored to their current levels.

3.2 Existing Site Uses

3.2.1 On-site

Existing site uses have been established from review of the Ove Arup and Partners Geotechnical and Geo-environmental Desk Study [2], completion of a walkover by AtkinsRéalis in July 2022, knowledge of the site gained from GCRE, and observations made during the supervision of Stage 1 and Stage 2 GI works. Figure 3-2 presents an Existing Site Layout plan showing the land uses identified within the site and wider Washery during the site walkover completed by AtkinsRéalis on 12 July 2022. Appendix D contains photographs, walkover records and a photograph location plan. Appendix A contains a larger scale version of this Figure.

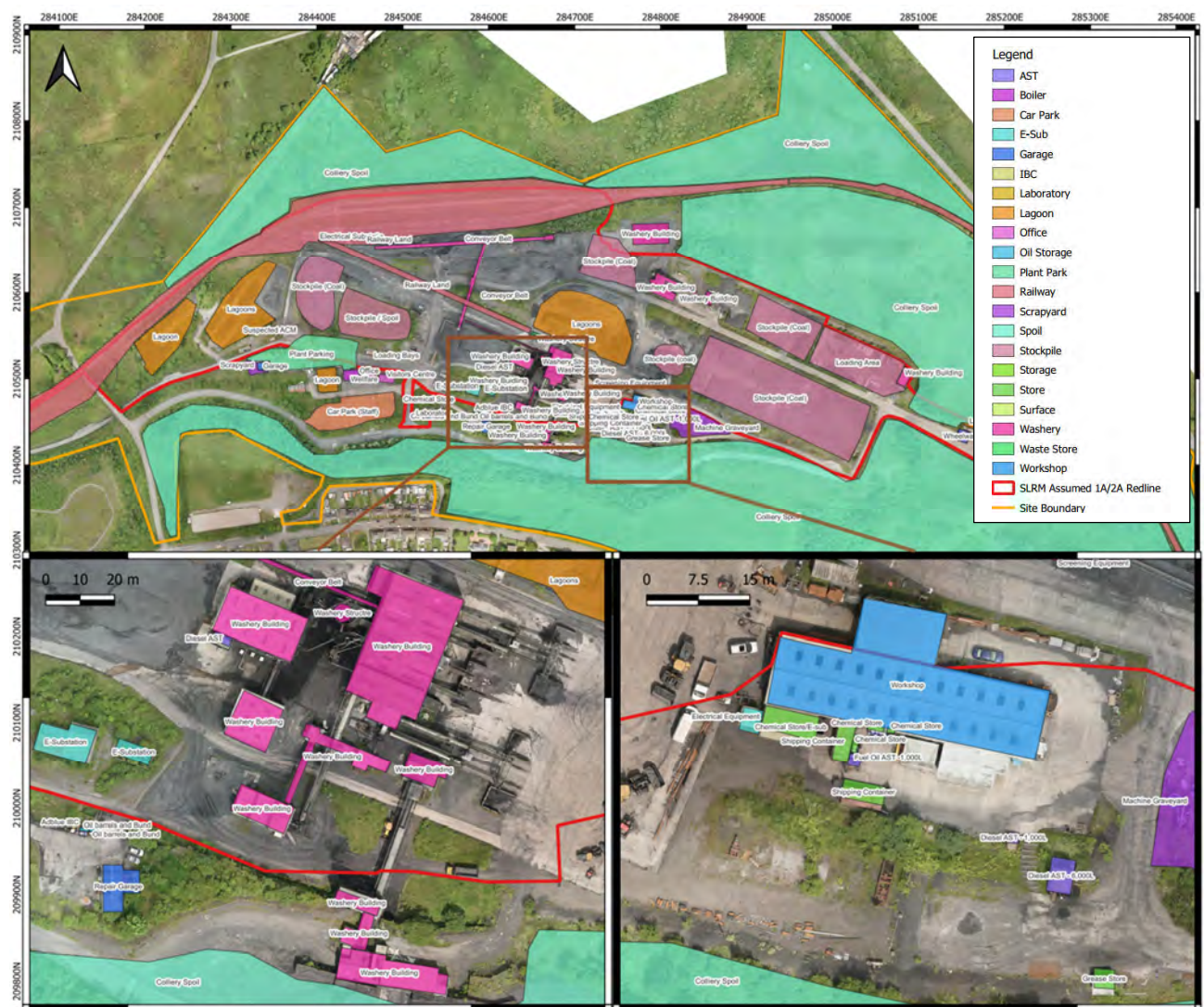


Figure 3-2: Existing Site Uses Identified in Walkover

The northernmost portion of the site (approximately a fifth of the site) consists of areas of vegetated reworked colliery spoil and railway land (a mixture of active and disused sidings) with the Neath and Brecon Railway branch line entering the Washery and site from the west and disused railway line exiting the site then the Washery to the east. The railway land included a disused electrical equipment cabin. The trackbed is ballast (of varying ages and levels of fines) with concrete or wood sleepers supporting the railway line and sidings, that has been placed on Made Ground of colliery spoil. The majority of site surfacing in this area is Made Ground which falls slightly to the east. The boundary of this area is formed by a steep bank in the centre of the site with a raised conveyor belt sited on its crest.

The centre of the site is occupied by a series of coal and spoil stockpiles, locations where stockpiles were formerly located, and lagoons which are interlinked by access roads and disused / derelict railway lines. Historical mapping shows colliery spoil to have been tipped in this area in the past, with reworking of the land form to enable the Washery use. Prior to the decision to commence the GCRE development coal was transported to stockpiles and loaded onto trains via a series of elevated conveyor belts running parallel to the railway land and connecting to Washery buildings in the south of the site. Limited areas of concrete and hardstanding are present, with the majority of the site surface made up of reworked naturally occurring material that has been generated by the former collieries located to the north and south of the site. The lagoons act as reservoirs for water used in the coal washing process or as settling lagoons. Lagoons are clustered as follows:

- Western cluster of eight lagoons at the point where the mineral railway connects to the main railway line; and
- Cluster of five lagoons located in the centre of the site, north of Washery plant.

The south of the site is from west to east occupied by several clusters of buildings which include:

- A scrap yard, vehicle repair garage and area of plant parking. Scrap yard contains engine parts, tires and machinery containing suspected asbestos containing material (ACM);
- Area of asphalted car parking with a lagoon and separate welfare building, office and visitors centre to north;
- Chemical store, laboratory (analysis of coal), vehicle repair garage with external AdBlue tanks, bunded fuel / oil storage, and two electricity sub-stations;
- Washery buildings involved in the washing of coal from the Nant Helen Open Cast Mine. These hold a series of hoppers, frothing tanks, crushing and screening machinery and a modern diesel above-ground storage tank (AST).
- Workshop building with associated chemicals external shipping containers and prefabricated buildings used for storage (including paint, chemical store and bunded external racks holding barrels of oil and a bunded 1000 litre fuel oil AST).
- South-west of the workshop are two further bunded ASTs, a grease store, and area of open ground used as a machine grave yard are located to the east of these fuel tanks. The first AST holds 1,000 litre diesel and the second 6,000 litre diesel,

The buildings in the south of the site are linked by an access road that enters the site from the east off the A4221 and exits the site to the west onto Onllwyn Road. On the eastern arm of the access road is an area with a car park, weigh bridge, office building and vehicle wash. The southern most edge of the site consists of a strip of undulating open land, beyond which is the wider Washery. Surfacing around the buildings used for washing coal is a concrete slab, with large areas of permeable Made Ground exposed, some of which is vegetated with scrub.

3.2.2 Off-site

3.2.2.1 North

To the immediate north-west of the site is located the portion of the wider site known as the Land at Nant Helen, which consists of an opencast mine operated by Celtic Mining that is currently undergoing restoration.

The Nant Helen extension, located within the north-west of the Land at Nant Helen, (approximately 1.7 km) from the site, is the location of the most recent phase of opencast mining that has supplied coal to the Washery. In the Nant Helen Extension, overburden (natural soils / and rock and Made Ground associated with previous colliery and industrial uses) has been removed and excavation occurred to a depth circa 150 m lower than the surrounding ground surface. Areas that are not in active use by the opencast mine are vegetated with a mixture of grassland and scrub, with land to the north of the Nant Helen Extension covered by forestry. Coal extraction at the opencast mine has ceased and activities in the Land at Nant Helen relate to restoration of the Nant Helen extension.

Immediately north of the centre of the site's northern boundary is an area of open farm land that rises gently to the north and which is within the wider Washery.

Land immediately adjacent to the eastern portion of the sites north-eastern boundary is also within the wider Washery. This is an area of rough grass land, scrub and lagoons with an undulating surface due to the historical placement of colliery spoil in this area. South of this is the A4221 (0-500 m), beyond this is open countryside

3.2.2.2 East

Immediately east of the site is the A4221, then open countryside, with the River Camnant 35 m east at its closest point.

3.2.2.3 South

Immediately south of the site is an additional part of the Washery this extends between 35 m to 250 m south, this land is a mixture of woodland, scrub and grassland with an undulating surface due to the historical tipping of colliery spoil. Portions of this area are used for the grazing of horses and informal leisure activities (the land is crossed by footpaths) connecting the villages of Dyffryn and Onllwyn with the Washery and land north of the site. The Washery's southern boundary is immediately adjoined by Heol Gaer / Wembley Avenue (A4109) to the south-east, a terrace of residential houses to the south and an area of open land to the south-west. Immediately south of Heol Gaer / Wembley Avenue is the village of Dyffryn (primarily residential) with open fields beyond.

3.2.2.4 West

Immediately west of the site is Onllwyn Road and a bridge that crosses the Neath to Brecon Railway line. The railway line extends to the west off-site towards Neath, land to the south and north of the railway is for approximately 330 m part of the wider site.

3.3 Topography

The wider Washery is located on the floor of a valley that rises to the north and south, and which also deepens to the west and east. The site is considered to straddle a saddle of land that divides the catchment of two streams which respectively flow to the west and east. These streams are the Dulais (flows to the west) and the Camnant (flows to the east). The lowest elevation on-site is approximately 230 m above ordnance datum (AOD) at the westernmost and easternmost extents of the site, with a high point of circa 236 m between them. The sites elevation then rises from north (230-236 m AOD) to south (250 m AOD). Across the site placement of recent stockpiles and historical colliery spoil deposition (Section 3.4) has altered the topography with cut and fill having occurred to generate level surfaces on which buildings have been constructed.

3.4 Land use

3.4.1 Historical land use

Historical features and constraints have been identified through a review of historical mapping sets (1876 to 2022) and historical aerial photography (1985 to 2021), purchased from Groundsure [7] (Appendix C). The mapping sets cover a range of scales from 1:1,250 to 1:10,560. This was supplemented through the review of aerial photographs acquired from Groundsure [8], publicly available online satellite imagery (GoogleEarth), and aerial imagery from a 2023 drone survey completed by Walters. The site history is summarised below in Table 3-1. Generally, the historical land uses identified on-site were industrial activities associated with historical coal mining from prior to 1876 to 1982 and the recent coal washery activities that came after. This includes railway land associated with the mineral railway, an unspecified works, and mining activities (including a feature labelled as a shaft). Historical colliery buildings were present to the north and south of the site.

Table 3-1: Summary of historical development

Mapping Epoch	On-Site	Off-Site
1876 to 1877	The site shows extensive evidence of ground workings prior to the earliest mapping epoch. These workings are labelled as 'old quarries.' The majority of the Washery is labelled as being marshy. Within the east of the Washery are two features labelled Old Coal Levels. Several ponds, land drains and a spring are shown and the eastern boundary of the site is formed by a stream named the River Camnant which flows to the north. A branch line from the Neath and Brecon Railway runs through the centre of the site (east to west). Coal workings from the off-site Onllwyn Pit coal extend on-site in the south-east. Several tracks cross the site and two unlabelled buildings are shown in the east. A tramway enters the site from the west and runs west to east before turning to the	Most of the land north, south and east of the site is open countryside consisting of moorland and a number of old quarries, coal, gravel, and clay pits. Land to the north of the site is an area of marshland called Gors Llwyn. Land to the north-east is labelled as Cefy-y-byrle and several residential / farm buildings are present with a railway line running east to west also present, additionally an Old Level (Ironstone) is labelled along with several quarries. To the east of the site is a watercourse named the River Camnant and a spring is located south of the Site. To the south of the wider Washery is the village of Onllwyn, the Onllwyn Coal Pit and an independent chapel. Directly to the north-west of the site, the Land at Nant Helen is undeveloped moorland with an old quarry in the south-

	south to run parallel to the Washery's eastern boundary.	west and the Cwm Mawr old coal level entrance in the south-east. The north contains the Abercraf Colliery which is surrounded by numerous old quarries, old coal levels and active coal levels, and works/spoil heaps associated with the off-site to the north International Anthracite Colliery. In the north of the Land at Nant Helen, a reservoir is present and the Neath and Brecon Railways runs west to east adjacent to the northern boundary. Additionally, eight unnamed streams originate from within the northern portion of the Land at Nant Helen and flow to the north before discharging into the River Tawe. Onllwyn Station, a post-office and Public House (Hallway House) are located surrounding the railway line. An old coal pit is present north of the railway.
1900 to 1905	The site is predominantly unchanged. Dyrn Colliery is now present on land to the north of the railway line in an area with several old shafts and building. A new section of tramway connects a spoil heap to an off-site feature labelled Old Tramway. The Neath and Brecon railway and the tramway are still present and have expanded to cover a wider corridor with additional lines and tram tracks running in parallel to each other. A spring is labelled to the south of the railway line and this appears to be feeding a stream that flows to the west and is later labelled as the Dulais.	The majority of land north and east of the Washery remains undeveloped and unchanged. Circa 20 m north of the Washery is an old quarry, with a spring, circa 240 m north. Land immediately south of the Washery has undergone development with two 'Old Coal Levels' and an 'Old Quarry' present. Additionally, a spring is still present south of the Washery. The Dyrn Colliery is present within the Land at Nant Helen boundary. The collieries in the north develop and expand, including development of buildings labelled the International Purification Works (Sewage and Water) and an engine house. The Onllwyn Colliery has expanded and extends into the south of the Washery.
1914 to 1921	The tramway that was present is now called the Mineral Railway. Additionally, on-site there are two rises (areas where water rises from the ground), one in the centre of the site and one on the southern boundary.	To the north and east of the Washery, no major changes have occurred. The town of Onllwyn continues to develop/expand and Onllwyn Colliery continues to develop to the south. Further old quarries, levels and old drift are labelled to the south and south-west. Within the Land at Nant Helen, the Dyrn colliery is now marked as the Dulais Colliery and has expanded with several new structures to the north of the tramway. By 1914, the Glynllich Colliery is labelled to the north, a previously labelled Old Tramway is no longer shown and has been replaced by

		a tramway that's runs to the north-east to from the Glynlllich Colliery to the Neath and Brecon Railway. A further engine house is present near the International Anthracite Colliery in the north of the wider site. Further small sections of tramway are shown in relation to coal workings in the north.
1948	Land that was not previously in use in the eastern half of the site is now occupied by several railway sidings which are associated with a brickworks, assumed 'Washery' infrastructure, and localised spoil heaps. In the north, an area is now labelled as a colliery with an aerial ropeway present.	Expansion of Onllwyn to the south of the Washery continues, with notable new uses including a second chapel, a cemetery and recreation ground. Within the Land at Nant Helen, the Dulais Colliery is now labelled as disused and all the coal mining related infrastructure that was previously shown is no longer shown. A 'slag tip' [Sic] is labelled to the east of Abercraf Colliery. Tramways in the north have been removed and are no longer labelled. Disused shafts, levels and mines are labelled to the north-west.
1964 to 1965	Further development has occurred within the site with demolition and replacement of several structures now labelled as works. The brickworks from 1948 is now marked as a works and a further works is marked north of the railway lines. Large portions of the site are now shown as being covered by 'slag heaps' [Sic]. The description of slag heaps is considered to be a misnomer for spoil heaps.	Wembley Avenue now borders the south of the Washery boundary. To the south, the recreation ground has been marked as a football ground. An area of spoil is labelled as a refuse tip approximately 250 m south / south-west of the Washery. Dulais Colliery buildings and features no longer shown. Within the Land at Nant Helen, the old tramway is marked as the Dismantled tramway. Structures and buildings associated with collieries in the north (Abercraf Colliery and Glynlllich) are present, however, surrounding levels are noted as disused. A 'sink' (area of surface water infiltration) is present in the north-west.
1984/1993	A disused tip is present within the south-eastern quadrant of the site and continues to the south-west beyond the site boundary. Tanks are labelled in the centre of the site east of the railway tracks, with three ponds associated with them.	Refuse tip to south / south-west of the Washery now labelled as disused. To the east of the football ground is now a tennis court. A further tip is now present immediately adjacent to the south-eastern boundary. Residential land to the north now includes a playground area that immediately adjoins the Washery. Within the Land at Nant Helen, the branch line of the Neath and Brecon railway running

through the north of the is marked as dismantled from 1987 onwards. Virtually all buildings in the north of the site associated with the former collieries have been demolished. Disused workings are shown in the east.



4. Existing information

4.1 Previous work

The following sources of information relating to previous work for the project have been reviewed in preparation of this report:

- Land at Nant Helen and Onllwyn Coal Washery, Geotechnical and Geo-environmental Desk Study, Arup, 2018 [2]: A desk study for the proposed wider site near Onllwyn in Powys, including a summary of the site history and ground conditions, including topography, geology, hydrogeology, hydrology, and coal mining legacy. Included a preliminary CSM, preliminary engineering assessment, summary of the identified geotechnical and geo-environmental risks and opportunities and recommendations for further work;
- Detailed Mine Workings Study, Arup, 2020 [9]: An addendum to the mining section of the Geotechnical and Geo-environmental Desk Study presenting a detailed review of the available mine abandonment plans, a more detailed assessment of the subsidence risks across the whole GCRE development footprint and the available information on the extent and depth of opencast backfill. Provided recommendations for targeted intrusive ground investigation for areas identified to be at significant risk of subsidence as a results of mining activity;
- Environmental Statement, Arup, 2020 [10]: An environmental statement document prepared to support the full planning application submitted to PCC and NPTC;
- Ground Investigation Specification, Arup, 2021 [11]: Specification for ground investigation works at the wider site in accordance with UK Specification for Ground Investigation [12]. The specification included works (geophysical, trial pitting and rotary open holes) to target the risk areas identified by the Detailed Mine Workings Study;
- Ground Investigation Factual Report, Quantum Geotechnical Limited, 2022 [13]: Factual report detailing ground investigation fieldwork undertaken across the wider site between 15 November 2021 and 19 January 2022. Includes an account of the fieldworks undertaken, descriptions of strata encountered and subsequent laboratory test results;
- Ground Investigation Report, Arup, 2022 [3]: Geotechnical and geo-environmental interpretation of the ground and groundwater conditions encountered in the ground investigation undertaken by Quantum Geotechnical Limited and to support the discharge of the project's planning conditions. Includes an initial mine gas risk assessment, human health generic quantitative risk assessment (GQRA) and controlled waters GQRA;
- Coal Mining Risk Assessment, AtkinsRéalis, 2023 [14]: Reviews and expands on Arup's Detailed Mine Workings Study using information from the Quantum Ground Investigation Factual Report and Arup GIR; and
- Zone 1A Geo-Environmental Interpretive Report, AtkinsRéalis, 2023 [15]: Geo-environmental interpretation of the ground and groundwater undertaken by Quantum Geotechnical Limited as well as data from the AtkinsRéalis Stage 1 Ground Investigation. Includes a ground gas risk assessment, human health GQRA and controlled waters GQRA and an updated CSM.

4.2 Published geology

The geology beneath the whole site has been interpreted through a review of published geological sources and existing reports (Section 4.1) and are shown in Figure 4-1 and Figure 4-2. These sources include the British Geological Survey (BGS) 1:10,560 geological mapping (sheet SN 81 SW) [16], the BGS 1:50,000 geological mapping (Sheet 231) [17], the BGS GeoIndex online viewer [18], and Groundsure (report presented in Appendix B).

Additionally, mining records for the opencast sites have been referenced to inform the interpretation of the geological conditions.



4.2.1 Artificial ground

Made Ground is indicated by Groundsure data [8] to be present across the site. Groundsure [8] also indicates that there are areas of disturbed ground to the immediate north-east and south of the site. Figure 4-1 presents 1:50,000 BGS mapping of artificial and superficial geology at the site and its surrounds overlaid on aerial imagery obtained from a drone survey.

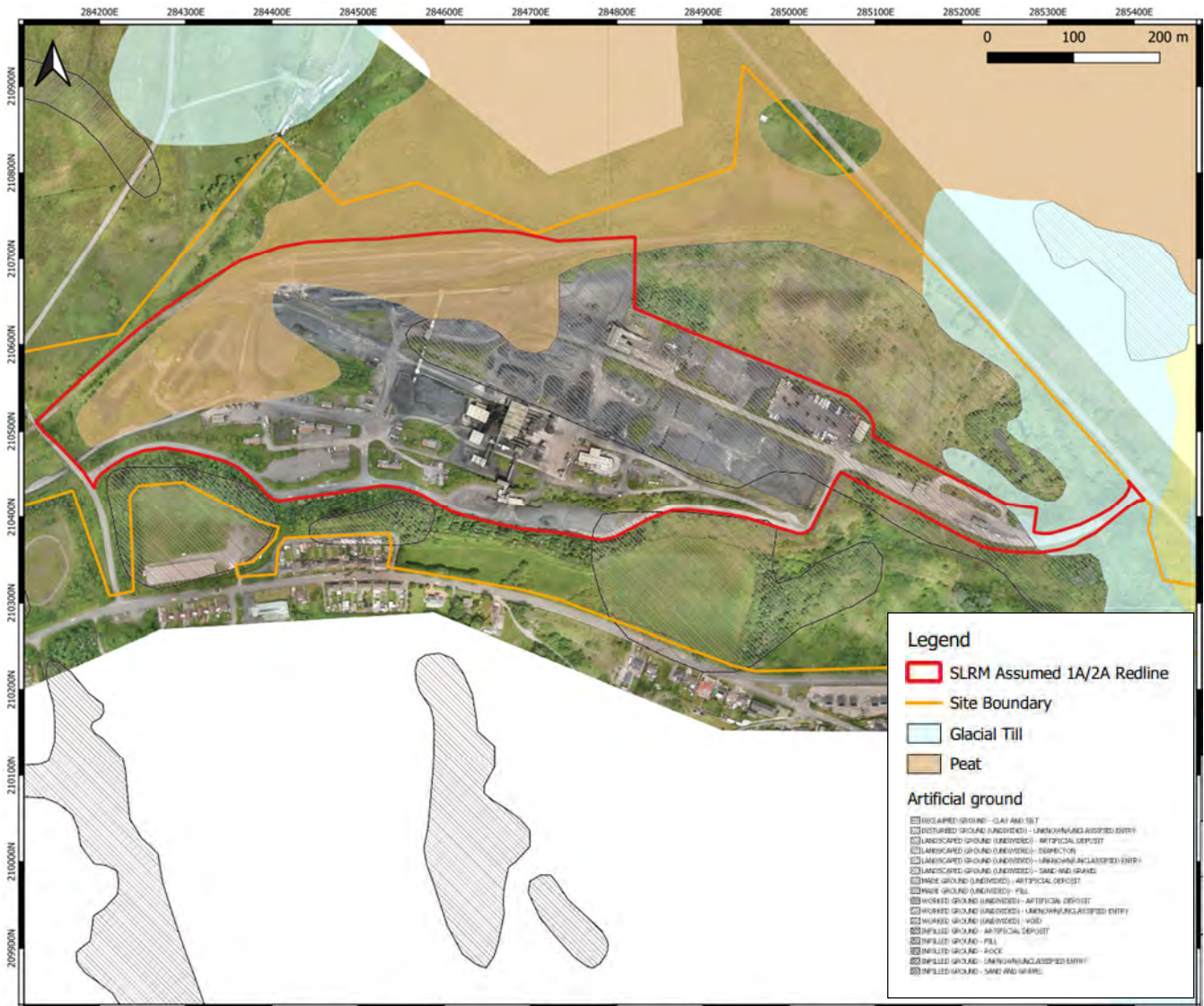


Figure 4-1: 1:50,000 Artificial & Superficial Geology plan

Made Ground is likely to be associated with levelling areas of the site to allow the railway sidings and buildings to be constructed, with further areas of Made Ground arising from railway land use, the demolition of historical colliery buildings, as well as placement of colliery spoil which historical mapping shows to have been tipped across the site and wider Washery to the north and south.

4.2.2 Superficial deposits

BGS mapping [18] indicates the presence of peat in the west and north of the site, as shown in Figure 4-1. The peat is described by the BGS as 'partially decomposed mass of semi-carbonized vegetation which has grown under waterlogged, anaerobic conditions, usually in bogs or swamps' [19].

BGS mapping [18] shows Glacial Till (Diamicton) to be present in the east of the site. It also shows Alluvium to approach within approximately 10 m of the sites eastern boundary and to be present within the wider GCRE planning footprint to the south.

Superficial deposits are not mapped in the south and centre of the site.

4.2.3 Bedrock geology

BGS mapping [18] indicates the western portion of the Washery is underlain by South Wales Middle Coal Measure Formation (SWMCM), and the east of the Washery is underlain by South Wales Lower Coal Measure Formation (SWLCM), as shown in Figure 4-2.

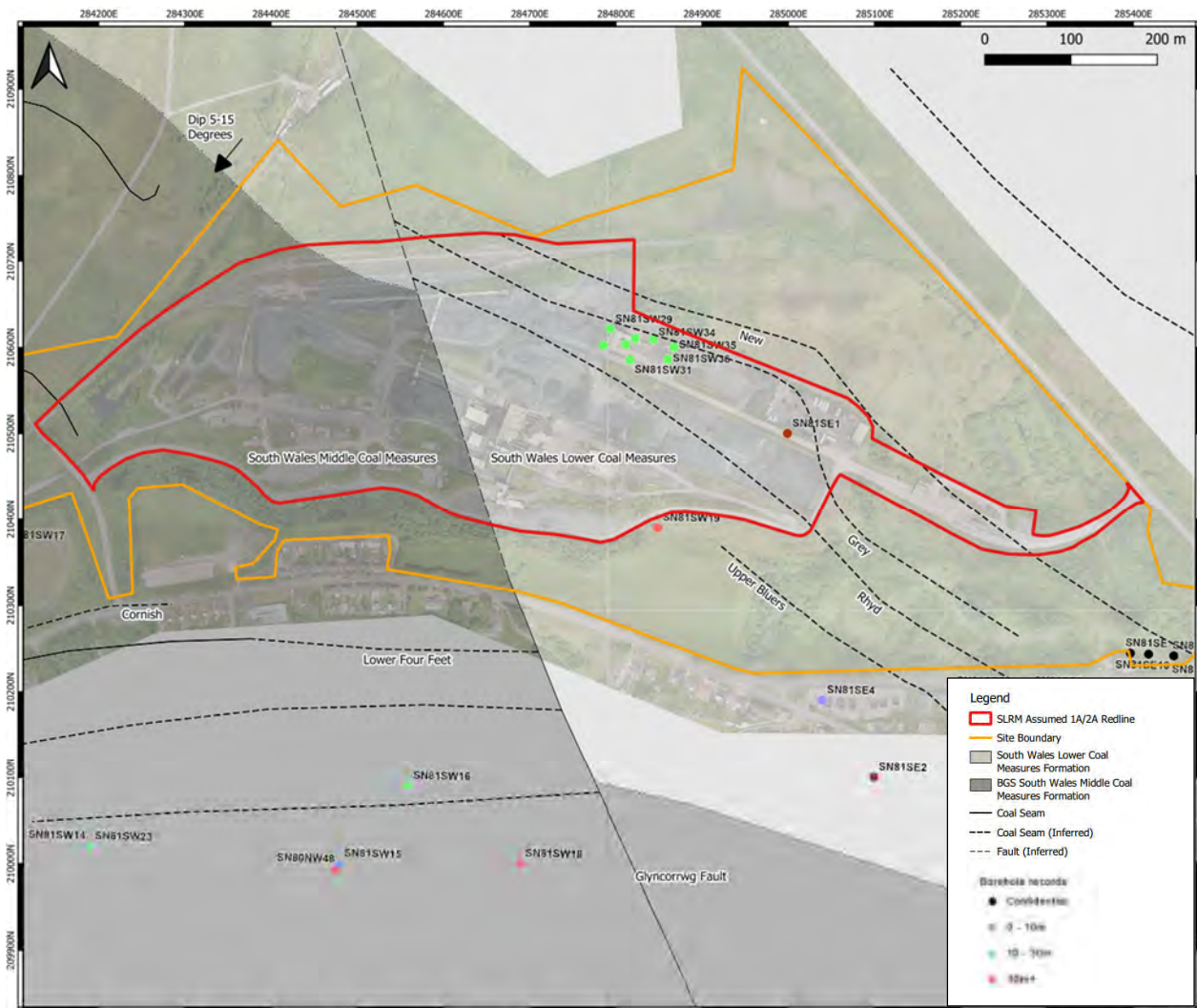


Figure 4-2: 1:50,000 Faults, Coal Seams, BGS Boreholes and Bedrock Geology plan

These formations are described as 'grey, (productive) coal-bearing mudstones / siltstones, with seatearths and minor sandstones'. The Geological memoir (Sheet Memoir 231) [20], details that nodular masses of pyrite, up to 0.15 m thick, are often present within the Middle and Lower Coal Measures Formations.

Due to the similarity of the Middle and Lower Coal Measure Formations and the difficulty of differentiating them in the field they have been treated as one unit for the purposes of this report.

The 1:10,560 geological mapping [16] typically indicates that the bedrock dips in a west south-westerly direction at angles ranging from between 5° and 15°. However, there are localised variations to this, with several anticlines and synclines shown.

The Glyncorrwg Fault is shown on the published geological maps crossing the centre of the site with a NNW-SSE strike. Several inferred coal seams are shown by the BGS, and it is possible that there are other unidentified faults and/or coal seams within the site boundary.

4.3 Mining

The site is located within the South Wales Coal Field and is designated as a Development High Risk area by the Coal Authority [21] and the wider development has a known extensive history of coal mining, including the current opencast mining. In total, 16 coal seams have been identified within the Land at Nant Helen. Off and on-site coal seams are shown in Figure 4-2 .

For more detailed information relating to the mining history and risk, refer to Section 7.2, and the AtkinsRéalis 2023 Coal Mining Risk Assessment [14] (this is currently being updated and a revised CMRA will be issued shortly).



4.4 Hydrogeology

4.4.1 Background

The following sections present a summary of the hydrogeological regime in the immediate vicinity of the site. The hydrogeology of the wider site is drawn from previous assessments prepared by Arup [2] [3], Celtic Energy [22] and AtkinsRéalis [5].

The historical mine workings identified on-site may affect the hydrogeological regime, with potential backfilled areas, adits and voids presenting pathways for groundwater migration through the sub-surface. Furthermore, the Glyncorrwg Fault identified crossing the centre of the Washery with a NNW-SSE strike may provide a pathway for groundwater migration.

Prior to the development of the site, several ponds, drains, and springs were identified in historical maps across the wider Washery area.

BH01, located approximately 80 m west of the site encountered artesian conditions during drilling [3]. Two groundwater strikes were recorded, at 5 m bgl where bedrock was encountered, and at 13 m bgl where a coal seam was encountered. Groundwater rose to 0.5 m above ground level (228.8 m AOD) on both occasions and was assumed to be present due to ground level being lower in this area, and due to the overlying deposits being cohesive, confining the groundwater.

Detailed analysis is presented in Section 7.3.

4.4.2 Aquifer properties and classifications

Superficial deposits of peat are mapped as being present across the north-west of the site (Section 4.2), Glacial Till is mapped as being present in the east of the site. There is also a small area of Alluvium mapped as approximately 50 m east of the site.

The peat and Alluvium are classified by the BGS [23] and Natural Resources Wales (NRW) [24] [25] as an Unproductive Aquifer. Glacial Till is classified as a Secondary Undifferentiated Aquifer, a category assigned where it is not possible to attribute either category A or B to a rock type which might previously have been mapped as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.

Glacial Till deposits within the east of the site are understood from Arup's GIR [3] to be predominantly comprised of well graded gravels, cobbles and boulders within a low permeability silty clay matrix which limits recharge to, and confines water in, the underlying bedrock formations. Where lenses of higher permeability silt and more continuous bands of stratified sand and gravel occur, AtkinsRéalis agrees with Arup [2] [3] that these may be considered to act as localised perched aquifers but are not considered to alter significantly the role of the strata as a barrier to vertical flow.

The underlying rhythmic sequences of mudstones, siltstones, sandstones, fireclays and coals which make up the South Wales Coal Measures (SWCM) are collectively classified by NRW [24] as a Secondary A Aquifer. The permeable siltstones and sandstones are understood to form a multi-layered aquifer system supporting large quantities of water at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers or emerging as springs where basal horizons of subordinate sandstones intersect the ground surface.

4.4.3 Groundwater vulnerability

The BGS GeoIndex [18] indicates that the SWLCM and SWMCM on-site are designated as Secondary A Aquifers with a medium groundwater vulnerability designation..

4.4.4 Groundwater source protection zones and abstraction licenses

The Welsh Government's Data Map [26] indicates the site is not within a groundwater source protection zone.

No active or historical licensed groundwater abstractions or private water supplies are located within 1 km of the wider Washery developments boundary. Dewatering previously occurred within the Land at Nant Helen in order to enable open cast mining to occur, this has however ceased. The Arup Environmental Statement [10] recording a private water abstraction recorded 250 m north of the land at Nant Helen in Caehopkin.

Due to the presence of coal mine workings below the site and to the north and south it is considered unlikely that potable water abstraction from the Secondary A aquifer is likely to occur on-site or within the close proximity to the wider development.

4.5 Hydrology

4.5.1 Water catchments

Ordnance Survey 1:50,000 mapping indicates that the River Dulais flows in a west-south-westerly direction through the western part of the wider Washery west of the site. While on-site surface drains feed into the Dulais OS mapping shows the river to be located 580 m west of the sites boundary. The River Camnant is present approximately 35 m east of the site at its closest approach, historically the Camnant was present within the wider Washery before its channel shifted to the east in 1979.

Interactive mapping from the NRW Water Watch Map Gallery [27] shows that the entirety of western portion of the site is located within the Dulais catchment while the eastern half of the site is located within the River Pyrddin catchment (into which the Camnant discharges).

The River Dulais catchment also includes:

- Nant Ystalwyn, a tributary of the Dulais: Nant Ystalwyn is understood [2] to be fed by a selection of former water treatment ponds within the body of the Land at Nant Helen which are in-turn fed by the drainage features present on the southern face of the large overburden storage area.
- Man-made drainage features: On-site surface drains pass beneath Onllwyn Road before feeding into a collection of ponds within wider Washery, these then discharge into surface drains that connect to the Dulais.

The River Pyrddin catchment includes:

- The River Camnant which flows into the River Pyrddin approximately 1 km east from The Washery.
- Man-made drainage features: these flow along the south-eastern site boundary, discharge off-site to the east and are assumed to connect into the River Camnant.

4.5.2 Discharges to surface water

The data from Groundsure [8] indicates that seven permitted discharge consents have been granted in relation to surface water for the wider site.

Of these only three are still active. A further one active permitted discharge consent has been recorded within 250 m of the site. No active groundwater discharge consents are recorded.

A summary of the active on-site and off-site (within 250 m) licensed discharges to controlled waters is presented in Table 4-1.

Table 4-1: Surface water discharge consent summary

Permit Number	Address	Receiving water	Distance from site (m)	Direction from site	
BA2010001	Onllwyn Washery Neath	Afon Dulais (Tributary of River Nea)	On-site	NA	30/03/1994
BB4027001	Vedmore Sidings Outlet B	Nant Camnant	On-site	NA	20/03/1989
BB4027002	Vedmore Sidings Outlet B	Nant Camnant	On-site	NA	20/03/1989
BP0135001	Onllwyn SPS, OPP 1 Heol Gaer, Onllwyn, Neath, SA10 9HT	Afon Camnant	14	West	17/12/2019
BP0135001	Onllwyn SPS, OPP 1 Heol Gaer, Onllwyn, Neath, SA10 9HT	Afon Camnant	14	West	17/12/2019
BP0135001	Dyffryn Cellwen, NR 7 Sisters	Afon Camnant to Pyrddin	15	East	20/02/2009

4.5.3 Surface water abstraction licences

The data from Groundsure [8] indicates there are no active or historical licensed surface water abstractions on-site or within 250 m.

4.5.4 Flood risk

The data from Groundsure [8] indicates that there is a low risk of river or coastal flooding on-site. The site does not lie within an area of flooding by sea or river. It also indicated that the highest risk of groundwater flooding on-site is low. Table 4-2 presents a summary of the flood risk datasets assessed.

Table 4-2: Summary of flood risk datasets

Dataset	Summary
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Flood Defences	There are no flood defences on-site.
Areas Benefiting from Flood Defences	There are no area benefiting from flood defences within 250 m of the site.
Flood Storage Areas	There are no flood storage areas within 250 m of the site.
Flooding Zone 2	There is one Flood Zone 2 area on-site, within the south-east of the site.
Flooding Zone 3	There is one Flood Zone 3 area on-site, within the south-east of the site.

4.6 Environmental records

4.6.1 Landfill

According to the Groundsure Report [8], there are no active or recently closed landfills at or within 500 m of the site.

There are no recorded licensed historical landfills within 250 m, however a waste exemption was recorded to be 157 m south of the site, and a refuse tip was recorded on 1961 mapping approximately 10 m south of the site.

4.6.2 Pollution incidents

According to the Groundsure Report [8], there were two pollution incidents recorded on-site and three off-site within 250 m. A summary has been provided in Table 4-3 below.

Table 4-3: Summary of Pollution Incidents

Incident Identification	Pollutant and Description	Distance from Site (m)	Direction from Site	Date	Water Impact	Land Impact	Air Impact
1168129	Materials and Wastes – Coal	On-Site		16/10/2013	Category 2 (Significant)	Category 4 (No Impact)	Category 4 (No Impact)
10516	Sewage Materials – Crude Sewage	On-Site		21/06/2001	Category 3 (Minor)	Category 4 (No Impact)	Category 4 (No Impact)
6625	Sewage Materials – Crude Sewage	1m	South-East	25/05/2001	Category 3 (Minor)	Category 4 (No Impact)	Category 4 (No Impact)
/1245993	Materials and Waste – Construction and Demolition	7m	South	16/06/2014	-	Category 4 (No Impact)	Category 4 (No Impact)

4.6.3 Control of Major Accident Hazards (COMAH)

According to the Groundsure Report [8], there are no recorded COMAH (Control of Major Accident Hazards) sites, within 250 m of the site.

4.6.4 Sensitive land uses

According to the DEFRA Magic Map [28] and the Groundsure Report [8], there are no statutory designated Special Areas of Conservation (SAC), Special Protection Areas (SPA), RAMSAR, Areas of Outstanding Natural Beauty, National Parks, Local Nature Reserves (LNR) or National Nature Reserves (NNR) within 1 km of the site.

One Site of Special Scientific Interest (SSSI), Onllwyn Gorsllwyn 150 m north-east, is located within 1 km of the site.

The site is not located within 1 km of a Nitrate Vulnerable Zone [28].

4.6.5 Archaeology

According to the DEFRA Magic Map [28], there are no scheduled monuments, registered battlefields and registered parks and gardens within 1km of the site. However, the Groundsure report [8] states that there is one scheduled ancient monument approximately 500 m north-west of the site, within the Land at Nant Helen. This is the Tramroad at Ystradgynlais.

4.6.6 Unexploded Ordnance (UXO)

The site is located in an area of low risk of unexploded ordnance on the online regional bomb risk map for the area [29], which is defined as having 15 bombs per 1000 acres or less.

5. Initial conceptual site model

5.1 Introduction

Land contamination is assessed through development of a CSM which describes the links between contamination which may be present from current and historical activities on-site (including any off-site activities from which contaminants may migrate onto a site), receptors to that contamination and pathways between the two.

Sources of contamination and associated contaminants, receptors to that contamination and the pathways are identified and assessed to determine whether all three are present or are likely to be present. If all three are present, then they form a Potential Contaminant Linkage (PCL). These PCLs can then be subjected to the risk assessment process.

The approach adopted in this assessment is in accordance with the guidance presented in the Environment Agency LCRM document [1], as endorsed by NRW. LCRM provides a technical framework for identifying and remediating contamination through the application of a risk management process. The decision of whether a risk is unacceptable in a particular case involves not only scientific and technical assessment, but also appropriate criteria by which to judge the risk and conclude exactly what level of risk would be unacceptable. Decisions regarding a site may be informed by:

- Tier 1 Preliminary Risk Assessment (PRA) – typically a desk study review to develop an initial CSM with an assessment of risk considering the likelihood and severity of the potential consequences (associated with the PCLs);
- Tier 2 Generic Quantitative Risk Assessment (GQRA) – typically a review of ground investigation and monitoring data, development/refinement of the CSM with an assessment of risk using precautionary Generic Assessment Criteria (GAC) relevant to the PCLs; and
- Tier 3 Detailed Quantitative Risk Assessment (DQRA).

A Tier 1 PRA, including a qualitative environmental risk assessment of the PCLs identified, has been carried out based on proposed scheme details and Desk Study [2] information summarised in the preceding sections of this report. A Tier 2 GQRA has been undertaken and presented in Section 8. A revised CSM is presented in Section 9, taking into account the GQRA and the development proposals. A Tier 3 assessment, should it be required, is outside the scope of this report.

Under current health and safety legislation, construction and maintenance workers are required to carry out appropriate risk assessments and instigate appropriate mitigating measures to protect themselves, other human receptors and the environment from contamination that may be present. Such risks must be adequately mitigated by the measures required under current legislation, specifically the Construction Design Management (CDM) Regulations [30], which requires that potential risks to human health and the environment from construction activities are appropriately identified and all necessary steps taken to eliminate / manage that risk. Risks in relation to short term exposure to contamination by construction workers have therefore not been considered further as part of this assessment. Acute exposure risks will need to be assessed as part of the development of the construction phase health and safety plan and managed through standard good practice health and safety procedures. This assessment provides an initial indication of chronic long-term risks to construction and maintenance workers.

5.1.1 Initial conceptual site model

Through a review of available historical and published information (e.g., geological, hydrogeological and hydrological information), potential sources of contamination and associated contaminants were identified

and / or discounted. Those sources / contaminants, that are not discounted, are then considered in relation to potential receptors that may be harmed by the source, and potential pathways that may link the sources to the receptors, i.e., source-pathway-receptor relationship.

Several historical and current land uses have been identified on-site and within 250 m of the site which may have given rise to contamination.

The risk assessment has been undertaken in consideration of the proposed future uses of the site.

5.1.2 Potential sources

Based on the review of available information, the following key potentially contaminative sources have been identified within the site boundary:

- On-site:
 - Made Ground associated with historical and current industrial activities (coal washery, coal mining (Onllwyn and Dulais Collieries), railway land, construction of supporting infrastructure);
 - Contamination associated with current coal washery activities;
 - Washery equipment operation;
 - Vehicle / plant repair;
 - Plant storage;
 - Electrical substations;
 - Laboratory;
 - Stockpiled coal / spoil;
 - Waste storage;
 - Vehicle wash;
 - Hydrocarbon storage;
 - Chemical storage;
 - Potentially contaminated surface water / road run-off from current mineral railway and coal washery;
 - Potentially contaminated groundwater where there is no superficial deposit and where leaching may have occurred;
 - Localised spillages of hydrocarbons / fuels / lubricants from current mineral railway activities and washery activities;
 - Historical coal workings; and
 - Peat (potential natural source of ground gas).
- Off-site:
 - Historical tips within 250 m of the site;
 - Contamination and Made Ground associated with historical and current mining and quarrying activities;
 - Fuel storage;
 - Electricity substations;
 - Vehicle repair activities and plant storage;
 - Equipment repair shops;
 - Machine graveyards;
 - Railway land;
 - Potentially contaminated surface water/run-off from historical and current mining activities;
 - Waste storage; and
 - Historic mine shafts and workings.

Contaminants of concern (CoC) associated with the above uses are:

- Metals (arsenic, boron, cadmium, chromium, chromium (VI) copper, lead, mercury, nickel, selenium, zinc),
- inorganics (asbestos, cyanides);
- organics (polycyclic aromatic hydrocarbons (PAHs), phenols, petroleum hydrocarbons, volatile organic compounds (VOCs), semi volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs); and
- ground gases and mine gas (methane, carbon dioxide, hydrogen sulphide or carbon monoxide) originating from Made Ground/shallow coal workings.

It should be noted that PCB, VOC and SVOC sources are predominantly in areas where access has been limited.

5.1.3 Potential receptors

As presented in the Masterplan Drawing 264904 003B (Appendix A), the proposals for the GCRE planning permission comprise:

- demolition of existing structures,
- development of an earthwork to support the installation of multiple sidings for rolling stock storage;
- construction of trackbed, railway line and sidings with overhead line equipment (OLE), signals and controls system;
- and construction of buildings that will support the operation of the rail test tracks including inspection and maintenance sheds, welfare, an Innovation Hub and a train repair depot in the south.

The above represents the final development, the current stage of works (Stage 1) involves;

- demolition of structures within the earthworks footprint,
- earthworks construction;
- construction of a single building for the United Kingdom Rail Research and Innovation Network (UKRRIN);
- Construction of limited railway, trackbed, railway line and sidings.

The following receptors have been identified at the site based on the development proposals for the Washery:

- Human health:
 - On-site: Future site users (site workers); and
 - Off-site: Users of recreational land (within wider development planning boundary), local residents, workers in commercial properties surrounding the site.
- Controlled waters:
 - Groundwater: Secondary undifferentiated aquifer (Glacial Till) & Secondary A Aquifer (bedrock); and
 - Surface Water: River Dulais and Camnant.
- Ecological:
 - Onllwyn Gorsllwyn SSSI, 150 m north-east of site; and
- Property and services:
 - Proposed new infrastructure;
 - Existing retained infrastructure (welfare building, site office and visitors centre);
 - Grazing land and livestock surrounding the site (within wider development planning boundary); and

- Neighbouring residential and commercial properties.

5.1.4 Potential pathways

Considering the identified receptors, several pathways are considered plausible based on the information gathered to date.

Human health:

- Dermal contact with and ingestion of contaminants in soils, soil-derived dusts and water;
- Ingestion / inhalation of soil, soil-derived dust, fibres and gas / vapours;
- Migration of ground gases and vapours along preferential pathways such as permeable ground, services, mine workings, and faults.

The current stage of proposed development does not contain enclosed spaces where gases / vapours may accumulate within on-site structures, except for the UKKRIN building.

However, further enclosed spaces are proposed for the final development including inspection and maintenance sheds, carriage wash facilities, several buildings forming an Innovation Hub, a depot, as well as further industrial / commercial developments. It should be noted that the design and layout of these structures has not been finalised and further investigation is planned to support this stage of the development.

Grazing land and livestock:

- Inhalation and ingestion of site originating wind-blown dust;
- Plant uptake; and
- Ingestion of surface water run-off or groundwater fed surface waters originating from site.

Controlled waters and ecology:

- Leaching of contaminants in soil to groundwater in the underlying aquifer;
- Migration of contaminated water through preferential pathways such as underground services, pipes and granular material to groundwater in the underlying aquifer;
- Lateral migration of contaminated groundwater with discharge to surface watercourses as base flow;
- Lateral and vertical migration through Made Ground, superficial deposits and bedrock, mine workings (with either voids or infilled material), including through artesian water;
- Discharge of contaminants entrained in surface water run-off followed by overland flow and discharge; and
- Intake and uptake of contaminants in water/soil and soil-derived dust by flora and fauna (relating to SSSI).

Property and services:

- Direct contact of contaminants in soil and / or groundwater with buried structures and / or services; and
- Migration of contaminated groundwater, ground gas and/or vapours along strata and preferential pathways such as service routes or differentially permeable strata.

It is assumed that piled foundations are not required within the Washery. Should piled foundations be required the risk of creation of a preferential pathway should be assessed in a Piling Risk Assessment and the piles designed to mitigate the creation of a pathway for potential contamination.

5.1.5 Qualitative risk assessment

Table 5-1 below provides the qualitative risk matrix, based on CIRIA C552 Contaminated Land Risk Assessment, A Guide to Good Practice [31], in which the likelihood or probability of each contaminant linkage being realised is ranked against the severity of the consequences. The result is the relative risk classification, the results of which can inform the due diligence process and allow prioritisation of any further assessments or the implementation of risk management measures.

Table 5-1: Qualitative risk assessment

		Severity of consequence			
		Severe	Medium	Mild	Minor
Probability of contaminant linkage	High likelihood	Very high risk	High risk	Moderate risk	Moderate/low risk
	Likely	High risk	Moderate risk	Moderate/low risk	Low risk
	Low likelihood	Moderate risk	Moderate/low risk	Low risk	Very low risk
	Unlikely	Moderate/low risk	Low risk	Very low risk	Very low risk

Definitions of the risk, probability and severity of consequence classifications presented in the guidance are given in Table 5-2, Table 5-3 and Table 5-4.

Table 5-2: Risk classification descriptors

Risk class	Definition
Very high risk	High probability of severe harm to a designated receptor from an identified source, or there is evidence that severe harm to a designated receptor is currently happening.
High risk	Harm is likely to arise to a designated receptor from an identified source.
Moderate risk	It is possible that harm could arise to a designated receptor from an identified source. However, it is relatively unlikely that any such harm would be severe, or if any harm were to occur it is more likely that the harm would be relatively mild.
Low risk	It is possible that harm could arise to a designated receptor from an identified source, but it is likely that this harm, if realised, would at worst normally be mild.
Very low risk	There is a low possibility that harm could arise to a receptor. In the event of such harm being realised it is not likely to be severe.

Table 5-3: Probability of linkage occurring classification

Probability class	Definition
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High likelihood	There is a pollution linkage, and an event appears very likely in the short term and almost inevitable over the long term, or there is evidence at the receptor of harm or pollution.
Likely	There is a pollution linkage, and all the elements are present and in the right place, which means it is probable that an event will occur. Circumstances are such that the event is not inevitable, but possible in the short term and likely over the long term.
Low likelihood	There is a pollution linkage and circumstances are possible under which an event could occur. However, it is by no means certain even over a longer period such event would take place and is less likely in the short term.
Unlikely	There is a pollution linkage, but circumstances are such that it is improbable the event would occur even in the long term.

Table 5-4: Hazard classification

Hazard class	Definition
Severe	Short term (acute) risk to human health likely to result in 'significant harm' as defined by the Environment Protection Act 1990, Part 2A. Short-term risk of pollution of sensitive water resources. Catastrophic damage to buildings or property. A short-term risk to a particular ecosystem or organism forming part of that ecosystem. Due to the specific hazards ground gas and asbestos place these will always generate a severe hazard classification where potentially present.
Medium	Chronic damage to human health. Pollution of sensitive water resources. A significant change in a particular ecosystem or organism forming part of that ecosystem
Mild	Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services. Damage to sensitive buildings, structures, services or the environment.
Minor	Harm, not necessarily significant harm, which may result in financial loss or expenditure to resolve. Non-permanent health effects to human health (easily prevented by use of personal protective clothing etc). Easily repairable effects of damage to buildings, structures and services.

The individual sources, pathways and receptors identified in previous sections are judged against this risk matrix and professional judgement has been used to estimate the combination of probability of a contaminant linkage being realised and the consequence of the harm that might result in line with CIRIA C552 [31]. Details of the potential contaminant linkages and associated risks are recorded in Table 5-5.

Table 5-5: Initial conceptual site model and preliminary risk assessment

Sources	Pathway	Receptor	Probability	Consequence	Classification of Risk
<u>On-site</u> Made Ground associated with historic and current industrial activities (coal washery, former colliery, railway land, spoil heaps). Infilled ground associated with underlying historic mine shafts, quarries, and workings. Potentially contaminated surface water / road run-off from current Mineral Railway and Coal Washery. Loss of hydrocarbons / chemical from on-site AST. Localised spillages of hydrocarbons / fuels from current Mineral Railway activities. Historic contamination associated with historic industrial activities. Natural soils with a potential to generate ground gases (peat) Possible contaminants include: - Asbestos; - Metals; - Phenols - Cyanides - PAHs; - Petroleum hydrocarbons; - VOCs/SVOCs; - PCBs; and - Ground gases and mine gas (methane, carbon dioxide, hydrogen sulphide or carbon monoxide) originating from Made Ground / shallow coal workings.	Inhalation, ingestion and dermal contact with contaminants in soil and soil derived dust.	Human Health future users of site: site workers and maintenance staff during the operational phase	Likely	Severe	High Risk with respect to asbestos/Moderate otherwise Made Ground is present beneath the majority of the site due to historic mining activities, placement of spoil from the former Onllwyn and Dulais Collieries operations and Made Ground originating from their structures, railway land and the current site land use. The majority of the Made Ground is reworked natural material, either reworked superficial deposits or South Wales Coal Measures excavated during the historical operation of the neighbouring collieries. These uses present a High risk to future redevelopment from inhalation of asbestos if present and a Moderate risk for other potential contamination linkages. The planned development will result in a substantial cut / fill operation and engineered fill that has been assessed as suitable for use being placed to deliver the levels required for GCRE's operation. It is anticipated that clean material will be placed to break the majority of inhalation, ingestion and dermal contact pathways once construction is complete, with material that exceeds human health assessment criteria placed at depth within the Earthworks.
	Migration of ground gases and vapours along preferential pathways such as permeable ground / services / mine workings / faults. Accumulation within confined spaces.		Likely	Severe	High Risk Made Ground and shallow mine workings are present beneath the site, wider Washery and neighbouring land and are a potential source of ground gas / coal mine gas. Mine workings are identified at depths of <30 m and shafts / adits are recorded on-site and within the wider Washery area. The majority of on-site mine workings are likely to predate 1880 (a limited area of workings in the south-east of the site are associated with the Onllwyn Colliery and predate the Onllwyn and Dulais collieries closure in 1982), groundwater levels are considered to be shallow, with mine workings likely to be flooded. The proposed earthworks do not present confined spaces where gas will present a risk, however the UKRRIN building will contained enclosed spaces where vapours and ground gases could potentially accumulate. Later stages of development will introduced additional buildings to the site with additional GI planned to inform their design. Risks of explosion and asphyxiation to human health and explosion damage to property.
	Migration of ground gases and vapours along preferential pathways such as permeable ground / services / mine workings / faults. Accumulation within confined spaces.	Property and Services Future and existing on-site properties	Likely	Severe	
	Migration of ground gas / vapour along strata and preferential pathways such as permeable ground / services / mine workings / faults leading to accumulation and explosion.	Human Health neighbouring residential properties, nearby commercial properties including the wider site	Likely	Severe	High Risk The Made Ground and shallow mine workings present beneath the site and wider Washery are a potential source of ground gas / coal mine gas. Mine workings are identified at depths of <30 m and shafts / adits are recorded on-site and within the wider Washery area. The majority of on-site mine workings do not have closure plans associated with the Coal Authority and are therefore likely to predate 1880 (a limited area of workings in the south-east of the site are associated with the Onllwyn Colliery and predate the Onllwyn and Dulais collieries closure in 1982), groundwater levels are considered to be shallow, with mine workings therefore likely to be flooded. The villages of Dyffryn and Onllwyn are off-site to the south and underlain by considerable coal workings, shafts and adits. No information has been provided in relation to whether ground gas or vapour mitigation measures were included in the construction of neighbouring buildings.
	Migration of ground gas / vapour along strata and preferential pathways such as permeable ground / services / mine workings / faults leading to accumulation and explosion.	Property and Services Off-site properties	Likely	Severe	High Risk The Made Ground and shallow mine workings present beneath the site and wider Washery are a potential source of ground gas / coal mine gas. Mine workings are identified at depths of <30 m and shafts / adits are recorded on-site and within the wider Washery area. The majority of on-site mine workings do not have closure plans associated with the Coal Authority and are therefore likely to predate 1880 (a limited area of workings in the south-

Sources	Pathway	Receptor	Probability	Consequence	Classification of Risk
					east of the site are associated with the Onllwyn Colliery and predate the Onllwyn and Dulais collieries closure in 1982), groundwater levels are considered to be shallow, with mine workings therefore likely to be flooded. The villages of Dyffryn and Onllwyn are off-site to the south and underlain by considerable coal workings, shafts and adits some of which present potential migration pathways for on-site ground gas / coal mine gas to migrate off-site. No information has been provided in relation to whether ground gas or vapour mitigation measures were included in the construction of neighbouring buildings.
	Inhalation and ingestion of wind-blown dust. Plant uptake. Leaching of contaminants and migration within groundwater.	<u>Grazing Land and Livestock</u> 60 m south of the site boundary	Low	Medium	Moderate/Low Risk Made Ground is present beneath the majority of the site, with colliery spoil extending off-site to the south and north and into the wider Washery where livestock are grazed. On-site contaminants may migrate to grazing land and livestock beyond the site's boundaries via leaching to groundwater and wind-blown dust.
	Direct contact of foundations/services with aggressive soils and or groundwater. Chemical attack to buried structures.	<u>Property and Services</u> Future and existing on-site property and services.	Low	Mild	Low Risk Current and future-below ground infrastructure is assumed to have been / will be constructed to appropriate standards for the site to withstand attack from soil chemistry.
		<u>Property and Services</u> neighbouring residential and commercial properties.	Low	Mild	Low Risk Distance to off-site property is considered to be sufficient to mitigate risk to a low level.
	Leaching or dissolution of contaminants in unsaturated soils and subsequent migration. Lateral and vertical migration through Made Ground, superficial deposits and bedrock, mine workings (with either voids or infilled material), faults, and artesian water. Migration via preferential pathways e.g. existing drainage, foul sewer, proposed service pipes/trenches, piled foundations.	<u>Groundwater Controlled Waters</u> Secondary Undifferentiated (superficial) Secondary A Aquifer (bedrock).	Likely	Medium	Moderate Risk The works are likely to result in disturbance of soils and colliery spoil during excavation and construction which may result in the release of contaminants with a potential to migrate to groundwater, in addition to leachate generation during the operational phase. Groundwater below the site is present at a shallow depth. The distance to identified abstractions and surface waters is such that groundwater is considered to have a medium sensitivity.
	Leaching or dissolution of contaminants in unsaturated soils and subsequent migration. Lateral and vertical migration through Made Ground, superficial deposits and bedrock, mine workings (with either voids or infilled material), faults, and artesian water. Surface water run-off. Migration of contaminated water in drainage ditches to controlled surface waters.	<u>Surface Water Controlled Waters</u> Camnant (135 m to east of site) Dulais (located to immediate west of site and fed by on-site surface water drains).	Likely	Medium	Moderate Risk The construction works are likely to result in disturbance of shallow unsaturated soils which may result in the release of contaminants in unsaturated Made Ground soils and disused mine workings with potential migration to surface water, in addition to leachate generation during the operational phase. Given the distance of the nearest surface water course, the risk of contaminants migrating to affect this receptor is moderate. Potentially contaminated groundwater may migrate to the site from within the wider Washery to the north and south, potentially affecting surface water.
	Lateral migration of contaminated water within the aquifer. Intake and uptake of contaminants in soil and soil-derived dust by flora and fauna	<u>Ecological</u> Onllwyn Gorsllwyn SSSI 150 m north-east of the wider site's boundary.	Likely	Medium	Moderate Risk Onllwyn Gorsllwyn SSSI is considered to be a medium sensitivity, and there is potential for contaminated surface run-off from the Washery to interact with it due to the sites topographical profile. It is anticipated that some of the groundwater within the eastern half of the site is moving towards the receptor and therefore there is a likely probability of the potential linkage being realised.

Sources	Pathway	Receptor	Probability	Consequence	Classification of Risk
<u>Off-site</u> Historical landfill within 80 m of site. Contamination and Made Ground associated with historical and current mining and quarrying activities. Potentially contaminated surface water/run-off from historical and current mining activities in Nant Helen and wider Washery areas. Possible contaminants include: - Asbestos - Metals - PAHs - Petroleum hydrocarbons - VOCs/SVOCs - Ground and mine gases (methane, carbon dioxide, hydrogen sulphide or carbon monoxide)	Inhalation, ingestion and dermal contact with contaminants in soil derived dust.	<u>Human Health</u> –future users on-site	Unlikely	Medium	Low Risk Off-site land uses in the wider Washery are similar in nature to those identified on-site, historical contaminating uses that are located outside of the Washery are typically covered by vegetation and not exposed directly to atmosphere.
	Migration of ground gases and vapours along preferential pathways such as permeable ground/services/mine workings/faults. Accumulation within confined spaces such as the proposed cabin. Inhalation/asphyxiation/explosion		Likely	Severe	High Risk Off-site Made Ground, spoil tips, mine workings, and natural soil present potential sources of ground gases, which may migrate to site via permeable strata. Mine workings are identified at depths of <30 m and shafts / adits are recorded off-site and within the wider Washery area. The majority of off-site mine workings to the north and south are associated with the Dulais and Onllwyn Collieries and were therefore last worked prior to 1982, shafts and adits are also recorded to the north and south of the site. Off-site groundwater levels are considered to be shallow, with mine workings likely to be flooded. The proposed earthworks do not present confined spaces where gas will present a risk, however the UKKRIN building will contained enclosed spaces where vapours and ground gases could potentially accumulate. Later stages of development will introduced additional buildings to the site with additional GI planned to inform their design.
	Migration of ground gases and vapours along preferential pathways such as permeable ground/services/mine workings/faults. Accumulation within confined spaces such as the proposed cabin. Inhalation/asphyxiation/explosion	<u>Property and Services</u> <u>Future and existing on-site properties</u>	Likely	Severe	Moderate/Low Risk Potentially contaminated groundwater may migrate to site from off-site sources and the wider Washery. Works in the wider Washery are likely to result in disturbance of soils and colliery spoil which may result in the release of contaminants with a potential to migrate to groundwater. Due to the absence of abstractions within 500 m of the site, presence of mine workings and secondary A and secondary undifferentiated aquifer designation groundwater is considered to have a moderate sensitivity.
	Leaching or dissolution of contaminants in unsaturated soils and subsequent migration Lateral and vertical migration through Made Ground, superficial deposits and bedrock, mine workings (with either voids or infilled material), faults, and artesian water. Migration via preferential pathways e.g. existing drainage, foul sewer, proposed service pipes/trenches.	<u>Groundwater</u> <u>Controlled Waters</u> Secondary Undifferentiated (superficial) Secondary A Aquifer (bedrock).	Likely	Mild	

6. Field and laboratory studies

6.1 Introduction

Several site walkovers, surveys and ground investigations have been undertaken across the site and the wider GCRE planning footprint. The relevant field studies to this geo-environmental assessment and CSM are outlined below.

6.2 Walkover surveys

6.2.1 Arup November 2018

A general site-wide walkover survey was undertaken by Arup on 28 November 2018. The walkover comprised a broad overview of the wider site looking at many areas in limited detail. The following key features were identified:

- Stockpiles of colliery spoil were noted by Arup in many locations across the wider Washery. The material was noted to be predominantly gravel sized fragments of mudstone and siltstone with larger cobble and boulder sized inclusions. The cobble and boulder sized inclusions were noted to be fractured;
- The eastern part of the wider Washery was not examined in significant detail but was noted by Arup to rise gently to the north-west; and
- The Washery area in the south-east corner was also not examined in detail although a large pond was noted by Arup adjacent to The Washery infrastructure.

6.2.2 AtkinsRéalis July 2022

A land contamination walkover was undertaken by AtkinsRéalis on 6-7 July 2022 and a hydrogeological site walkover was undertaken for the Land at Nant Helen by AtkinsRéalis on 12 July 2022.

The AtkinsRéalis' site walkovers undertaken in July 2022 focused on both hydrogeological aspects, to identify surface water features present on the wider Nant Helen site, and contamination features present within the Washery. Photographs and a plan identifying potential contamination sources are presented in Appendix D and within Figure 3-2. The key findings are detailed in Section 3.2

6.3 Ground investigation

Exploratory hole and surface water sampling locations are presented in Figure 6-1 (reproduced at a larger scale in Appendix A). The following sections summarise the stages of site characterisation work that have been completed. Copies of Factual Reports are presented in Appendix F, Appendix G and Appendix H.



6.3.1 BGS Exploratory hole records

There are nine historical exploratory holes located within the site that are available through the BGS online GeolIndex database [18]. The location of these borehole are presented in Figure 6-1 and have been used to inform the CSM however no sampling or analytical information is available for them.

Eight historical exploratory holes were drilled by cable percussion and follow on rotary coring to a maximum depth of 30 m below ground level (bgl), these are understood to have been undertaken in a single phase in 1989. These BGS borehole are labelled SN81SW29 to SN81SW36.

An additional exploratory hole labelled SN01SW19 was rotary drilled to a depth of 45.11 m bgl in 1969.

6.3.2 Arup preliminary ground investigation (2021 to 2022)

6.3.2.1 Exploratory holes

A ground investigation of the wider GCRE planning footprint was scoped and specified by Arup (the investigation supervisor) on behalf of GCRE Ltd and undertaken by Quantum Geotechnical Limited between 15 November 2021 and 19 January 2022. Arup's preliminary GI exploratory hole locations are presented in Figure 6-1. The factual report is presented in Appendix F.

- Six boreholes (BH29R, BH30R, BH31R, BH32R, BH33R and BH34R) were progressed up to 35.0 m bgl within the site, while BH01 was progressed to 30 m bgl west of site along the railway, drilled using cable percussive with either rotary probe/rotary following on methods; and
- 21 trial pits progressed to between 2.0 m and 4.6 m bgl.

Further investigation occurred within the Land at Nant Helen, but is not considered relevant and is not reported on in this document.

6.3.2.2 Instrumentation and monitoring

The following instrumentation was installed during the works, with the location of each borehole where monitoring wells were installed presented in Figure 6-2.

- Six holes were fitted with 50 mm standpipes to allow groundwater level / ground gas monitoring, including two locations fitted with dual installations (BH31 and BH34); and
- Groundwater and ground gas monitoring was undertaken fortnightly for 12 weeks from the completion of the site works (between 20 January 2022 and 25 April 2022).

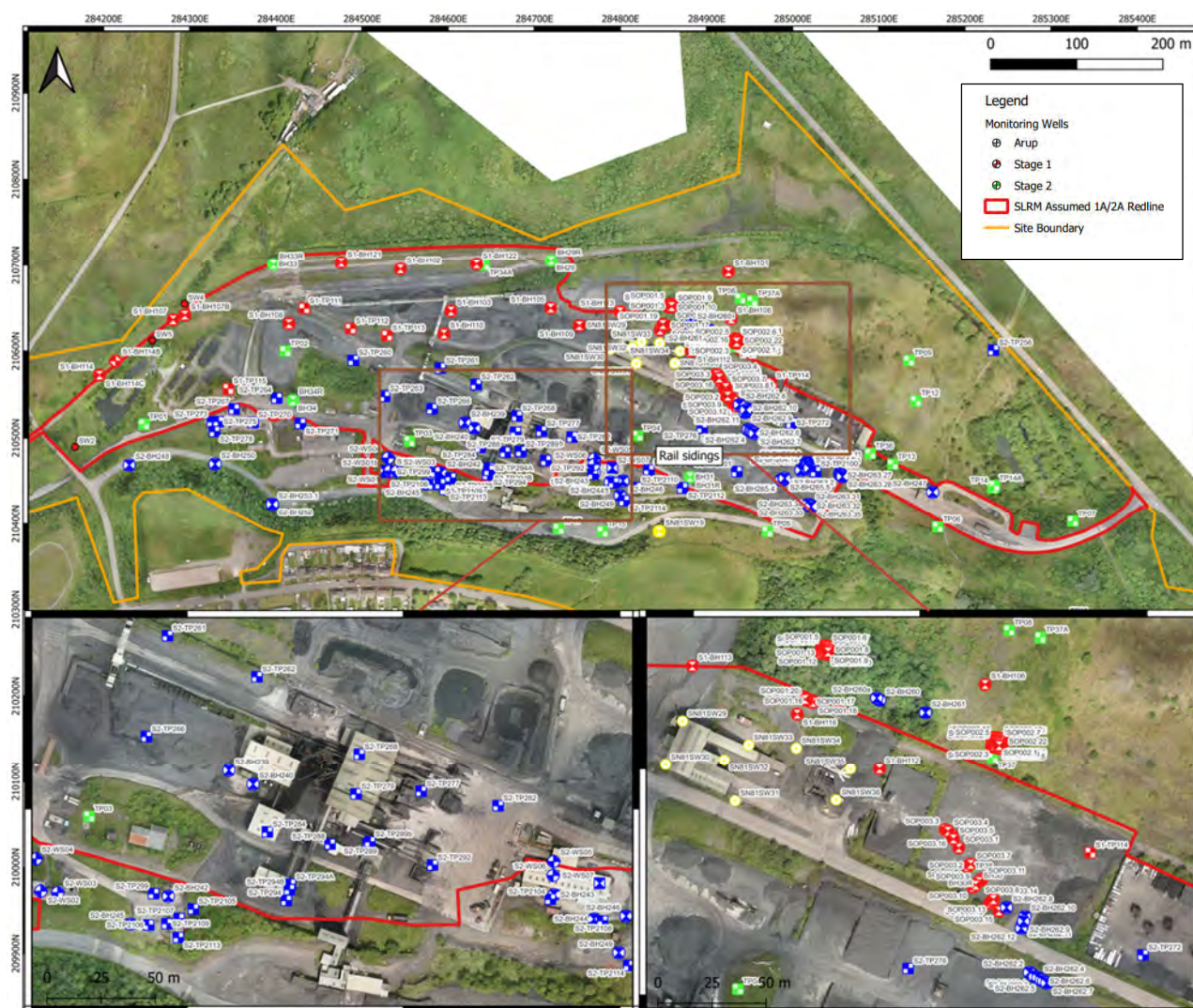


Figure 6-2: Monitoring Well Location Plan

6.3.2.3 Investigation constraints

Taking into account the proposed development and the variable and challenging ground conditions present at the site the ground investigation described above, due to its preliminary nature, had the following limitations:

- Exploratory holes were generally widely spaced with up to 400 m between individual exploratory holes in some areas of the site. This was considered as being too widely spaced to take full account of the variable geological ground conditions across the site;
- A significant proportion of the field geological descriptions were not recorded in accordance with BS 5930 [32] guidance with only drillers descriptions provided, where open hole rotary drilling was undertaken;
- Due to the spacing between boreholes, there was therefore considered to be limited groundwater data available for a suitable assessment;
- In some locations, materials which may not have wholly homogenous were given the same description;
- Significant thicknesses of Made Ground were anticipated, in many areas of the site there was considered to be the potential for Made Ground horizons derived from disposal of colliery spoil, multiple phases of historic use and associated with modern mining activities (haul roads, yards, former buildings) potentially in close juxtaposition. Made Ground of differing age and composition will present different risk profiles to construction workers and future users of the site, knowledge of its distribution or definitive absence would allow a more nuanced assessment of risk; and

- Completed ground investigation works did not involve headspace sampling and no comments regarding the presence or absence of hydrocarbon odours and visual evidence of contamination other than noting the presence of ash and coal in some Made Ground were reported in the ground investigation.

6.3.2.4 Geo-environmental soil testing

Under the direction of Quantum Geotech, contamination laboratory analysis was undertaken by Eurofins Chemtest, in accordance with the laboratory's quality control system. Eurofins Chemtest are an UKAS and MCERTS accredited analytical laboratory. The testing certificates are present in the corresponding factual report (Appendix F).

Thirty two soil samples were subject to a general suite of analysis based on the desk study and ground conditions encountered, including the following:

- Metals (arsenic, boron, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, zinc);
- Polycyclic Aromatic Hydrocarbons (PAHs);
- Total Petroleum Hydrocarbons Criteria Working Group (TPHCWG) including benzene, toluene, ethylbenzene and xylenes (BTEX);
- Total cyanide, free cyanide, phenols;
- pH, Soil Organic Matter (SOM);
- Volatile organic compounds (VOC) & semi volatile organic compounds (SVOC);
- Hexavalent chromium; and
- Asbestos.

Two soil derived leachate samples were also obtained and scheduled for analysis outlined below:

- Metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium, zinc);
- Cyanide, phenols; and
- PAHs.

Logs from the Factual Report [13] are in most cases based on drillers descriptions with limited detail on Made Ground composition other than to describe the material as colliery spoil and to note the presence of coal and ash amongst the clayey gravel that was typically recovered. No observations on odour, headspace testing, or visual evidence of contamination are reported.

6.3.2.5 Geo-environmental groundwater testing

Twelve groundwater samples were also obtained from six locations (BH29, BH30, BH31, BH32, BH33 and BH34) over two rounds of sampling, and were scheduled by Quantum Geotech for the following analysis:

- Metals (arsenic, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium, zinc);
- PAHs;
- TPH CWG inc. BTEX; and
- pH, total cyanide, Sulphate as SO₄, Dissolved Organic Carbon (DOC), total phenols.

6.3.3 AtkinsRéalis stage 1 ground investigation (2022 to 2023)

6.3.3.1 Exploratory holes

A combined geotechnical and geo-environmental ground investigation at the site was scoped and specified by AtkinsRéalis (the investigation supervisor) on behalf of GCRE and undertaken by Jackson GeoServices. Ground investigation works commenced 7 November 2022, with the geo-environmental element completed in December 2023. Figure 6-1 shows the location of each Stage 1 GI exploratory hole.

The ground investigation targeted the northern part of the site (previously described as Zone 1A) and the purpose was to address the data gaps identified within the Arup preliminary ground investigation. Additional Stage 1 GI occurred within the Land at Nant Helen, however this is not relevant to this report and is not considered further.

The draft factual report is presented in Appendix G. The investigation comprised the following intrusive works within Zone 1A:

- Seventy seven boreholes progressed to between 4.0 m and 30.8 m bgl drilled using either dynamic, open hole rotary or rotary coring, including those locations undertaken for mining/geotechnical purposes only;
- Five machine-excavated trial pits progressed to between 0.7 m and 4.0 m bgl; and
- Environmental samples were taken from each trial pit and sixteen boreholes. The remaining boreholes were undertaken for mining/geotechnical purposes.

6.3.3.2 Instrumentation and monitoring

The following instrumentation was installed during the works, with the location of monitoring wells presented in Figure 6-2.

- Eleven boreholes (S1-BH102, S1-BH-103, S1-BH105, S1-BH108, S1-BH112, S1-BH113, S1-BH121, S1-BH122 and SOP003.16) were fitted with 50 mm standpipes to allow for groundwater level / ground gas monitoring. A single location, S1-BH112, was fitted with a dual installation and a further location S1-BH101 is located 80 m north of the current sites northern boundary.
- Headspace testing using a Photo Ionisation Detector (PID) was undertaken at each location;
- Ground gas monitoring, and groundwater monitoring and sampling, has been obtained during site works and from six monitoring rounds, undertaken on 29 November 2022, 9 January 2023, 16 January 2023, 24-25 January 2023, 31 January 2023 to 2 February 2023 and 13 to 17 February 2023;
- Additional groundwater monitoring was completed daily following during the intrusive field work period; and
- Eleven surface water samples were collected during sampling rounds completed on 24 to 25 January 2023, 1 to 2 February 2023 and 13 to 14 February 2023, from the locations detailed in Table 6-1.

6.3.3.3 Geo-environmental soil testing

As scheduled by AtkinsRéalis, contamination laboratory analysis was undertaken by Eurofins Chemtest, in accordance with the laboratory's quality control system. Eurofins Chemtest are an UKAS and MCERTS accredited analytical laboratory. The testing certificates are present in the corresponding draft factual report (Appendix G).

Sixty seven soil samples were subject to a general suite of analysis based on the desk study and ground conditions encountered, including the following:

- Metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium, zinc);

- PAHs;
- TPHCWG inc. BTEX;
- Total cyanide, free cyanide, phenols;
- pH, SOM;
- Hexavalent chromium; and
- Asbestos.

Twenty nine soil derived leachate samples were also obtained and scheduled for analysis outlined below:

- Metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium, zinc);
- Hexavalent chromium; and
- Cyanide, phenol.

Soil leachate samples were not analysed for PAHs, as this testing is not considered by AtkinsRéalisis to be representative in leachate analysis.

No indications of olfactory contamination were identified during the ground investigation works. Headspace testing was undertaken with a PID. The majority of readings were close to or below the limit of detection. Elevated readings were recorded as follows:

- S1-BH10 (1m): 3.7 parts per million by volume (ppmv);
- S1-BH103 (4.2m): 65.7 ppmv;
- S1-BH121 (2m): 15.8 ppmv; and
- S1-TP115 (0.3m): 1.5 ppmv.

6.3.3.4 Geo-environmental groundwater and surface water testing

Chemical test results were analysed for 25 groundwater samples, obtained from nine monitoring locations (as detailed in 6.3.3.2) during five monitoring rounds undertaken on 29 November 2022, 16 January 2023, 24 to 25 January 2023, 1 to 2 February 2023 and 13 to 14 February 2023. These samples were scheduled for the following analysis:

- Metals (arsenic, boron, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, vanadium, zinc);
- Hexavalent Chromium;
- PAHs;
- TPHCWG inc. BTEX; and
- pH, Total Cyanide, Sulphate as SO₄, DOC, total phenols.

The test certificates are present in the corresponding factual report (Appendix G).

Eleven surface water samples have been taken, during sampling rounds completed on 24 to 25 January 2023, 1-to 2 February 2023 and 13 to 14 February 2023, from the locations detailed in Table 6-1:

Table 6-1: Surface water sampling details

Location ID	Detail	Distance	Number of Samples
SW1	Dulais downstream of site boundary	680 m south-west of site	3
SW2	Surface water drainage ditch discharging to Dulais	On-site	3



SW3	Off-site Camnant (Level with site)	35 m south-east of site	3
SW4	Surface water ditch discharging to Dulais	On-site	1
SW5	Surface water ditch discharging to Dulais	On-site	1

Each sample was tested for the following analysis:

- Metals (arsenic, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, vanadium, zinc);
- PAHs; and
- pH, total cyanide, sulphate as SO₄, total phenols.

6.3.4 AtkinsRéalis stage 2 ground investigation (2023)

6.3.4.1 Exploratory holes

Stage 2 GI combined geotechnical and geo-environmental ground investigation and was scoped and specified by AtkinsRéalis (the investigation supervisor) on behalf of GCRE and undertaken by Jackson Geo Services. The Stage 2 ground investigation works commenced 27 March 2023, with the geo-environmental aspects completed on 27 June 2023 and geotechnical investigation completed on 5 July 2023. Figure 6-1 shows the location of each exploratory hole where environmental samples were taken within the Washery (excluding the locations undertaken for mining/geotechnical purposes only).

This ground investigation covered the south of the Depot Area (formerly Zone 2A) and the Land at Nant Helen. This report only summarises data obtained from the site.

The draft factual report is presented in Appendix H. The investigation comprised the following intrusive works within the site:

- Twenty boreholes progressed to between 10.00 m and 25.00 m bgl drilled using either dynamic sampling then rotary open hole rotary or rotary coring, including some locations undertaken for mining / geotechnical purposes only;
- Eight windowless sampled boreholes progressed between 0.6 m and 5.45 m bgl;
- 118 probe holes progressed between 2.0 m and 25.00 m bgl around six locations, drilled using open hole rotary for mining / geotechnical purposes only;
- 39 machine-excavated trial pits progressed to between 0.5 m and 4.0 m bgl; and
- Environmental samples were taken from 30 trial pits and 13 boreholes. The remaining boreholes samples were collected for mining / geotechnical purposes.

6.3.4.2 Instrumentation and monitoring

The following instrumentation was installed during the works, with the location of monitoring wells presented in Figure 6-2.

- Fourteen boreholes (S2-BH239, S2-BH240, S2-BH242, S2-BH243, S2-BH244, S2-BH245, S2-BH246, S2-BH247, S2-BH248, S2-BH249, S2-BH250, S2-BH252, S2-BH256 and S2-BH261), were fitted with 50 mm standpipes to allow for groundwater level / ground gas monitoring. Eight of these locations (S2-BH239, S2-BH243, S2-BH244, S2-BH246, S2-BH248, S2-BH249, S2-BH250, S2-BH252, S2-BH256, S2-BH261) were fitted with a dual installation to enable either monitoring of water levels in differing geological units or ground gas / vapour monitoring from monitoring wells installed above the water table.
- Headspace testing using a Photo Ionisation Detector (PID) was undertaken at 11 of the borehole locations and ten of the trial pit locations.



- Ground gas monitoring obtained from three monitoring rounds undertaken on 26 June 2023 - 4 July 2023, 24 to 31 July 2023 and 21 to 24 August 2023.
- Groundwater monitoring and sampling, has been obtained during site works and from three monitoring rounds, undertaken on 26 June 2023 to 4 July 2023, 24 to 31 July 2023 and 24 to 25 August 2023.
- Additional groundwater monitoring completed daily following during the intrusive field work period.

6.3.4.3 Geo-environmental soil testing

As scheduled by AtkinsRéalis, contamination laboratory analysis was undertaken by Eurofins Chemtest, in accordance with the laboratory's quality control system. Eurofins Chemtest are an UKAS and MCERTS accredited analytical laboratory. The testing certificates are present in the corresponding draft factual report (Appendix G).

One hundred five soil samples were subject to a general suite of analysis based on the desk study and ground conditions encountered, including the following:

- Metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium, zinc);
- PAHs;
- TPHCWG inc. BTEX;
- Total cyanide, free cyanide, phenols;
- pH, SOM;
- Hexavalent chromium; and
- Asbestos.

Twenty eight soil derived leachate samples were also obtained and scheduled for the analysis outlined below:

- Metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium, zinc);
- Hexavalent chromium; and
- Cyanide, phenol.

Soil-leachate samples were not analysed for organics, as this testing is not considered by AtkinsRéalis to be representative in leachate analysis.

Hydrocarbon odours were noted within the Made Ground of S2-BH239, S2-BH244, S2-BH248 and in the SWCM of S2-BH244. 'Possible asbestos' was noted on the borehole logs for S2-WS01 and S2-WS-1b.

Headspace testing was undertaken with a PID. The majority of readings were close to or below the limit of detection. Headspace readings that exceeded 0.1 ppmv were recorded as follows:

- S2-BH239 (1.8m) : 16.3 parts per million by volume (ppmv);
- S2-BH239 (2.5m) : 10.2 ppmv;
- S2-BH239 (2.8m) : 3.3 ppmv;
- S2-BH244 (1.8m) : 25 ppmv;
- S2-BH244 (5.3m) : 2.5 ppmv;
- S2-BH245 (2.5m) : 0.3 ppmv;
- S2-BH248 (3.0m) : 0.4 ppmv;
- S2-BH248 (3.5m) : 3.5 ppmv;
- S2-BH248 (4.5m) : 0.3 ppmv;
- S2-TP2104 (3.8m) : 0.2 ppmv;
- S2-TP272 (2.5m) : 0.2 ppmv; and
- S2-WS06 (0.2m) : 0.2 ppmv.



6.3.4.4 Geo-environmental groundwater testing

Chemical test results have been received for 28 groundwater samples, obtained from 11 monitoring locations (as detailed in Appendix H) during three monitoring rounds undertaken on 27 June 2023, 24-26 July 2023 and 21 August 2023. These samples were scheduled for the following analysis:

- Metals (arsenic, boron, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, vanadium, zinc);
- Hexavalent Chromium;
- PAHs;
- TPHCWG inc. BTEX; and
- pH, Total Cyanide, Sulphate as SO₄, DOC, total phenols.

The test certificates are present in the corresponding factual report (Appendix H).

No surface water sampling was undertaken during the Stage 2 GI. For the purpose of controlled water screening, the data from the Stage 1 GI has been used.

- Metals (arsenic, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, vanadium, zinc);
- PAHs; and
- pH, total cyanide, sulphate as SO₄, total phenols.

6.4 Drainage studies

Two BRE365 soakaway tests were attempted on-site within TP01 and TP02 during the Arup Preliminary GI, but due to water failing to drain were unsuccessful.

Five BRE365 soakaway tests were attempted on-site within S1-TP112, S1-TP113, S1-TP114, S1-TP115 during AtkinsRéalis's Stage 1 GI, but due to rapid ingress of groundwater were not able to be completed.

No soakaway tests were undertaken during the Stage 2 GI within the site boundary. All of the soakaway tests undertaken during Stage 2 were in the main site.

7. Ground summary

7.1 Ground Model

7.1.1 General

Ground conditions were found to generally comprise of Made Ground overlying intermittent superficial materials of Peat and Glacial Till underlain by bedrock of South Wales Coal Measures Formation. Each of these units are discussed in the following sections with a summary of the ground conditions provided within Table 7-1: Ground Model summary. A revised ground model combining the Preliminary, Stage 1 and Stage 2 GIs is currently being produced by the Geotechnical Engineering team and will be utilised to aid design of the earthworks and foundations of proposed structures.

7.1.2 Made Ground

Made Ground was encountered in 108 of the 111 (including probe holes) exploratory hole locations excavated across the site. It generally occurs from the ground surface (227.3 to 243.5 m AOD) with a varying thickness across the site.

Within the Zone 1A area, the material was predominantly encountered as gravel described as “*black to dark grey, slightly sandy, silty, clayey, fine to coarse, angular to sub-angular gravel of mudstone, siltstone and sandstone with coal and ash*” interbedded with occasional “*medium dense, black, silty, gravelly, fine to coarse sand derived from coal*” and rare “*soft to firm, dark grey to black, silty, sandy, gravelly clay*”. Based on the available descriptions and the historical mining and coal washery usage of the site, the Made Ground is interpreted to be colliery spoil material originating from the adjacent Onllwyn and Dulais Colliers rather than the more recent open cast mining activities in the Land At Nant Helen.

Two boreholes to the east of the site, S1-BH101 and S1-BH106, encountered the thickest accumulation of Made Ground at 21.6 m and 11.3 m respectively. The cause of these thicker accumulations of Made Ground is unconfirmed, but is likely to be either associated with a backfilled mining feature or a stockpile of spoil material placed within a topographical depression. Across the remainder of the site, the Made Ground was found to vary in thickness from 0.5 m to 9.6 m.

7.1.3 Glacial Till

Glacial Till was encountered by 19 of the 111 (including probe holes) exploratory hole locations excavated across the site. It was encountered predominantly in the east of the site. The material was encountered at varying depths from the ground surface to 8.3 m bgl (224.6 to 237.5 m AOD) and ranged in thickness from 0.4 m (S1-BH114B) to 4.7 m (S1-BH103).

This stratum was generally described as “*soft to stiff, brownish grey mottled orangish brown, slightly sandy, very gravelly, silty clay with cobbles and boulders where gravel is angular to sub-rounded mudstone, siltstone and sandstone*”, “*brownish grey, clayey, gravelly, fine to coarse sand where gravel is angular to subrounded*” and “*brownish grey, clayey, sandy, very angular to rounded, fine to coarse gravel*”.

7.1.4 Peat

A consistent layer of Peat described as “*soft to firm (some spongy) brown to dark brown fibrous to pseudo-fibrous Peat with occasional plant remains*” was encountered within areas of the site which the available BGS 50k superficial mapping [17] for the area indicated to be underlain by Peat deposits. These areas were also indicated to be marshland by available historical mapping.

This layer of Peat was encountered at depths of between 1.3 and 6.8 m bgl (227.2 to 231.9 m AOD) with thicknesses ranging from 0.4 m (S1-BH114) to 2.1 m (S1-BH102). Based on the currently available information, it is anticipated that a significant layer of Peat material up to 2 m thickness encountered approximately 2 m bgl is located along the northern extent of the site (BH33, BH33R, S1-BH121, S1-BH102, S1-BH122, BH29 and BH29R) which extends to the centre of the site (S1-BH103 & S1-BH110) decreasing in thickness to the south. Peat outside of these areas is possible, as indicated by the BGS mapping.

Outside of this area, thin (thicknesses generally ranging from 0.05 – 0.2 m) layers of organic/peaty material were also recorded within additional location. A number of these were recorded by the BGS historic exploratory holes (SN81SW32, SN81SW33, SN81SW34, SN81SW35 & SN81SW36), however, were also recorded within five of the Stage 1 GI locations (S1-BH105, S1-BH109, S1-BH112 & S1-BH116) and one of the preliminary GI locations (TP38). The material was generally encountered interbedded within, or at the base of, the Made Ground within these areas, and considering the relatively small thickness, this material has been interpreted as relic topsoil and is not anticipated to form part of the more significant Peat deposits.

Additionally, S1-BH114B encountered a layer described as “*soft dark brown peaty CLAY with occasional rootlets and rare plant remains*” of 1.25 m thickness. Due to the proximal location, it is anticipated that this material is associated with the more significant peat material encountered to the north of the site.

7.1.5 South Wales Coal Measures Formation

Undifferentiated South Wales Middle and Lower Coal Measures Formation (SWCM) were encountered underlying the site within 99 of the 111 (including probe holes) exploratory hole locations, with the remaining locations terminated before encountering bedrock.

This stratum was encountered at varying depths from the ground surface to 26.2 m bgl (219.6 to 240.4 m AOD) and was generally described as a weathered rock described as a “*soft to very stiff, slightly sandy (fine to coarse), slightly gravelly (mudstone and siltstone), slightly silty grey Clay*” (thicknesses ranging 0.1 to 3.2 m) overlying a more competent “*weak to moderately strong, thickly laminated to thinly bedded, grey to dark grey Mudstone with closely spaced sub-horizontal to randomly spaced discontinuities*” with interbedded “*weak to strong, thinly bedded, grey to dark grey Siltstone, with sub-horizontal to 20° closely spaced fractures infilled with silt*” and “*medium strong to strong, medium bedded, grey, fine Sandstone, with sub-horizontal to 30° locally medium spaced fractures infilled with fine sand*”.

Coal and voiding were also encountered within the bedrock, related to the site history of shallow coal mining.

7.1.6 Ground model summary

A summary of the ground conditions encountered across the site is provided below in Table 7-1. However, as the ground conditions are highly variable across the site, the ground conditions should be considered on a location specific basis.

Table 7-1: Ground Model summary

Strata	Top Depth (m bgl)	Top Depth (m AOD)	Thickness (m)
Made Ground	0.0 to 0.1	225.8 to 262.2	0.5 to 26.2
Glacial Till	0.0 to 8.3	224.6 to 244.7	0.2 to 4.7
Peat	1.3 to 6.8	227.2 to 234.9	0.1 to 2.1
South Wales Coal Measures	0.0 to 26.2	219.6 to 240.4	Base not encountered

7.2 Coal mining

7.2.1 General

A summary of work completed with respect to coal mining risk is presented in the following sections. Figure 7-1 (reproduced from the MMR [6]) details borehole locations that recorded evidence for underground mining features with final depth annotated. Figure 7-2 [6] visually presents the locations of known underground mine workings, shafts, adits and areas where GI works encountered unrecorded mine workings that are detailed in the sections below.

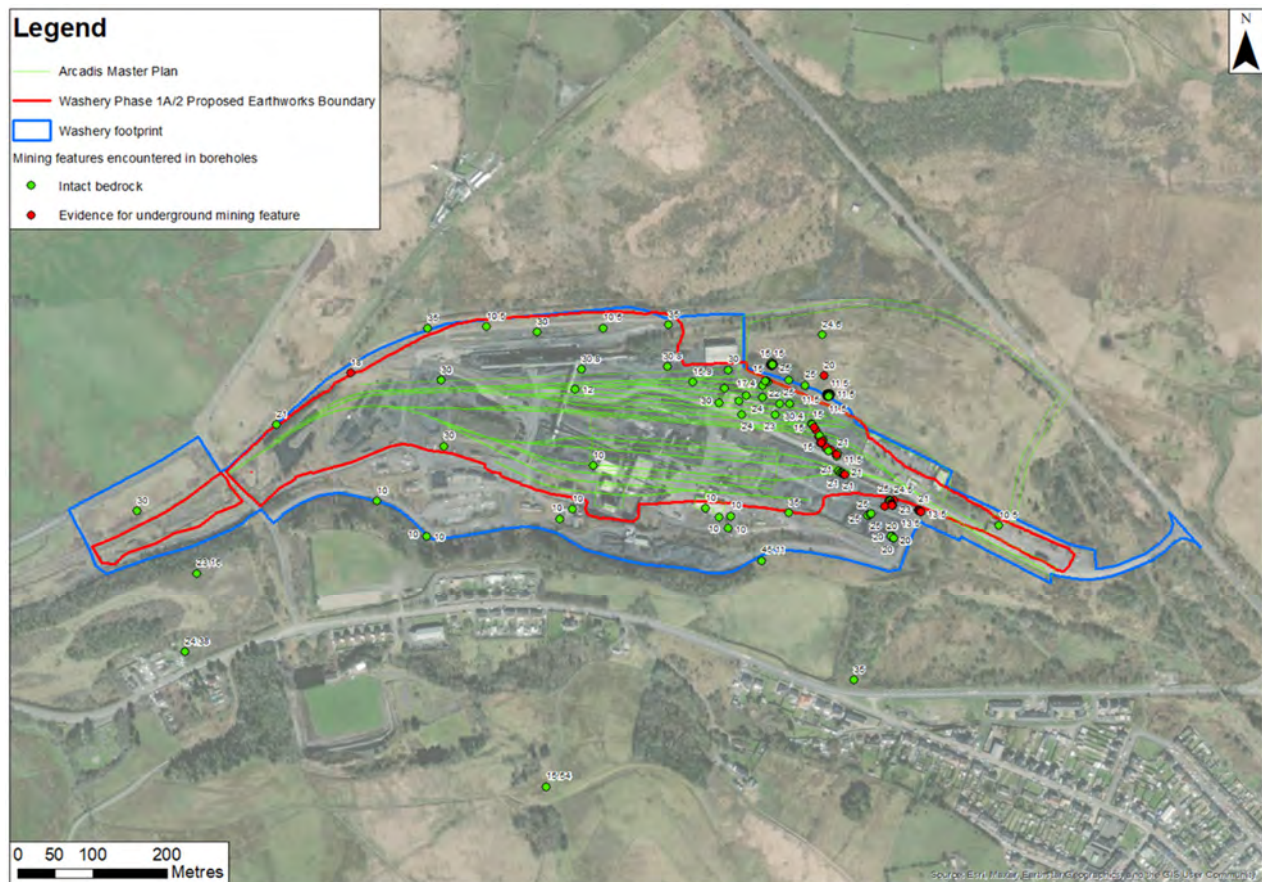


Figure 7-1: Borehole locations that recorded evidence for underground mining features with final achieved depth annotated

7.2.2 Previous work

7.2.2.1 Arup Preliminary GI

Arup previously completed a Geotechnical and Geo-environmental Desk Study Report [2], Detailed Mine Workings Study [9] and Ground Investigation Report [3] to inform the assessment of coal mining risks within the entire GCRE development footprint. These reports focused on the entire scheme.

The Arup Desk Study [2] identified mining risk zones across the site and recommended further assessment be carried out to inform the assessment of risk.

The Arup Mine Workings Study [9] reported on the study of abandonment plans obtained from the Coal Authority, with the aim of further refining the risk assessment and to inform ground investigation proposals.

A preliminary ground investigation, which included exploratory holes to investigate mining, was carried out between November 2021 and January 2022. The Arup Ground Investigation Report [3] was completed in May 2022. The preliminary GI found coal seams at five borehole locations within the Washery Footprint (BH01, BH30R, BH31R, BH33R and BH34R) with thicknesses of up to 3.2 m, as summarised in Appendix A.2, Table 6-3 of the AtkinsRéalis MMR [6].

Borehole BH30R also encountered two distinct levels of voiding and / or soft material infill, which were interpreted as underground mining features. The shallowest void was 2 m wide and 3.20 m below rockhead, while the deepest was 1 m wide and 13.6 m below rockhead. A list of the evidence for underground workings from the preliminary GI is provided in Appendix A.2, Table 6-4 of the MMR [6].

Borehole BH34R was drilled to 30 m bgl to investigate workings within the Bluers Seam, but encountered no direct evidence for workings. However, a 1.9 m thickness of coal was recorded at 22.1 m bgl, with 12.2 m of bedrock cover, suggesting a potential for shallow workings.

Additionally a geophysical surveying was completed by Terradat to investigate a select number of mine entries in and around the Washery Footprint, two of these areas straddled the sites southern boundary. The investigation comprised magnetic, electromagnetic and microgravity geophysical surveys. Further details of the geophysical anomalies encountered in the Washery are provided in the Terradat Geophysical Survey Report, which is included in Appendix IX of the Quantum Geotech Factual Report [13]. Anomalies were detected that corresponded to identified mine entries, these anomalies were then investigated by trial pits which did not uncover evidence of coal workings.

7.2.2.2 AtkinsRéalis Stage 1 GI

The key coal mining findings from the Stage 1 GI in the Washery were as follows:

- On the western limit of the proposed earthworks, borehole S1-BH107B encountered 0.7 m wide void at 15.4 m bgl, with 10 m of bedrock cover. This void agrees with the location of recorded workings within the Peacock Seam.
- In the centre of the proposed earthworks, boreholes S1-BH110 encountered a 0.6 m wide void at 9 m bgl, with 1.65 m of bedrock cover. No mine abandonment plans are available this part of the site, indicating these are unrecorded workings.
- Approximately 25 m north-east of the site, borehole S1-BH106 encountered a 0.9 m wide void at 16.1 m bgl, with 3.6 m of bedrock cover. No mine abandonment plans are available this part of the site. This is interpreted as unrecorded workings within the New Seam.
- Adit 284210-035 was investigated, with voiding recorded in a linear alignment, trending north-west to south-east. The extents of the voiding were constrained on three sides (in the north-west, south-west and north-east) but not constrained south-east, where it continued beyond the previous development extent. Voids were encountered at a total of three distinct levels across the probe holes:
 - 1 to 1.5 m wide voiding at 10 to 10.7 m bgl, with 4 to 4.6 m of bedrock cover (probe holes SOP003.2, SOP003.5, SOP003.6, SOP003.8 and SOP003.9);
 - 1 m wide voiding at 14 m bgl, with 8 m of bedrock cover (probe hole SOP003.16); and
 - 1.7 m wide voiding at 19.5 m bgl, with 13.5 m of bedrock cover (probe hole SOP003.16).
- Adit 284210-023 and shaft 284210-029 were investigated by probing but found no evidence for mine entries.

- All other rotary-cored boreholes encountered intact coal seams and recorded no evidence of mine workings.

A summary map of the above mentioned findings is presented on Figure 4.4 and Figure 4-6 of the MMR [6].

7.2.2.3 AtkinsRéalís Stage 2 GI

The key findings from the Stage 2 GI in the Washery are as follows:

- Adit 284210-035 was investigated further to delineate its trend further south-east. The investigation encountered additional 1.3 to 1.5 m wide voiding at 10 to 10.2 m bgl, with 4.2 to 5.5 m of bedrock cover (S2-BH262.7, S2-BH262.8, S2-BH262.9 and S2-BH262.11).
- Adit 285210-001 was investigated where it trends beneath the proposed development. The investigation found 1.5 to 2.5 m wide voids 21 to 22 m bgl, with 13.5 to 16 m of bedrock cover (S2-BH264.5 & S2-BH264.7-13). The voiding was constrained on the north-west side, but not constrained on the remaining sides (south-west, north-east and south-east).
- Adit 285210-026 was investigated where it trends beneath the proposed development. The investigation found 1.5 m wide voids 12 m bgl, with 4.5 m of bedrock cover (S2-BH263.2 & S2-BH263.26-29).

A summary map of the abovementioned findings is presented within Figure 4.6 of the MMR [6].

This information summarised above is in the process of revision to take account of the current site footprint and a revised Mining Risk Review is being prepared.

7.2.3 Detailed risk assessment summary

The findings of the Coal Mining Risk Review are provided within Appendix E. Figure 7-2 (reproduced from the MMR) visually presents the locations of known and suspected coal workings, shafts, adits and coal seam outcrops within the site, wider Washery area and surrounding land that is outside of the GCRE planning footprint.

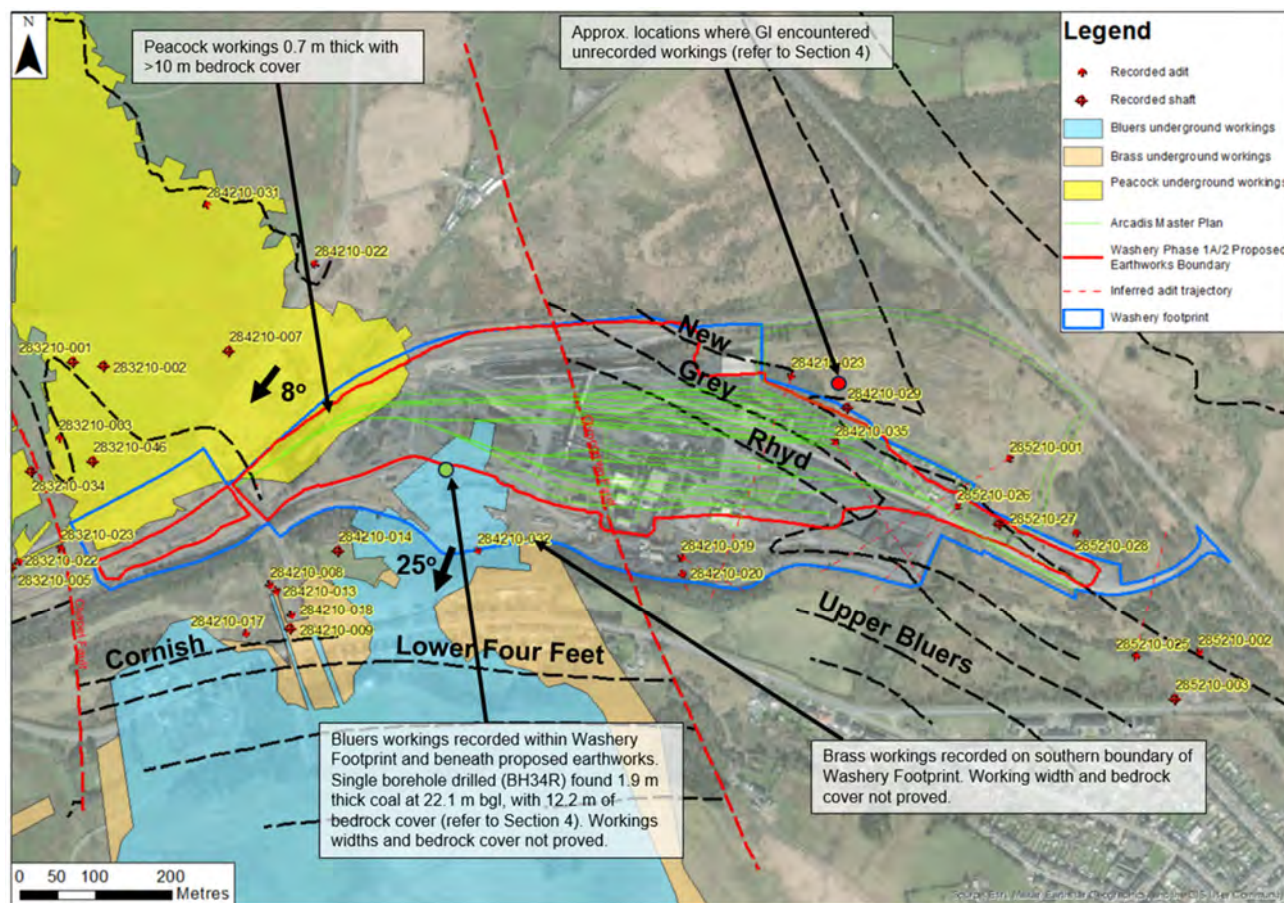


Figure 7-2: Summary of available information on mine workings within the washery

A significant risk of instability was identified associated with legacy coal mining activities within the Middle and Lower Coal Measures in the following seams, located within the wider site:

- Brass;
- Peacock (Brass);
- New Seam;
- Grey Seam;
- Rhyd Seam; and
- Unrecorded workings.

Within the site, the highest stability risks identified were:

- Lack of data coverage in the area;
- Shallow workings from the Dulais Colliery East Slant in the Peacock (Brass) seam are present in the far west of the site and shallow workings from the Bluers seam extend north from below the village of Dyffryn into a localised portion of the south-western site.
- Numerous mine entries relating to the Onllwyn Colliery; and
- The inferred presence of the “New”, “Grey”, “Rhyd” and “Upper Bluers” seam outcrops.

The key hazards include:

- Shallow underground workings influencing the footprint of the proposed scheme alignment where rockhead cover is insufficient to prevent migration of voids to surface;

- Shafts with collapse zones that encroach to within the footprint of the proposed alignment;
- Adits and / or roadways with collapse zones that encroach to within the footprint of the proposed alignment and where rockhead cover is insufficient to prevent migration of voids to surface; and
- Bell pits that potentially encroach into the footprint of the proposed alignment.

Open workings, interpreted to be in the New Seam, are located at approximately 15-20 m bgl and overlap with the eastern boundary of sites boundary. An adit roadway from mine entry 284210-035 is located at approximately 10 m bgl within the site boundary heading south-east away from the site. Two further adits from mine entries 284210-019 and 284210-20 with adit roadways respectively heading east-south-east and south-south-east are present in the south of the site. A cluster of six mine entries, centred approximately 70-150 m south-west of the wider site boundary, lead to shafts 284210-009 and 284210-014, and adits 284210-008, 284210-013, 284210-017 and 284210-018. Underground workings on the Peacock seam, mapped to underlie the sites western boundary, were encountered at approximately 15-20 m bgl and may be backfilled. Onllwyn Bluers underground workings are also mapped to underlie the southern boundary of site, and extend below the proposed earthworks platform..

Additionally, Appendix A Drawing GCRE001-AWJV-00-XX-DR-GE-00019 shows, in cross section 4, AtkinsRéalís understanding of the geology, coal measures and proven workings below the site following the Quantum Factual Reports [13] production.

7.3 Hydrogeology

GI works have confirmed the presence of the superficial and bedrock geological units identified during the desk based data review.

Peat is located in the north and west of the site, and is classified by the BGS [23] and NRW [24] [25] as an Unproductive Aquifer. Glacial Till is also located within the east of the site in a strip running parallel to the A4221 and is classified as a Secondary Undifferentiated Aquifer.

The underlying rhythmic sequences of mudstones, siltstones, sandstones, fireclays and coals which make up the SWCM are collectively classified by NRW [24] as a Secondary A Aquifer. The permeable siltstones and sandstones are understood to form a multi-layered aquifer system supporting large quantities of water at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers or emerging as springs where basal horizons of subordinate sandstones intersect the ground surface.

The Glyncorrwg Fault crosses the centre of the Washery with a NNW-SSE strike may provide a pathway for groundwater migration. Furthermore, historical mine workings identified on-site may affect the hydrogeological regime, with potential backfilled areas, adits and voids presenting pathways for groundwater migration through the subsurface.

Artesian water was previously encountered in BH01 during the preliminary GI [3], located approximately 80 m west of Zone 1A. Water rose to 0.5 m above ground level (228.8 m AOD) when struck during drilling at 5 m bgl within bedrock and 13 m bgl where a coal seam was encountered. During the Stage 1 GI, artesian conditions were encountered in S1-BH114 and S1-BH107 this is consider to potentially be the result of a driving head in flooded mine workings (peacock workings) that dip to the south-west and are in close proximity to these boreholes. Groundwater was struck in S1-BH114 at 4 m bgl, within the SWCM, and rose to 1 m above ground level. Groundwater was struck in S1-BH107 at 7 m bgl, within the SWCM, and rose to 1.1 m above ground level. The exploratory holes where artesian conditions were encountered were located within the west of site, where the topography is generally lower. No artesian conditions were found during the Stage 2 GI and in the south of the site.

Historical information has indicated the presence of shallow groundwater, with several ponds, drains, and springs identified in historical maps across the wider Washery.

Table 7-2 summarises minimum and maximum groundwater levels recorded on-site during three post-ground investigation monitoring periods. The first AtkinsRéalis monitoring periods were undertaken during winter and early spring months, from November to April, where groundwater levels would be expected to be higher relative to the rest of the year, and the second AtkinsRéalis monitoring period was completed during spring and summer, from April to August where groundwater levels would be anticipated to be reduced.

Table 7-2: Groundwater levels within The Washery

GI	Arup 2022 and Atkins 2022-2023 (Stage 1)				Atkins 2023 (Stage 2)			
Strata	Min of Water Level (m AOD)	Max of Water Level (m AOD)	Min of Water Level (m bgl)	Max of Water Level (m bgl)	Min of Water Level (m AOD)	Max of Water Level (m AOD)	Min of Water Level (m bgl)	Max of Water Level (m bgl)
Made Ground	229.73	236.30	0.15	10.66	231.84	235.84	1.28	7.21
Peat	230.12	230.45	0.43	0.76	236.15	236.45	1.88	2.18
South Wales Coal Measures Formation	226.43	241.82	0.10	12.35	227.47	234.20	1.74	11.58

Appendix J.1 Table 1 presents groundwater monitoring data each monitoring well monitoring wells with hydrographs (Appendix J.2) showing water levels in the Made Ground, Superficial Deposits and SWCM.

Figure 7-3 presents hydrographs for monitoring wells installed within the sites Made Ground.



Figure 7-3: Made Ground Hydrographs

Groundwater levels in the Made Ground were consistent throughout all monitoring periods, varying from 227.98 m AOD to 237.04 m AOD. Water levels tended to be shallowest in the centre and north of the site and to fall slightly in monitoring wells to the west and east with depth to water increasing with the rising topography in the north of the site relative to the lower lying areas in the south. These changes correspond to the sites changing topography. Typically water levels varied within individual installations by less than 1 m over the course of the monitoring period. No NAPL was encountered during groundwater monitoring in the Preliminary, Stage 1 and Stage 2 monitoring.

During Stage 1, only a single monitoring standpipe response zone was located within the peat, S1-BH121 located north-west of Zone 1A's centre. Groundwater levels were recorded at elevations from 230.12 m to 230.45 m AOD. This was the same in Stage 2 as only S2-BH242 was found to be recording water levels in Peat. The elevations within this borehole ranged from 236.15 m to 236.45 m AOD.



Figure 7-4: SWCM Hydrograph

Groundwater levels recorded within the SWCM in Stage 1 GI ranged from 226.43 m to 241.82 m AOD and had a higher range than the Stage 2 GI groundwater monitoring results which were more consistent with a range of 236.45 m to 236.15 m AOD. Additionally the water levels in individual boreholes within the SWCM were more variable than those in the overlying Made Ground varying by 1.5 – 2 m over the course of the monitoring period.

Groundwater levels within the Made Ground are typically around 2-5 m higher than recorded in the SWCM, although this varies spatially throughout the site. In some of the boreholes within the site, a layer of lower hydraulic conductivity material such as clay or peat separates the granular Made Ground from the underlying SWCM, retarding the movement of groundwater to the underlying aquifer.

Groundwater monitoring has been completed based on the footprints of the previous planned development zones and therefore monitoring data is not available across the whole hydrogeological cycle or and a data set that is contemporaneous is not available for the whole site. Monitoring suggests that water levels are more directly controlled by precipitation in the preceding days / weeks rather than are exhibiting a pronounced seasonal variation. For example all locations monitoring in May-June-July-August 2024 show a drop in groundwater levels of circa 1-1.5 m in late June that then recover in July. The Dulais (off-site to the west) and surface water drains in the Washery have held water throughout the spring and summer period, suggesting basal flow from the superficial deposits / Made Ground is present, this suggests that water levels in the Washery do not significantly change throughout the year.

The hydrogeological regime within the wider site's surroundings is complex, owing to a combination of geological structure, hydraulic properties, historical groundwater control, mine workings and backfilling of opencast voids.

8. Land contamination assessment

8.1 Background

This contamination assessment uses site-specific soil, leachate, ground gas, groundwater and surface water data collected from the site during the preliminary, Stage 1 and Stage 2 ground investigations to undertake a Generic Quantitative Risk Assessment (GQRA). This combined dataset was used to determine the level of risk to human health, property, and controlled waters receptors associated with the proposed development. The factual reports are presented Appendix F (Quantum), Appendix G (Jackson) and Appendix H (Jackson), and screening sheets are presented in Appendix J.

Figure 6-1 details the locations of exploratory holes and surface water monitoring points, and Figure 6-2 presents the locations of monitoring wells.

8.2 Human health

8.2.1 Assessment methodology

To support the evaluation of potential risks to human health, soil chemical analysis results from the site have been screened against Category 4 Screening Levels (C4SLs) and AtkinsRéalís Soil Screening Values (SSV), collectively termed generic assessment criteria (GAC). The soil samples have been screened against GACs protective of a commercial land use. This is considered to be an appropriate level of conservatism for the receptors of the site under its future land use.

AtkinsRéalís has produced SSVs for a variety of land uses based on SOM contents of 1% and 6%. The 1% values provide more conservative SSVs and are based on a sandy soil type, whereas the 6% values are based on a sandy loam soil type (the default within Science Report (SR) 3 [33]). For the purposes of generic screening the SSVs used have been based on a conservative site SOM of 1% in order to be suitably protective.

C4SLs are modelled using Contaminated Land Exposure Assessment (CLEA) [34] for standard land uses and are concentrations of contamination in soil (with 6% SOM) which are considered by DEFRA to represent a 'low risk' derived from updated exposure assessment parameters and toxicological data based on a 'Low Level of Toxicological Concern' [35]. As per the accompanying Policy Statement, DEFRA state that:

"A Low Level of Toxicological Concern represents an exposure equivalent to an intake of low concern but that definitely does not approach an intake level that could be defined as causing a Significant Possibility of Significant Harm to human health" [35]

The C4SLs were derived based on remaining 'strongly precautionary' for the purposes of generic screening.

The potential for exposure from asbestos in soil is based on a number of factors including (amongst others) the quantity and type of asbestos present, the properties of the soil, the presence of any confining or covering layer, bioturbation, and rates of weathering and erosion due to site use or climate, as well as the actions undertaken on site and exposure scenario. Due to the nature of risk associated with asbestos and uncertainties associated with the above properties, a GAC cannot be derived. Therefore, for the purposes of this GQRA, the presence of asbestos in soil as identified from field observations or laboratory analysis is considered to be an appropriate initial screening criterion. If positive asbestos identification is reported, further quantitative analysis will be undertaken in order to facilitate an assessment of asbestos related risk under the future site use.



The scheme's masterplan Drawing 264904 003B, presented in Appendix A shows the development proposal for site and wider Washery. GCREs intention is for development within the Washery to occur in three stages:

- Stage 1 – construction of earthworks, limited railway trackbed and sidings and UKRRIN building (current stage of works);
- Stage 2 – construction of additional track bed and sidings, and a train repair depot building within the earthworks footprint;
- Stage 3 – construction of additional buildings (offices, research buildings, engineering), site access roads and soft landscaping outside of the earthworks footprint.

The current stage of development (Stage 1) will comprise the construction of an earthworks (area of cut and fill intended to produce a level platform), and the construction of sidings and UKRRIN building on top of the earthworks. Members of the public will not have access to site. As such, site workers during the operational phase are considered the critical receptor, and commercial land use GACs are deemed suitably protective of human receptors in GQRA. Later stages of development will add further sidings and buildings such as train maintenance depots, further research buildings, welfare and offices.

The combined dataset provide by the Preliminary GI, Stage 1 GI and Stage 2 GI provides chemical analysis on 181 soil samples from site. AtkinsRéalis has screened the soil data against GACs for a commercial setting with a 1% SOM content (for the AtkinsRéalis SSVs and C4SL where used), as this is considered to be the most conservative criteria.

8.2.2 Results

Table 8-1 presents a summary of soil chemistry analysis results that exceed the GAC.

Table 8-1: Summary of soil GAC exceedances

Determine- and	Unit	Number of Samples	GAC	Number of Exceed- ances	Min. Value	Mean Average	Max. Value	Location of Exceedance
Lead	mg/kg	181	2310	1	0.96	75.9	3300	S1-BH106 2.50-2.70m
Asbestos (Chrysotile)		160	See main report text	3	See main report text	See main report text	See main report text	S2-TP268 1.9m, S2-TP2108 0.5m, S2-TP2114 0.2m

Appendix K.1 provides a summary of screening results for all determinands listed in comparison to the GAC utilised in the screening. All analysis results, bar lead and asbestos did not exceed their relevant GAC and are not considered to present an unacceptable risk to human health.

Asbestos was not detected in the Preliminary GI and Stage 1 GI soil samples scheduled for asbestos ID however, chrysotile asbestos was detected in three of the 105 samples from the Stage 2 GI. Asbestos quantification was subsequently scheduled and the sample from S2-TP2108 recorded 0.001% chrysotile fibres / clumps, S2-TP2114 <0.001% chrysotile fibres / clumps and S2-TP268 <0.001% chrysotile fibres /

clumps, these represent a trace to low concentration of asbestos. Additionally during site walkover suspected visually ACM was visually identified in an area of hardstanding that was targeted by S1-TP115 (intended to investigate asbestos presence in this area) and in S2-WS01. Samples from S1-TP115 and S2-WS01 did not record any asbestos detects.

Of the remaining determinands tested, a single exceedance of the assessment criteria was recorded for lead. No other exceedances were recorded. The lead exceedance of 3,300 mg/kg (S1-BH106 2.5-2.7 m) is elevated relative to the GAC, however the next highest lead value recorded (150 mg/kg) was over an order of magnitude less than the GAC. The lead concentration encountered at S1-BH106 is considered to be a hotspot, however there is no justification for its removal from the data set.

The full screening results for the 181 soil samples tested are presented in Appendix K.1.

8.2.3 Discussion

Results of the soil screening process record a single exceedance of the commercial land use GACs. Lead was recorded at concentration 50% greater than the assessment criteria in sample S1-BH106 at a depth of 2.50 m bgl. The soil is described as “*black and dark grey gravel, containing coal and possible slag*”. S1-BH106 is located 35 m north-east of the site in an overgrown area of the wider Washery, formerly used for disposal of colliery spoil. Within the development masterplan (Appendix A), this area is proposed to be developed for use as sidings, however it falls outside of the area where Stage 1 development is planned and is in an area where development is not currently planned. If incorporated into the earthworks placement of this material a minimum 1 m depth below finished formation levels would address the human health risk that it presents. Placement below a minimum depth of 1 m is suggested as final earthworks levels are not currently confirmed and a time gap will likely exist between earthworks completion and construction of the trackbed and the UKKRIN building. The 1 m depth suggested would, if erosion / weathering of the earthworks were to occur between completion of construction and trackbed placement, or trimming of the built earthworks to achieve an altered final level, provide a margin for error with respect to the sufficient clean cover providing a protective barrier against exposure of human receptors to unsuitable material.

Asbestos was not detected in the 71 samples analysed from the Stage 1 GI works, however, chrysotile asbestos was found in three of the 105 samples from the Stage 2 GI. Chrysotile detects occurred at:

- S2-TP268 at 1.9 m depth (trial pit excavated below slab level in the footprint of one of the Washery buildings) within the Stage 1 development area;
- S2-TP2108 at 0.5 m depth (trial pit targeting a 1,000 litres AST adjacent to a machine repair shop) within the Stage 3 development area; and
- S2-TP2114 at 0.2 m depth (trial pit targeting the grease store located 23 m south-east of TP2108) within the Stage 3 development area;

Quantification was subsequently scheduled and the sample from S2-TP2108 recorded 0.001% chrysotile fibres / clumps, S2-TP2114 <0.001% chrysotile fibres / clumps and S2-TP268 <0.001% chrysotile fibres / clumps. These concentrations represent a trace to low concentration of asbestos. S2-TP2108 and S2-TP2114 are located outside of the area where the Stage 1 construction works detailed above will occur and are in an area that will be developed during Stage 3 works. Stage 3 works as currently envisaged would overlay this area with hardstanding in the form of buildings, yard areas, roads and car parking or will have soft landscaping comprising imported topsoil placed (within the site there is no on-site source of Topsoil's and soft landscaping material would require importing and be subject to verification testing). These would mitigate the asbestos presence once constructed, however, further consideration of the asbestos risk here should occur in conjunction with the Stage 3 development design. S2-TP268 is within the earthworks footprint and is an area where engineered fill will be placed. The fill will provide cover and break exposure pathways once construction is complete. However a risk will be present to construction workers and demolition workers during the construction phase.

There is a potential risk that further asbestos may be present in anthropogenic Made Ground, especially around areas of former buildings, and its mitigation, if found, should be considered as part of the construction works design. The potential for asbestos presence within colliery spoil i.e. reworked natural material is considered to be unlikely.

8.2.4 Recommendations & Data Gaps

Asbestos detects at trace to low concentrations occurred in S2-TP2108, S2-TP2114 and S2-TP268. A risk to the human health of future site users will potentially be present if soils containing asbestos are placed on the surface of the proposed earthworks without suitable pathway mitigation measures being implemented. S2-TP268 is located within the earthworks footprint / Stage 1 Development area, and the S2-TP2108 and S2-TP2114 locations are in the Stage 3 development area to the south which would also be part of an area likely to be accessed by construction worker and plant working on Stage 1. The proposed development details for Stage 1 allow soils identified as containing asbestos to be placed at a depth in the earthworks so that they would not pose a risk to human health receptors on the surface.

The asbestos encounters also indicate there is a potential risk of asbestos exposure for construction workers coming into contact with the soils at S2-TP2108, S2-TP2114 and S2-TP268 during construction of the earthworks. Delineation of these locations is recommended in order to manage asbestos risks to construction workers and compliance with CAR 2012 [36].

A lead exceedance occurred within one soil sample (S1-BH106 at a depth of 2.50 m) located 35 m north-east of the site, indicating that localised hotspot in this part of site could pose a human health risk to future site users if placed at shallow depth (<1 m deep) within the earthworks.

It should be noted that material reuse will need to either comply with the Definition of Waste: Code of Practice (DoW:CoP) [34] (where soils / geology are natural or contain anthropogenic material that is not classified as mining waste) or the Mining Waste Directive (MWD) [35] (where soil / overburden consists of spoil from mining activities). The DoW:CoP requires a Material Management Plan (MMP) to be prepared then declared by a Qualified Person (QP), then submission of a MMP Verification Report to CLAIRE. The MWD requires that a Waste Management Plan (WMP) is prepared if mining waste is not classified as inert waste or unpolluted spoil. Both the DoW:CoP and MWD require collection of verification data demonstrating that their requirements have been complied with during construction works to avoid regulatory action. Further consideration of Materials Management and Waste Classification is provided in Section 10.

Non-compliance with the waste regime exposes a developer or contractor to prosecution by the regulator and substantial fines, additional His Majesty Revenue and Customs (HMRC) can require that landfill tax is paid on materials / wastes that they deem to have an incorrect waste classification or have been illegally landfilled.

- AtkinsRéalis recommends that further asbestos delineation is completed at S2-TP2108, S2-TP2114 and S2-TP268 during demolition and enabling works, this information should then be utilised to undertake construction works in compliance with the Control of Asbestos Regulations (CAR) 2012 and the risk assessment above revised.
- Construction of the earthworks required to produce the planned site levels will entail between 5 – 15 m of cut in the east of the site and placement of a similar amount of fill in the western part of site. The cut will not currently include the lead hotspot, if reused in Stage 1 due to an expansion of the earthworks footprint this should be placed at least 1 m below finished formation levels.
- Site investigation by its nature is not able to sample all soils at a site and access to some areas has been restricted due to the presence of buildings, lagoons, services, ground conditions and site operations, therefore further verification testing of the soils will be required during the earthworks or following demolition. Specifically further work should be targeted on the AST and electricity sub-station

locations following their demolition, while headspace results, soil logs and analysis results do not support a VOC / SVOC / PCB source additional data collection from below this areas is recommended during future verification works.

- Material reuse, subject to the nature of the material, will require either use of the DoW:CoP and a MMP, a Waste Management Plan prepared under the MWD or use of an appropriate permit / exemption. In all cases verification of materials and recording of materials use will be required.
- Completion of additional GI at locations where demolition has not occurred or access constraints have prevented GI at identified potential sources of contamination (i.e. electricity substations, Washery buildings, laboratory footprint). These activities can be undertaken when access becomes available in the future at negligible risk to the completed earthworks / Stage 1 development.
- Additionally, during construction and earthworks a watching brief should be undertaken with validation sampling and analysis of soils proposed for reuse especially in areas of landscaping or at shallow depths where exposure of future site staff to contaminants could occur.
- Further details on the above can be incorporated into a remediation strategy for the proposed development.

It should be noted that 17 of the 76 Stage 1 soil samples tested have been noted as deviating by the laboratory due to holding times being exceeded. This was due to a delay between the laboratory receiving samples prior to Christmas and the Christmas / new year shut down period. It should be noted however that other lines of evidence (headspace testing, visual and olfactory observations) have not identified evidence of TPH or VOCs within Zone 1A's soils. The analysis is therefore considered to be fit for purpose. No deviations were recorded from samples collected during the Stage 2 GI.

A number of TPH and PAH tests were listed as unaccredited on the testing laboratory certificates due to a change in the Chemtest Eurofins accreditation during the GI period. The laboratory changed their accredited test method to a replacement method that was also accredited, with the former methods accreditation then being withdrawn. Due to logistical issues associated with the new analysis method a return to the previous method that was no longer accredited was required. The previous methods reliability had not changed from when it was previously accredited and this is not considered to reduce the reliability of the tests undertaken on the corresponding samples. AtkinsRéalis consider them to be suitable for assessing risk within the Washery.

8.3 Controlled Waters

8.3.1 Assessment methodology

The potential risks to identified receptors has been assessed by comparison of soil-derived leachate, groundwater and surface water analytical results against screening criteria determined based on the nature of the identified relevant receptors.

The primary surface water receptors are the River Dulais, which flows in a west-south-westerly direction through the western part of the Washery (wider site) approximately 600 m west, and the River Camnant which is present 35 m east of the site boundary. The Environmental Quality Standards (EQS), as per the EU Water Framework Directive as implemented by the Water Framework Directive (England and Wales) 2017 [37] (where available), have been selected as appropriate water quality standards (WQs) in order to protect identified surface water receptors.

Overall, it is considered that groundwater likely contributes baseflow discharge to identified surface watercourses, rather than migrating to aquifer units hydraulically downgradient from the site (although this cannot be completely discounted). The bedrock underlying the site is a Secondary A Aquifer while the superficial aquifers are Secondary Undifferentiated in the Glacial Till and the peat, with the Alluvium classed as an Unproductive Aquifer. Therefore, the UK Drinking Water Standards (DWS), as set out in The Water

Supply (Water Quality) Regulations (England and Wales) 2018 [38], have been chosen as WQS considered protective of the Secondary A Aquifer present beneath, and down hydraulic gradient of, the wider Washery area.

Bioavailable determinands have been assessed against Predicted No Effect Concentrations (PNECs) (which is the concentration at which a chemical will likely have no toxic effect to the identified receptors) using the Water Framework Directive UK Technical Advisory Group metal bioavailability assessment tool (M-BAT) [39] using receptor-specific parameters for hardness, pH and Dissolved Oxygen Carbon (DOC) measured within the nearby surface water (AtkinsRéalis, 2022-2023). As there is no surface water data from the Stage 2 GI, the Stage 1 data has been used to inform the leachate and groundwater screening. The calculated PNECs are presented in Appendix K.4

Where results are reported as below the Limit of Detection (LOD) it has been assumed they are below the LOD rather than equal to it.

8.3.2 Leachate test results

Thirty one soil leachate results from the preliminary and Stage 1 GI and 28 soil leachate results from the Stage 2 GI were analysed and screened. The full screening sheets are provided in Appendix K.2. Table 8-2 summarises EQS and PNEC exceedances recorded for all determinands. Single exceedances were recorded for anthracene, benzo(a)pyrene and fluoranthene, thirteen exceedances were recorded for copper, two free cyanide, three lead, six exceedances were recorded for pH and eight were recorded for zinc.

Table 8-2: Summary of leachate EQS (including PNEC) values and exceedances

Determinand	LOD (mg/l)	Assessment Criteria (mg/l)	No. of Samples	Min. Value (mg/l)	Max. Value (mg/l)	No. of Exceedances	Locations of Exceedances
Anthracene	0.00001	0.0001	2	<0.00001	0.0014	1	BH33
Benzo(a)pyrene	0.0005	0.00000017	2	<0.0005	0.0018	1	BH33
Copper	0.0005	0.005*	59	<0.0005	0.013	13	S2-TP294, S2-TP279, S2-TP261; S2-BH245; S2-TP270; S2-BH250; S2-BH252; S2-TP2115; S2-BH261; S2-BH250; S2-BH240; S2-TP284; S2-TP256
Cyanide (free)	0.05	0.001	59	<0.05	0.36	2	BH33, S1-TP114
Fluoranthene	0.0005	0.00000063	2	<0.0005	0.0054	1	BH33
Lead	0.0005	0.0024*	59	<0.0005	0.0069	3	S1-TP111, S2-TP294 S2-BH250
Nickel	0.0005	0.004*	59	<0.0005	0.004	0	-
pH	0	pH 6.0-9.0	57	pH 5.9	pH 11.4	6	S1-BH109, S2-TP2112, S2-TP294, S2-TP279, S2-BH240, S2-TP284
Zinc	0.0025	0.017*	59	<0.0025	0.025	8	S2-TP271, S2-TP270, S2-BH250, S2-BH252, S2-BH250, S2-TP242, S2-TP279, S2-BH240

* Calculated PNEC value

Table 8-3 summarises exceedances of DWS. Exceedances were recorded for benzo(a)pyrene, cyanide, PAH sum of 4, and pH.

Table 8-3: Summary of leachate exceedances of DWS

Determinand	LOD	GAC (mg/l)	No. of Samples	Min. Value (mg/l)	Max. Value (mg/l)	No. of Exceed-ances	Locations of Exceed-ances
Benzo(a)pyrene	0.0005	0.00001	2	<0.00001	0.0018	1	BH33
Cyanide (Total)	0.05	0.05	59	<0.05	0.36	2	BH33 S1-TP114
PAH sum of four*	0.00004	0.0001	2	<0.00004	0.00332	1	BH33
pH	0	pH 6.5-9.5	57	pH 5.9	pH 11.4	6	S1-BH102, S1-TP111, S2-TP294, S2-TP279, S2-BH240, S2-TP284

* Sum of four PAH analytes: benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene and indeno(123 -cd)pyrene

8.3.3 Groundwater test results

Figure 6-2 presents the monitoring well locations, where 61 groundwater samples were obtained. Table 8-4 summarises the response zones and the number of monitoring rounds completed relative to each monitoring well.

After the Stage 1 GI it was intended to undertake three rounds of groundwater sampling following completion of GI works however the first monitoring round was disrupted by cold weather and samples were not collected from frozen monitoring wells. After the Stage 2 GI it was intended that another three rounds of groundwater sampling would occur across the site, however due to access constraints this did not happen in all monitoring wells. Data obtained from the preliminary GI and Stage 1 and Stage 2 GIs has been assessed.

Table 8-4: Monitoring well summary

Exploratory Location	Slotted Section Range (m bgl)	Response zone	Monitoring Rounds Completed
BH29	12.2 – 15.2	SWCM	2
BH30	1.0 – 4.0	Made Ground	2
BH31 (shallow)	1.0 – 5.0	Made Ground	2
BH32	12.5 – 17.5	SWCM	2
BH33	15.0 – 20.0	SWCM	2
BH34 (shallow)	1.0 – 3.0	Made Ground	2
S1-BH101	11.0 – 14.0	Made Ground	2
S1-BH102	6.0 – 9.0	SWCM	3
S1-BH103	2.0 – 5.5	Made Ground	3
S1-BH105	11.0 – 15.0	SWCM	3

Exploratory Location	Slotted Section Range (m bgl)	Response zone	Monitoring Rounds Completed
S1-BH112	8.0 – 15.0	SWCM	2
S1-BH113	3.0 – 5.5	Made Ground	2
S1-BH121	2.0 – 3.5	Peat	3
S1-BH122	1.0 – 1.9	Made Ground	3
SOP003.16	10.0 – 13.0	SWCM	4
S2-BH239 (Shallow)	1.0 – 3.6	Made Ground	2
S2-BH239 (Deep)	7.0 – 10.0	SWCM	2
S2-BH240	1.0 – 6.0	Made Ground	2
S2-BH242	1.0 – 3.7	Made Ground/Glacial Till	2
S2-BH243	5.0 – 6.0	SWCM	3
S2-BH244	4.5 – 10.0	SWCM	2
S2-BH246	3.5 – 8.0	SWCM	2
S2-BH248	6.5 – 9.5	Made Ground	1
S2-BH249	3.5 – 8.0	SWCM	3
S2-BH250	7.5 – 9.5	SWCM	1
S2-BH252	6.0 – 9.0	SWCM	2
S2-BH261(Shallow)	3.0 – 8.0	Made Ground	1
S2-BH261(Deep)	10.0 – 15.0	SWCM	1

Thirty seven groundwater samples were obtained from the Preliminary GI and Stage 1 GI monitoring wells, and 24 groundwater samples were obtained after the Stage 2 GI.

Groundwater analysis was screened against freshwater EQS and UK DWS, as presented in Table 8-5 and Table 8-6. The full screening assessment is presented in Appendix K.3.

Groundwater EQS (including PNEC) exceedances were recorded for copper in a single sample, cadmium in a five samples, chromium in four samples, and zinc in three samples, manganese in 39 samples, nickel in 22 samples, sulphate in two samples and pH in six samples.

DWS exceedances were recorded for manganese, pH and sulphate determinands.

Table 8-5: Summary of groundwater EQS (including PNEC) values and exceedances

Determinand	LOD (mg/l)	GAC (mg/l)	No. of Samples	Max. Value (mg/l)	No. of Exceedances	Locations of Exceedances
Cadmium	0.00011	0.00008	61	0.00055	6	S1-BH112, S2-BH242, S2-BH249,



Determinand	LOD (mg/l)	GAC (mg/l)	No. of Samples	Max. Value (mg/l)	No. of Exceed- ances	Locations of Exceed- ances
						S2-BH261
Chromium (total)	0.0005	0.0047	61	0.0089	4	BH30, BH32
Chromium (dissolved)	0.0005	0.001	24	<0.0005	6	S2-BH239, S2-BH242, S2-BH249, S2-BH252, S2-BH244, S2-BH261
Copper (dissolved)	0.0005	0.005*	61	0.01	1	S2-BH239
Manganese (dissolved)	0.0005	0.12*	49	9.8	39	S1-BH101, S1-BH102, S1-BH103, S1-BH105, S1-BH112, S1-BH113, S1-BH121, S1-BH122, SOP003.16, S2-BH239, S2-BH240, S2-BH242, S2-BH243, S2-BH249, S2-BH244, S2-BH248, S2-BH261
Nickel (dissolved)	0.0005	0.00 4*	61	0.03	22	BH30, BH31, S1-BH102, S1-BH105, S1-BH113, SOP003.16, S2-BH239, S2-BH242, S2-BH243, S2-BH249, S2-BH252,



Determinand	LOD (mg/l)	GAC (mg/l)	No. of Samples	Max. Value (mg/l)	No. of Exceed-ances	Locations of Exceed-ances
						S2-BH244, S2-BH240, S2-BH248, S2-BH261
pH	0	pH 6.0-9.0	61	pH 8.4 (min = pH 4.1)	6	S1-BH102, S1-BH105, S1-BH112, S1-BH121, S1-BH122, SOP003.16
Sulphate	1	400	61	420	2	S2-BH249, S2-BH240
Zinc (dissolved)	0.0025	0.017*	61	0.043	8	BH31, BH32, BH33, S2-BH239, S2-BH249, S2-BH246, S2-BH261

* Calculated PNEC value

Table 8-6: Groundwater exceedances of DWS

Determinand	LOD (mg/l)	GAC (mg/l)	No. of Samples	Max. Value (mg/l)	No. of Exceed-ances	Locations of Exceed-ances
Cyanide (total)	0.05	0.05	61	0.06	3	S1-BH102, S1-BH121, S1-BH122
Manganese	0.0005	0.05	49	9.8	44	S1-BH101, S1-BH102, S1-BH103, S1-BH105, S1-BH112, S1-BH113, S1-BH121, S1-BH122, SOP003.16,



						S2-BH239, S2-BH240, S2-BH242, S2-BH243, S2-BH249, S2-BH252, S2-BH244, S2-BH248, S2-BH261
pH	0	6.5-9.5	61	8.4 (min = pH 4.1)	6	S1-BH102, S1-BH105, S1-BH112, S1-BH121, S1-BH122, SOP003.16
Sulphate	1	250	61	420	9	BH30, BH31, S1-BH113, S1-BH122, S2-BH249, S2-BH239, S2-BH240

8.3.4 Surface water testing results

Surface water sampling locations from the Stage 1 GI are detailed in Table 6-1 and visually presented in Figure 6-1.

Three surface water samples were taken from the Dulais at location SW1 approximately 680 m south-west of the site and three from an on-site surface water drain (SW2) that discharges to the Dulais. A further three samples were taken at SW3 from the Camnant 35 m east of the site.

An additional two surface water locations (SW4 and SW5), located adjacent to drilling works were sampled when artesian conditions were encountered in order to assess the risk posed to surface water receptors from artesian groundwater.

Surface water analysis was screened against freshwater EQS (including PNEC). The results of determinand which showed exceedances are presented in Table 8-7. The full screening assessment is presented in Appendix K.3.

Surface water EQS (including PNEC) exceedances were recorded for nickel in six samples, chromium in two samples, and cadmium, manganese and zinc each in a single sample. It should be noted the surface water chromium exceedances (SW4 and SW5) were recorded in on-site surface water drains, but not present within the Dulais (SW1) and Camnant (SW3) or on-site surface drain located on the sites western boundary (SW2) where sampled at their closest approach to the site.

Table 8-7: Summary of surface water PNEC values and EQS results

Determinand	LOD (mg/l)	GAC (mg/l)	No. of Samples	Max. Value (mg/l)	No. of Exceedances	Locations of Exceedances
Cadmium	0.00011	0.00008	11	0.00018	1	SW2
Chromium (total)	0.0005	0.0047	11	0.022	2	SW4, SW5
Copper	0.0005	0.005*	11	0.0013	0	-
Manganese	0.0005	0.12*	11	0.15	1	SW2
Nickel	0.0005	0.004*	11	0.0055	6	SW1, SW2, SW4, SW5
Zinc	0.0025	0.017*	11	0.031	1	SW1

* Calculated PNEC value

8.3.5 Ecological Risk

Onllwyn Gorsllwyn SSSI is located 150 m north-east of the site and risks to it from on-site development are most likely due to migration of contaminants in surface waters or groundwater and would be represented by screening of groundwaters against EQS. See section 8.3.4 and 8.3.3 for a summary of EQS exceedances. Exceedances are not considered to be significant enough to pose an unacceptable risk to the SSSI given the number of exceedances, their magnitude and the distance to the receptor.

Risks are potentially posed by contamination to the SSSI from surface waters during earthworks or groundwaters during mine working treatment if appropriate working methodologies and monitoring are not put in place during construction works. Compliance with CDM, surface water controls and appropriate design of construction works are considered to be sufficient to prevent unacceptable risks to the SSSI.

8.3.6 Discussion & recommendations

Exceedances of the DWS and / or EQS were recorded for cadmium, chromium (total), cyanide (total), lead, manganese, nickel, several PAHs, pH, sulphate, and zinc.

No leachate samples exceeded the EQS or DWS for cadmium, however five groundwater samples taken from S1-BH112, S2-BH242, S2-BH249 and S2-BH261 recorded an exceedance of its EQS. Cadmium also exceeded the EQS in a single surface water sample taken from SW2 which is located in a drain within the site boundary. No other off-site or on-site surface water monitoring locations recorded cadmium concentrations in exceedance of the EQS or DWS. This indicates that slightly elevated cadmium concentrations are present in the groundwater and surface water, however the on-site soils have not been identified as the source of the exceedances.

No leachate samples exceeded the EQS or DWS for chromium, however four groundwater samples taken from BH30 and BH32 recorded exceedances of the chromium EQS. Chromium also exceeded the EQS in two surface water samples, SW4 and SW5, taken from the western part of the site. This indicates that although elevated chromium concentrations are present in the groundwater and surface water, the on-site soils have not been identified as the source of the exceedances.

Respectively free and total cyanide exceedances of the EQS and DWS were recorded in two soil-leachate samples, BH33 located in the north-west of the site, and S1-TP114 located in the south-east of the site. No exceedances of cyanide EQS were recorded in groundwater samples or surface water samples taken from the site with all results below the LOD. This means that AtkinsRéalis considers soil-leachate cyanide exceedances to not present an unacceptable risk to surface waters. Three free cyanide exceedances of DWS were noted, however, given the mining history of the site and surrounds potable groundwater abstractions are not considered as plausibly occurring.

Two leachate exceedances of the lead EQS PNEC were recorded in samples S1-TP111, located west of the site's centre and S2-TP294, located in the centre of the site. No exceedances of lead were recorded within groundwater or surface water samples indicating that the theoretical leachate concentrations are not being realised at the receptor.

Thirty nine groundwater samples were recorded as exceeding the manganese EQS and 44 exceeding the manganese DWS. The concentrations recorded were typically 3-15 times the EQS, but there are some exceedances recorded from the Stage 2 GI that are up to 60 times the EQS. A single exceedance of the EQS PNEC was recorded in the surface water drain at SW2 with a further two results from this location not exceeding the EQS. Manganese did not exceed EQS in the Dulais off-site at SW1 or in the Camnant at SW3. This indicates that while elevated manganese concentrations are present in the groundwater beneath the Washery and intermittently in the on-site surface water drain it was not impacting the Dulais or the Camnant surface waters. Naturally originating manganese is often encountered at elevated levels in the SWCM. For these reasons the elevated concentrations of manganese are therefore unlikely to pose an unacceptable environmental risk, however if EQS are used to assess suitability for reuse under a Materials Management Plan or Environmental Permit a portion of the material on-site may exceed EQS. DQRA is considered necessary to demonstrate whether the manganese concentrations recorded in the soils would pose an unacceptable risk to controlled waters following reuse, and to calculate site-specific acceptability criteria to be applied to determine whether soils are suitable for re-use given the alternative may lead to potential fill being considered unsuitable for use in the earthworks.

No leachate samples exceeded the EQS PNEC for nickel, although 22 groundwater samples recorded an exceedance of the EQS PNEC. 14 nickel groundwater exceedances were from the SWCM, and the other eight from wells installed in Made Ground. Six samples of surface water slightly (typically less than 10% greater than the EQS) exceeded the EQS PNEC, with five of the exceedances being from on-site surface water drains and one from the Dulais beyond the site boundary. It is noted that none were recorded from SW3 at the Camnant, beyond Zone 2A boundary. This indicates that slightly elevated nickel concentrations are present in the groundwater and surface water, and that natural soils are the most likely source of nickel. The marginal nature of the surface water exceedances and data supporting a source in the SWCM rather than Made Ground means that AtkinsRéalis considers that the nickel exceedances do not present an unacceptable risk.

A single leachate sample (from two samples tested) recorded PAH exceedances, including anthracene, benzo(a)pyrene and fluoranthene exceeding the EQS, and benzo(a)pyrene and "sum of four" exceeding the DWS. The sample was taken from BH33, located north-west of the site's centre. PAH exceedances were not recorded in any groundwater or surface water sample taken, and therefore PAH concentrations present within the on-site soils are not considered to pose an unacceptable risk to the identified controlled waters receptors.

Six leachate samples recorded pH values outside of the EQS / DWS range, with two recorded as slightly alkaline, two recorded as moderately alkaline, and two as slightly acidic. Six groundwater samples recorded moderately acidic pH levels below the EQS / DWS, with the minimum pH recorded as pH 4.1. pH levels recorded in the surface waters were all within the acceptance range for EQS, indicating that these are not being significantly impacted by the low pH levels primarily recorded in the groundwater or the high pH levels recorded in the soil leachate. The lowest pH levels were recorded in S1-BH121 (and adjacent boreholes)

where the response zone is located within peat, indicating that the acidic conditions recorded are sourced from the natural peat material.

No leachate samples exceeded the EQS or DWS for sulphate, however two groundwater samples recorded exceedances of the EQS and nine samples recorded exceedances of the DWS. Four locations that the samples were taken from were in the Made Ground, and one was from groundwater within the SWCM. Additionally, sulphate did not exceed the EQS or DWS in any of the surface water samples analysed indicating no potential pollutant linkage from on-site sources. Given no abstractions are present on-site or likely to occur in the vicinity of The Washery, the groundwater sample exceedances are not considered to present an unacceptable risk.

Eight groundwater samples were recorded as exceeding the zinc EQS PNEC. Three of the exceedances were recorded during sampling from February-March 2022. Further groundwater sampling of newly installed monitoring wells was undertaken during the Atkins 2022-2023 investigation, however no further exceedances were recorded. Two locations had response zones installed within Made Ground, and the other six were within SWCM. A single exceedance of the zinc EQS PNEC was recorded in the surface water at SW1 (downstream of Zone 1A) during February 2023, with results from two further sampling rounds below the EQS. All other surface water samples analysed during the investigations did not exceed the zinc EQS. No leachate exceedances were recorded. The intermittent surface water exceedances, the absence of exceedances in the leachate and data supporting a groundwater source in the SWCM, rather than Made Ground, means that Atkins considers the zinc exceedances do not present an unacceptable risk.

It should be noted that soil-leachate tests can be overly aggressive, resulting in values that are not representative of actual hydro chemical conditions. For the majority of determinands, no apparent adverse correlation between soil-leachate exceedances and groundwater / surface water exceedances was recorded. It has not been confirmed whether on-site soils are the source of elevated manganese in the groundwater and surface water.

No exceedances of TPH or BTEX were recorded in the soil, groundwater or surface water.

DQRA should be undertaken to derive site-specific criteria to determine whether the on-site soils are posing a risk to controlled waters, and whether soils are suitable for re-use on the Washery or the wider site, particularly for manganese. Where soils are proposed to be re-used, further leachate tests (including manganese) should be undertaken to provide further information on the concentrations of these determinands within the on-site soils. The leachate results should be compared to suitable acceptability criteria. A remediation strategy should be developed, describing any proposed soil re-use alongside the derived acceptability criteria, and also detailing any remediation measures if deemed required.

Due to access constraints such as delays to demolition occurring some Stage 2 GI locations were not investigated as intended. Additionally there are areas of the site where while soil and groundwater analysis does not identify an unacceptable risk there is the potential for groundwater impact to be encountered as demolition works and site construction activities progress. For instance, where fuel storage and chemical storage has occurred in quantity and areas such as the electricity substations that are currently in operation. A watching brief is required at these locations.

AtkinsRéalis also recommend that a further site wide groundwater monitoring and sampling data set is acquired to improve knowledge of groundwater flow and inform the recommend DQRA.

8.4 Mine / ground gas assessment

8.4.1 Methodology

Potential sources of gas were identified within the initial CSM (Section 5). A preliminary ground gas risk assessment has been undertaken in accordance with the methodology presented within the Construction Industry Research Information Association (CIRIA) C665 methodology [40], BS 8485:2015+A1:2019 [41] and CLAIREs Good practice in the assessment of emissions from mine gas [42].

Risks from mine gas are assessed in compliance with CLAIREs Good practice in the assessment of emissions from mine gas [42] and consideration of the Coal Authority's (CA's) Good practice in the management of hazardous gases during drilling or piling [43]. Due to the uncertainty associated with collecting reliable monitoring data from mine workings the CLAIRE Mine Gas Risk Assessment approach requires a robust conceptual site model, the protection required by BS8485 for a given gas screening value (GSV) is then amended to reflect the CSM and associated uncertainties.

Potential gas sources, considered in the initial CSM set out in Section 5 are:

- Made Ground;
- Peat; and
- Coal Measures / Mine Workings.

8.4.2 Peat Gas Potential

Peat is considered to be laterally extensive in the north and west of the site, however, the vertical thickness is considered to be low (typically less than 1 m thick) with a maximum recorded thickness of 2.1 m. The peat is therefore not considered likely to present an ongoing source of ground gas and any settlement that were to occur would also not be likely to generate a sufficiently high magnitude flow to pose a risk to on-site property or human health. The peat is therefore not considered to present a plausible source of ground gas monitoring wells. Ground gas monitoring targeted Made Ground and Coal Measures with a limited number of monitoring wells targeted on the peat as a precautionary measure.

8.4.3 Made Ground

The majority of Made Ground present within the site comprises colliery spoil, originating from the SWCM, that was deposited within the Washery during the operation of the Dulais and Onllwyn Collieries prior to their closure. The majority of this material is therefore reworked natural material with a fraction of coal present within it that poses a potential ground gas source. Peak coal gas generation typically occurs within the 10-20 years of exposure of coal to atmosphere and therefore this material is likely to present a declining gas source due to its age with peak gas generation occurring prior to the closure of the collieries and when the material was placed. The sites colliery spoil derived Made Ground is therefore considered to be a plausible ground gas source and monitoring wells were installed within Made Ground to assess this risk.

8.4.4 Mine Gas Risk Assessment

8.4.4.1 Information Sources

Section 7.2 summarises previous work completed to investigate the presence of coal mine workings within the Washery. Reports considered are:

- Geotechnical and Geo-environmental Desk Study, Arup, 2018 [2];

- Detailed Mine Workings Report, Arup, 2020 [9];
- Ground Investigation Report, Arup, 2022 [3];
- Coal Mine Risk Review, AtkinsRéalis, 2023 [14]; and
- Mining Risk Review, AtkinsRéalis, 2024 (in preparation) [6].

The documents above include data provided by third parties (Arup and Celtic Energy); available CA mine abandonment plan; opencast completion plans from Celtic Energy; and open-access information from both the BGS and the CA, in additions to drilling records and borehole logs contained in the Stage 1 and Stage 2 GI Reports [44] [45] respectively contained in Appendix G and Appendix H.

8.4.4.2 Mining and Geology

Geology mapping and mining records, confirmed by ground investigation, have identified the presence of South Wales Middle and Lower Coal Measures at shallow depths (<30 m) below the Washery. Within the Washery area CA records record coal extraction from the Bluers and Peacock workings within the Washery's footprint with these workings intruding under limited areas of the west of the site. The following coal measures, where unrecorded coal working have been encountered during GI works, are recorded as present:

- Peacock;
- New Seam;
- Grey Seam; and
- Rhyd Seam

Additionally, the following features are identified from Ordnance Survey (OS) and CA mapping as present on-site:

- Adit 284210-035.
- Shaft 285210-26;
- Shaft 285210-27;
- Adit 284210-019; and
- Adit 284210-020

Further features are considered to be located in close enough proximity to the site that they have the capacity to potentially influence the site coal mine gas regime either because shafts are within 50 m of the site boundary or adits recorded off-site are projected to pass under the site:

- Shaft 284210-29;
- Adit 284210-023;
- Adit 285210-001;
- Shaft 285210-28; and
- Adit 285201-025

Table 8-8, presented below, details encounters with coal measures, mine workings and information on water strikes from the ground investigations that have occurred within the Washery.

Table 8-8: Coal measures and coal working observations

Borehole ID	Depth of working (m bgl)	Rockhead Depth (m bgl)	Rockhead Depth (m AOD)	Coal Seam Name	Coal Seam Depths (m bgl)	Coal Seam Depths (m AOD)	Coal Seam Thickness (m)	Other Observations
S1-BH101	-	21.60	219.56	-	-	-		Water strike 11.3 m bgl
S1-BH102	-	7.50	223.23	N/K	19.50	211.23	0.03	Water strikes at 0.6 m and 7.0 m bgl
				N/K	20.10	210.63	0.40	
S1-BH103	-	12.80	221.53	N/K	19.40	214.93	1.20	Water strike at 4.0 m bgl
S1-BH105	-	9.60	226.89	N/K	15.80	220.69	0.70	Water strike 7.0 m bgl
				N/K	16.70	219.79	0.05	
S1-BH106	Void/mine working at 16.10-17.0 (0.9 m thick)	11.30	229.97	New Seam	-	-	-	Water strike 1.0 m bgl
S1-BH107	-	2.00	227.89	-	-	-	-	Water strike 0.7 and 7.0 m bgl
S1-BH108	-	1.00	230.95	N/K	13.90	218.05	1.10	Water strike 0.4 m bgl
S1-BH109	-	10.60	225.77	Grey Seam	15.20	221.17	0.70	Strike 4.78 m bgl
S1-BH110	-	5.10	228.95	Rhyd Seam	7.35	226.70	1.35	
S1-BH112	-	6.00	231.94	Grey Seam	11.45	226.49	1.00	

Borehole ID	Depth of working (m bgl)	Rockhead Depth (m bgl)	Rockhead Depth (m AOD)	Coal Seam Name	Coal Seam Depths (m bgl)	Coal Seam Depths (m AOD)	Coal Seam Thickness (m)	Other Observations
S1-BH113	-	10.05	226.90	Grey Seam	12.27	224.68	0.41	Water strike 4.0 m bgl
S1-BH114B	-	1.55	227.17	-	-	-	-	Water strikes at 0.6 and 4.0 m bgl, rising to -1 m bgl. Strongly artesian
S1-BH116	-	8.40	228.85	Grey Seam	12.20	225.05	0.58	-
S1-BH121	-	3.60	227.28	-	-	-	-	-
S1-BH122	-	6.00	224.82	-	-	-	-	Water strike at 0.4 and 8.0 m bgl
BH30R	Void at 9.7-11.7 (2.0 m thick) Void at 20.1 – 21.1 (1.0 m thick)	6.60	232.50	N/K	13.64	-	-	Water strike a 6.6 m bgl, workings saturated and below water table
SOP003.16	Void at 19.5-21.2 (0.7 m thick)	4.00	234.78	-	-	-	-	Water level at 10.2-12.35 m bgl during monitoring
SOP003.1	Void at 10.1-11.5 (0.4m thick)	4.50	234.41	-	-	-	-	Void dry, but below recorded water table
SOP003.2	Void at 10.1-11.5 (0.4m thick)	4.00	234.99	-	-	-	-	Void Flooded
SOP003.13	Void at 10.7-12.0 (0.3 m thick)	4.00	234.95	-	-	-	-	



Borehole ID	Depth of working (m bgl)	Rockhead Depth (m bgl)	Rockhead Depth (m AOD)	Coal Seam Name	Coal Seam Depths (m bgl)	Coal Seam Depths (m AOD)	Coal Seam Thickness (m)	Other Observations
SOP003.14	Void at 10.7-12.0 (0.3 m thick)	4.00	235.09	-	-	-	-	Void flooded
S2-BH239	-	6.00	229.94	-	-	-	-	Water strikes at 0.4 and 2.0 m bgl
S2-BH240	-	-	-	-	-	-	-	Water strike at 2.0 m bgl Didn't reach bedrock
S2-BH242	-	8.50	229.83	-	-	-	-	Water strike at 3.4 m bgl
S2-BH243	-	4.80	232.95	-	-	-	-	Water strike at 4.0 m bgl. 4.0 - 4.8 m bgl wet.
S2-BH244	-	3.80	233.78	-	-	-	-	Water strike at 0.2 m bgl
S2-BH245	-	3.00	235.37	N/K	8.00	230.37	0.40	Water strike at 4.0 m bgl
S2-BH246	-	3.70	233.88	Rhyd Seam	7.70	229.58	0.30	Water strike at 3.2 m bgl
S2-BH247	-	1.80	235.32	Grey Seam	7.50	229.62	0.60	Water strike at 1.3 m
S2-BH248	-			-	-	-	-	Did not reach SWCM
S2-BH249	-	3.50	236.29	-	-	-	-	Water strike at 5.8 m bgl
S2-BH250	-	5.00	228.63	-	-	-	-	Water strike at 1.2 m bgl
S2-BH252	-	4.60	232.30	-	-	-	-	Water strike at 5.0 m bgl



Borehole ID	Depth of working (m bgl)	Rockhead Depth (m bgl)	Rockhead Depth (m AOD)	Coal Seam Name	Coal Seam Depths (m bgl)	Coal Seam Depths (m AOD)	Coal Seam Thickness (m)	Other Observations
S2-BH257	Voids between 19.7-22.2 (0.3-2.5 m thick)	1.00-2.00	235.06-233.85	-	-	-	-	
S2-BH258	Voids between 15.0-20.5 (3-5.5 m thick)	4.00-5.50	227.32-225.21	Nine Feet Seam	12.5-12.8	218.75-218.34	0.70-1.00	
S2-BH261	-	8.60	230.45	New Seam	9.00	230.05	6.00	Water strike at 15 m bgl, rising to 7.7 m bgl. Sub-artesian
S2-BH262	Voids between 10.0-11.5 (1.3-1.5 m thick)	4.00-5.00	236.04-235.06	Rhyd Seam	3.0-4.0	236.04-235.09	1.50	
				Rhyd Seam	6.0-6.5	233.25-232.59	1.50-2.00	
				Rhyd Seam	14.0-14.5	225.20-224.11	1.90-2.10	
S2-BH264	Voids between 21.0-24.5 (1.5-2.5 m thick)	3.00	236.82-235.85	Grey Seam	3.00	235.85	1.50	
				Grey Seam	16.0-16.5	223.15	1.30	
S2-BH265	-	10.00	229.86-229.58	Rhyd Seam	11.50	228.08-228.36	2.00	
				Rhyd Seam	17.00	222.85-222.58	1.50-2.50	
				Rhyd Seam	17.00	222.86	2.50	



NB: N/K = coal seam name not identified



Draft Mining Workings Remediation Plans and Profiles Drawings GCRE001-AWJV-00-XX-DR-GE-04007 and GCRE001-AWJV-00-XX-DR-GE-04008 are presented in Appendix A. Drawings GCRE001-AWJV-00-XX-DR-GE-04007 and GCRE001-AWJV-00-XX-DR-GE-04008 show the locations of mine workings, investigation locations that encountered mine workings and geological features, along with cross sections of the Washery.

CA records show the New Seam, Grey Seam and Rhyd Seam sub-cropping within the SWCM within the eastern side of the site, within the eastern wider Washery and below the off-site residential area to the south-east, and Nine Feet Seam to sub-crop in the west of the site. These seams sub-crop in the SWCM and are then overlain by a variable thickness of superficial deposits or Made Ground so not visible at surface level. Ground Investigation works summarised in Table 8-8 record these seams at depths of between 3.00 m and 20.10 m. Voids interpreted as corresponding to Adit 284210-035 (10.1 m – 12 m bgl) and a deeper working (19.5m – 21.2 m bgl) are present in the south-east at coal mining investigation borehole SOP003. An additional void was encountered approximately 35 m north of the site by S1-BH106 (16.1 m – 17.0 m bgl). Mapping indicates the entries of adits 284210-019 and 284210-020 within the north of the site and of Shaft 284210-29 approximately 10 m north of the site boundary and Adit 284210-023 15 m north of the sites boundary with its associated working extending south below the site, additionally there is a potential for unidentified workings to be present.

Table 7-2 summarises recorded water levels across the site. Water levels on-site during the Stage 1 GI (discussed in section 5) are reported at depths of between 226.43 m and 241.82 m AOD and water levels recorded from the Stage 2 GI are between 231.84 m and 235.18 m AOD. These are consistent with the water strikes recorded in Table 8-8.

Rockhead is recorded at between 219.56 m and 236.82 m AOD.

8.4.4.3 Coal Mine Gas Risk Assessment

Table 8-9 summarises the data that is relevant to assessing the level of risk posed by coal mine workings.

Table 8-9: Coal mine gas risk assessment

Factors	Discussion
Source	Shallow (<30 m) coal workings and coal measures are present below the site and the wider Washery with the following recorded: ▪ Shafts; ▪ Adits; ▪ Void / Coal Level working; and ▪ Unworked coal seams with potential for unknown workings including mine entrances. The cut and fill that will be required to produce the earthworks required. Fill in the west of the site generally will increase the distance between coal mine gas sources and on-site receptors by 5 - 15 m, while in the east between 5 - 15 m of cut will reduce the distance between receptors and the identified coal mine gas source. It should be noted that coal levels are known to sub-crop in the SWCM (overlain by superficial deposits and Made Ground) both on and off-site and following the development this would still be the case. Colliery spoil is also considered a potential gas source due to the coal content.
Water Level	Encountered water strikes and groundwater monitoring data shows that encountered coal measures and confirmed workings, with the exception of Adit 284210-035 where an air void was present in one drilling location, are all substantially below recorded groundwater levels and are flooded. The air void recorded by SOP003 in Adit 284210-035 is considered to be the result of the adit draining to the south-east at a rate that

	allows this working to be unflooded. When comparing to surrounding groundwater levels, there is also a possibility for S2-BH262 to not be completely flooded all of the time. Boreholes S1-BH114, S1-BH114C, S1-BH114B, S1-BH107 and S1-BH107B located in the west of site encountered artesian conditions and S2-BH261 to the east of the site encountered sub-artesian conditions. This represents a potential for groundwater to flow from a high pressure head to one which is lower and for degassing of methane and carbon dioxide to occur inside an enclosed space in these parts of the site (no enclosed spaces are intended in these parts of the development with Stage 1 development only involving construction of the UKRRIN building in the south of the site). Over the majority of the site groundwater is located within the Lower and Middle Coal Measures and the overlying Quaternary deposits and Made Ground are in continuity, with no driving head present.
Age of Workings	1982 is indicated as the completion plan date for the Onllwyn Colliery [3], and colliery mining operations are not considered to have continued on-site following this date. All workings have therefore been abandoned for at least 40 years. Submission of abandonment plans to the CA has been a requirement since 1880, adits and shafts that have been recorded within the Washery are not recorded on these records and are therefore considered likely to pre-date this requirement and to be greater than 150 years old.
Mitigation	A variable thickness of Made Ground (colliery spoil) and Quaternary Deposits (Devonian Till and/or Peat) overly the SWCM, this is not considered to present an effective barrier against mine gas migration. Abandoned mine methane (AMM) emissions are characterised by a high rate of release immediately following closure, which typically falls to much lower rates of emission over a period of 8 to 10 years. Below ground workings on-site are >40 years old and potentially date from prior to 1880 therefore peak gas generation is considered to have passed. Additionally, all workings with the exception of Adit 284210-035 and an unrecorded working encountered within S2-BH262 were flooded.
Receptors	Within site, development will consist of earthworks that will result in substantial (5-15 m) cut and fill to achieve the required levels. Areas of rail sidings and railway track with associated rail infrastructure such as signals and overhead line equipment will then be constructed on the earthworks. With the exception of the UKRRIN building no enclosed spaces will be present where a gas risk to human health or property could be present following the Stage 1 development works. Stage 3 works would introduce additional buildings to the south of the site and wider Washery area which will be receptors to coal mine gas. Off-site residential and commercial buildings (56 m to 245 m south) are also potential receptors, however given the distance, depths to workings, water levels and the off-site presence of further shafts, adits and workings in closer proximity to off-site residential and commercial receptors the development on-site is not considered as likely to change the off-site risk regime except potentially during the remediation of any below site mine workings.

As a consequence of the coal mine risk assessment set out above and the initial CSM presented in Section 5, ground gas monitoring wells have been installed in selected boreholes and ground gas monitoring in compliance with BS 8485 completed. This monitoring data is presented in Section 8.4.5 and the outcome of the risk assessment presented in Section 8.4.6.

8.4.5 Ground Gas & Coal Mine Gas Monitoring results

Monitoring was conducted during several post-ground investigation monitoring rounds.

- Preliminary ground investigation, - monitoring wells BH29 to BH34 were monitored on six occasions from 31 January 2022 to 25 April 2022.
- Stage 1 ground investigation - monitoring wells S1-BH101 to S1-BH105, S1-BH108, S1-BH112 (shallow), S1-CH112 (deep), S1-BH113, S1-BH121, S1-BH122 and SOP003.16 were installed and monitored on three occasions from 9 January 2023 to 17 February 2023.
- Stage 2 ground investigation, -monitoring wells S2-BH239 (Shallow), S2-BH239 (Deep), S2-BH240, S2-BH242, S2-BH243 (Deep), S2-BH243 (Shallow), S2-BH244 (Shallow), S2-BH244 (Deep), S2-BH245, S2-BH246 (Shallow), S2-BH246 (Deep), S2-BH247 (Deep), S2-BH247 (Shallow), S2-BH248 (Deep), S2-BH248 (Shallow), S2-BH249 (Shallow), S2-BH249 (Deep), S2-BH250 (Deep), S2-BH250 (Shallow), S2-BH252 (Shallow), S2-BH252 (Deep), S2-BH261 (Deep) and S2-BH261 (Shallow) were installed and monitored in three occasions on 26 June to 4 July 2023, 24 to 31 July 2023 and 21 to 24 August 2023.

CIRIA C665 suggests that for a low sensitivity commercial end use with a moderate to high gas generation potential a minimum of six monitoring rounds should be completed at fortnightly intervals. The data set considered below consists of a total of 12 monitoring rounds, 41 monitoring wells and covers a wide range of conditions. It is considered appropriate for the circumstances that are present within the site and the Stage 1 development.

Monitoring wells were targeted on peat, Made Ground, SWCM and mine workings sources of ground gas identified in the Initial CSM set out in Section 5 and Table 5-4. Boreholes were located to provide good coverage of the site, but also installed on targets of opportunity such as peat and in proximity to encountered mine workings.

During the preliminary GI atmospheric pressure ranged between 967 mb and 1020 mb including two periods of falling pressure, one period of steady pressure and three periods of rising pressure. Ground gas monitoring was undertaken using a GA2000 gas analyser. During the Stage 1 monitoring program atmospheric pressure ranged between 976 mb and 1021 mb including two periods of steady pressure and one period of rising pressure. During the Stage 2 monitoring program atmospheric pressure ranged between 983 mb and 997 mb including two periods of rising pressure and one of falling pressure. Ground gas monitoring was undertaken using a GA5000 gas analyser. Emissions of carbon dioxide, methane, hydrogen sulphide, carbon monoxide and oxygen were recorded during both monitoring periods, alongside flow rates. Atmospheric conditions and prevailing pressure trends were considered prior to ground gas monitoring rounds to ensure a range of conditions were monitored as recommended in CIRIA C665 [40].

The full results of the gas monitoring are presented in 12.K.5 which also details recorded groundwater levels at the time of monitoring. The full set of results are also presented in the factual reports presented in Appendix F, Appendix G and Appendix H.

Table 8-10 details the minimum oxygen concentrations, the maximum and steady state concentrations for methane, carbon dioxide, carbon monoxide and hydrogen sulphide concentrations, and flow rates recorded for each borehole during monitoring rounds. Table 8-10 also summarises the horizons that monitoring wells are screened within and details water levels at the time of monitoring.

Table 8-10: Summary of gas monitoring results

Borehole	Oxygen % v/v		Methane % v/v		Carbon Dioxide % v/v		Flow l/hr		H2S ppm	CO ppm	Screened Horizon (m bgl)	Horizon Screened	Comments
	Min Min	Min Steady	Max Peak	Max Steady	Max Peak	Max Steady	Max Peak	Max Steady	Max	Max			
BH29	17.80	17.80	0.70	0.70	2.90	2.90	0.0	0.0	0.0	0.0	12.0-15.0	SWCM	Flooded during all rounds
BH30	3.20	3.20	0.80	0.80	5.20	5.20	0.4	0.4	0.0	0.0	3.0-4.0	Made Ground	Flooded during two rounds
BH31 (Shallow)	16.10	16.10	0.10	0.10	4.80	4.80	-0.8	-0.8	0.0	0.0	1.0-5.0	Made Ground	
BH31 (Deep)	18.60	18.60	0.10	0.10	2.40	2.40	-0.8	-0.8	0.0	0.0	16.0-21.0	SWCM	Flooded during all rounds
BH32	16.4	16.4	2.3	2.3	3.3	3.3	25.2	25.2	0.0	0.0	12.5-17.5	SWCM (Coal Seam)	Flooded during all rounds
BH33	17.30	17.30	0.10	0.10	2.80	2.80	0.3	0.3	0.0	0.0	15.0-20.0	SWCM	Flooded during all rounds
BH34 (Shallow)	10.40	10.40	0.60	0.60	5.40	5.40	0.1	0.1	0.0	0.0	1.0-3.3	Made Ground	
BH34 (deep)	4.90	4.90	60.30	60.30	3.50	3.50	0.0	0.0	0.0	0.0	11.0-13.0	SWCM	Flooded during all round
S1-BH101	18.80	18.90	0.10	0.10	1.50	1.50	-7.3	-7.3	1.5	23.0	11.0-14.0	Made Ground	Flooded during all rounds
S1-BH102	14.40	14.40	8.90	8.90	4.50	4.50	-8.8	-8.8	0.0	2.0	6.5-9.0	SWCM	Flooded during all rounds
S1-BH103	15.90	3.20	0.20	0.20	4.70	4.70	0.20	0.20	0.0	1.0	2.10-5.45	Made Ground	
S1-BH105	5.00	5.00	35.10	34.10	3.90	3.90	8.30	8.30	0.0	88.0	0.5-5.0	SWCM	Flooded during all rounds



Borehole	Oxygen % v/v		Methane % v/v		Carbon Dioxide % v/v		Flow l/hr		H2S ppm	CO ppm	Screened Horizon (m bgl)	Horizon Screened	Comments
	Min Min	Min Steady	Max Peak	Max Steady	Max Peak	Max Steady	Max Peak	Max Steady	Max	Max			
S1-BH108	20.30	20.30	0.10	0.10	2.80	2.80	-6.2	-6.2	0.0	10.0	13.0-15.5	SWCM	Flooded during all rounds
S1-BH112 (Shallow)	9.00	9.00	0.20	0.20	2.00	2.00	0.2	0.2	0.0	1.0	1.0-2.5	Made Ground	
S1-BH112 (Deep)	8.50	8.50	0.20	0.20	2.30	2.30	-3.0	-3.0	0.0	2.0	8.0-15.0	SWCM	
S1-BH113	1.80	4.50	4.50	0.20	5.40	5.40	0.3	0.3	0.0	6.0	3.0-5.5	Made Ground	
S1-BH121	19.50	19.50	0.40	0.30	2.00	2.00	-12.0	-12.0	0.0	0.0	2.0-3.5	Peat	Flooded during all rounds
S1-BH122	18.90	18.90	0.30	0.30	2.20	2.20	11.00	11.00	1.0	2.0	0.8-1.8	Made Ground	Flooded during all rounds
SOP003.1 6	15.80	15.80	0.30	0.20	3.70	3.60	7.0	7.0	0.0	2.0	10.0-13.0	SWCM	Installed above Adit 284210-035
S2-BH239 (Shallow)	13.8	13.8	1.7	1.7	6.5	6.5	-	0.2	0	0	0.1-3.5	Made Ground	
S2-BH239 (Deep)	15.2	15.2	1.7	1.6	6.1	6.1	-	6.9	2	3	10.0-7.0	SWCM	Flooded during all rounds
S2-BH240	4	4	1.8	1.7	11.2	11.2	-	0.2	0	0	1.0-6.0	Made Ground	Flooded during one round an flow of 7 l/hr discounted
S2-BH242	13.2	15.1	1.6	1.6	4.3	4.3	-	0.4	2	0	1.0-3.7	Made Ground/ Peat/ Glacial Till	
S2-BH243 (Deep)	19.5	19.5	1.6	1.6	1.1	1.1	-	4.9	3	9	5.0-6.0	SWCM	Flooded during all rounds



Borehole	Oxygen % v/v		Methane % v/v		Carbon Dioxide % v/v		Flow l/hr		H2S ppm	CO ppm	Screened Horizon (m bgl)	Horizon Screened	Comments
	Min Min	Min Steady	Max Peak	Max Steady	Max Peak	Max Steady	Max Peak	Max Steady	Max	Max			
S2-BH243 (Shallow)	16.8	16.8	1.6	1.6	3.5	3.5	-	0.1	2	0	1.0-3.0	Made Ground	
S2-BH244 (Shallow)	14	14	1.7	1.7	4.8	4.8	-	0.3	1	0	1.0-3.5	Made Ground	
S2-BH244 (Deep)	15.8	17.8	1.7	1.7	3.6	3.3	-	3.5	2	1	4.5-10.0	SWCM	Flooded during all rounds
S2-BH245	11.3	11.3	1.7	1.7	4.3	4.3	-	0.4	0	0	1.5-4.0	Made Ground/ SWCM	
S2-BH246 (Shallow)	13.9	13.9	1.7	1.7	4.5	4.3	-	0.2	1	0	1.0-2.8	Made Ground	
S2-BH246 (Deep)	13.5	13.5	1.7	1.7	5.2	5.2	-	5.8	1	4	3.5-8.0	SWCM	Flooded during all rounds
S2-BH247 (Deep)	1	1	1.7	1.7	6.2	6.2	-	0.1	1	2	6.0-9.0	SWCM	No water level/ depth to base reading for one round
S2-BH247 (Shallow)	14.7	18.3	1.7	0.2	1.4	1.4	-	0.2	1	0	1.0-2.0	Made Ground	No steady methane reading for one round
S2-BH248 (Deep)	19.1	19.1	1.9	1.9	1.7	1.4	-	3.9	2	3	6.5-9.5	Made Ground	Flooded during all rounds
S2-BH248 (Shallow)	16.1	18.9	1.6	1.6	3.0	2.8	-	0.2	2	0	1.0-4.0	Made Ground	
S2-BH249 (Shallow)	6.5	6.5	1.7	1.6	10.2	10.2	-	0.2	1	3	1.0-2.8	Made Ground	
S2-BH249 (Deep)	6.9	6.9	1.6	1.6	9.3	8.9	-	0.2	2	1	3.5-8.0	SWCM	



Borehole	Oxygen % v/v		Methane % v/v		Carbon Dioxide % v/v		Flow l/hr		H2S ppm	CO ppm	Screened Horizon (m bgl)	Horizon Screened	Comments
	Min Min	Min Steady	Max Peak	Max Steady	Max Peak	Max Steady	Max Peak	Max Steady	Max	Max			
S2-BH250 (Deep)	17.1	17.1	1.6	1.6	4.6	4.6	-	6.1	1	3	7.5-9.5	SWCM	Flooded during all rounds
S2-BH250 (Shallow)	2.7	2.7	1.6	1.6	13.8	13.8	-	0.2	1	2	1.0-2.0	Made Ground	
S2-BH252 (Shallow)	15.2	15.2	1.7	1.6	5.2	5.1	-	0.1	1	0	1.0-2.6	Made Ground	
S2-BH252 (Deep)	18.9	18.9	1.6	1.6	2.1	2.0	-	7.3	2	5	6.0-9.0	SWCM	Flooded during all rounds
S2-BH261 (Deep)	9.9	9.9	1.7	1.7	3.9	3.9	-	1.9	1	2	10.0-15.0	SWCM	Flooded during two rounds
S2-BH261 (Shallow)	12.9	12.9	1.7	1.7	4.3	4.0	-	0.2	1	1	3.0-8.0	Made Ground	

NB: SWCM = South Wales Coal Measures

v/v = volume/volume

ppm = parts per million

m bgl = meters below ground level

l/hr = litres per hour

Grey shaded cells indicate flow data from flooded monitoring wells that has been discounted from the following risk assessment

Bold Text = maximum recorded values for gas concentrations and flow

Italic Text – minimum oxygen concentration recorded



Flow

Twenty out of the 41 monitoring wells that data has been collected from were flooded by shallow groundwater during the monitoring period. Flow rates from these flooded wells have been discounted from GSV calculations. Flow rates in unflooded locations were low to moderate with a maximum steady flow recorded in SOP003.16 of 7 l/hr, the second (-6.8 l/hr) highest magnitude flow was a negative flow also in SOP003.16. Flows in the other unflooded monitoring wells ranged between <0.1 to 0.4 l/hr. Flows in wells that were flooded and excluded from the assessment ranged between -12 l/hr to 25.2 l/hr and are considered to be an artefact of well design and water levels sitting above the screened horizons.

Methane

Methane concentrations within the site are typically low to moderate, however methane concentrations that exceed the lower explosive limit (LEL) are recorded within monitoring wells installed in the SWCM and Made Ground. The maximum steady methane concentration recorded was 60.3% in BH34 (Deep), a borehole that was flooded for the duration of the monitoring period and that is also screened in the SWCM.

The maximum recorded methane in an unflooded well was 1.7 % which occurred in seven monitoring wells (S2-BH239(S), S2-BH244(S), S2-BH245, S2-BH261(S), S2-BH261(D), S2-BH247(S), S2-BH247(D), with numerous values of a similar magnitude also occurring.

Carbon Dioxide

Carbon dioxide concentrations were typically low to moderate the highest steady concentration being 13.6% recorded within the Made Ground of S2-BH250.

Oxygen

Oxygen levels were typically reduced in all monitoring rounds with significant reductions in oxygen that would pose a risk if translated to an enclosed space recorded. Reduced oxygen was typically correlated with elevated methane or carbon dioxide. The minimum oxygen concentration recorded was 1 % in S2-BH247 (deep). The overlying shallow monitoring well S2-BH247 (shallow) recorded a minimum oxygen concentration of 14.7%.

Carbon Monoxide & Hydrogen Sulphide

Carbon monoxide was recorded at low concentration in all locations except S1-BH105 where one monitoring round recorded 88 ppm. Hydrogen sulphide concentrations were negligible to low ranging from 3ppm to 0.0 ppm.

Table 8-11 presented below, details changes in barometric pressure recorded at weather stations in Neath accessed via Weather Underground. The preliminary GI and Stage 1 GI data was taken from the Froggit WS3000 – INEATH17 station [46] however, this was taken offline before the Stage 2 GI. The barometric trends for the monitoring during the Stage 2 GI have been taken from ISWANS129 [47] the closest station with a similar elevation to the previous one. Table 8-11 shows pressure trends from 18:00 the day before each monitoring event to 12:00 of the event. The barometric pressure recorded on-site during the monitoring event is also reported.



Table 8-11: Monitoring visit pressure trend summary

Date of Monitoring Event	Barometric Pressures Record Prior to Monitoring Visit (mB)					Trend
	Preceding Day 18:00	Day of Visit 00:00	Day of Visit 06:00	Site Reading 08.30-12:00	Day of Visit 12:00	
31/01/2022	1018.8	1013.9	1015.9	1018	1019.9	Rising fast
22/02/2022	1011.9	1012.0	1007.6	1020	1008.4	Rising slightly
09/03/2022	1012.1	1015.4	1001.5	1015	1000.4	Gradual fall
23/03/2022	1015.9	1018.1	1018.7	1001	1018.8	Steady
06/04/2022	999.2	996	990.7	967	986.8	Sharp fall
25/04/2022	1000.8	1004.5	1005.2	989	1006.4	Rising slightly
09/01/2023	977.3	982.1	987.1	977	995.6	Rising fast
31/01/2023	1019.3	1043.0	1015.9	1000	1016.6	Steady
14/02/2023	1020.3	1021.0	1020.3	1003	1018.3	Steady
26/06/2023	1012.5	1015.6	1017.9	997	1020.0	Rising fast
25/07/2023	1018.6	1020.7	1020.7	985	1022.0	Rising slightly
22/08/2023	1030.1	1028.8	1028.8	949	1030.1	Rising slightly
25/08/2023	1022.0	1022.7	1021.0	985	1020.0	Gradual fall

Table 8-11 shows that falling pressure coincided with monitoring events on three occasions. Slightly falling pressure occurred during the 22 February 2022 and 25 August 2023 monitoring rounds and a sharp fall in pressure occurred on the 6 April 2022. Only the event of the 6 April 2022 is considered to represent worst case pressure conditions. It should be noted that the highest methane and lowest oxygen values recorded coincided with the most significant fall in pressure of the monitoring period on the 6 April 2024.

CIRIA C665 recommends 3-6 monitoring rounds for a low sensitivity commercial land use and the GCRE data set includes 12 separate rounds of data collection.

8.4.6 Gas Screening Methodology

BS8485:2015+A1:2019 [41] states that hazardous gas flow rates (Qhg) should be calculated for methane and carbon dioxide for every borehole for each visit and suggests the Qhg be presented alongside the gas monitoring results in a database (which is included in Appendix K.5). A worse case Qhg is calculated using the maximum gas concentration recorded (unless lower values can be justified) and the maximum flow rate (unless lower values can be justified) using the below formula:

$$Qhg \text{ (l/hr)} = \text{flow rate (l/hr)} \times [\text{gas concentration (\%)/100}]$$

The Gas Screening Value (GSV) is the flow rate of a specific hazardous gas considered to be representative of a site, following assessment of all borehole concentrations and gas flow rates, whilst taking account of other influencing factors. Such factors being, for example, whether a response zone was completely flooded (which can compromise gas data), the temporal / spatial nature of the data set, and the acute one-off nature of the risk.

BS8485:2015+A1:2019 [41] indicates that a decision must be made to determine whether the maximum Qhg in the dataset is appropriate to represent the site (and thereby be selected as the GSV), or whether maximum gas concentrations and maximum steady state flow rates should be combined from any borehole/visit to derive a “worst case GSV”.

The GSV considered representative for the site is then used to select a Characteristic Situation (CS), which is the ground gas regime assumed for design of gas protection measures for new buildings in accordance with BS8485:2015+A1:2019 [41].

Where monitoring wells were flooded flow data from these events has been excluded from the risk assessment as the flows are considered to be an artefact of the well design and water level, and not representative of ground conditions that would actually occur. Additionally, negative flows have been retained as they are considered to be indicative of potential positive flow conditions.

Gas screening values were calculated for the following situations:

- GSV calculated based on temporarily and location linked steady carbon dioxide or methane concentrations (whichever gas had the highest concentration) and steady flows. The highest of these GSV, subject to a robust data set being present is considered to represent the level of risk that is present most accurately;
- GSV calculated for each monitoring location using highest recorded steady flow and steady methane and carbon dioxide gas concentration (whichever gas had the highest concentration in that well) from all monitoring rounds (data from flooded locations excluded); and
- Site wide GSV calculated based on highest recorded steady state flow and gas concentration from peat, Made Ground and coal measures (data from flooded locations excluded).

BS8485:2015+A1:2019 [41] does not include an approach for assessing low oxygen levels, carbon monoxide or hydrogen sulphide. The relevant Workplace Exposure Limits (WELs) as outlined within the HSE EH40/2015 (2020) document [48] have been adopted for use in a preliminary assessment of carbon monoxide and hydrogen sulphide:

- carbon monoxide: 30 parts per million (ppm) for long-term (eight hours) exposure limit and 200 ppm for short-term (15 minutes) exposure limit;
- hydrogen sulphide: 5 ppm for the long-term exposure limit and 10 ppm for the short-term exposure limit; and
- Low oxygen levels are considered to be present when Oxygen concentration is less than 17.5%.

8.4.7 Gas screening values

Appendix K.5 Table 1 presents the ground gas monitoring data collected for the site. The maximum GSV calculated for temporally and location linked steady state data is 0.78 l/hr, occurs at location S2-BH240 and is driven by a steady carbon dioxide concentration of 11.2% and flow of 7 l/hr. The calculated GSV equates to Characterisation Situation 2 (CS2). While the majority of other GSVs equate to Characterisation Situation 1 (CS1), CS2 does occur at several other locations due to carbon dioxide concentrations exceeding 5% and methane exceeding 1%.

A summary of the characteristic situations of each monitoring well based on temporarily unrelated maximum steady flows and maximum steady gas concentration is included in Table 8-12 below.

Table 8-12: Summary of maximum hazardous gas flow rates

Location	Max Qhg/GSV (l/hr)	Characteristic Situation	Response Zone Flooded
BH29	0.00	CS1	Yes

Location	Max Qhg/GSV (l/hr)	Characteristic Situation	Response Zone Flooded
BH30	0.02	CS1	Yes
BH31 (s)	0.04	CS1	No
BH31 (d)	0.02	CS1	Yes
~~BH32~~	~~0.83~~	~~CS3~~	~~Yes~~
BH33	0.01	CS1	Yes
BH34 (s)	0.01	CS2*	No
~~BH34 (d)~~	~~0.00~~	~~CS4~~	~~Yes~~
~~S1-BH101~~	~~0.11~~	~~CS2~~	~~Yes~~
~~S1-BH102~~	~~0.78~~	~~CS3~~	~~Yes~~
S1-BH103	0.01	CS1	No
S1-BH105	2.83	CS3	Yes
S1-BH108	0.17	CS2	Yes
S1-BH112 (s)	0.00	CS1	No
S1-BH112 (d)	0.07	CS1	No
S1-BH113	0.02	CS2*	No
~~S1-BH121~~	~~0.24~~	~~CS2~~	~~Yes~~
~~S1-BH122~~	~~0.24~~	~~CS2~~	~~Yes~~
SOP003.16	0.25	CS2	No
S2-BH239 (s)	0.01	CS2*	No
~~S2-BH239 (d)~~	~~0.35~~	~~CS2~~	~~Yes~~
S2-BH240	0.78	CS2	No
S2-BH242	0.01	CS2*	No
S2-BH243 (d)	0.08	CS2	Yes
S2-BH243 (s)	0.00	CS2*	No
S2-BH244 (s)	0.01	CS2*	No
~~S2-BH244 (d)~~	~~0.06~~	~~CS2*~~	~~Yes~~
S2-BH245	0.01	CS2*	No
S2-BH246 (s)	0.01	CS2*	No
~~S2-BH246 (d)~~	~~0.30~~	~~CS2~~	~~Yes~~
S2-BH247 (d)	0.01	CS2*	No
S2-BH247 (s)	0.00	CS1	Occasionally Flooded
~~S2-BH248 (d)~~	~~0.08~~	~~CS2~~	~~Yes~~
S2-BH248 (s)	0.01	CS2*	No
S2-BH249 (s)	0.02	CS2*	No
S2-BH249 (d)	0.01	CS2*	No



Location	Max Qhg/GSV (l/hr)	Characteristic Situation	Response Zone Flooded
S2-BH250 (d)	0.20	CS2	Yes
S2-BH250 (s)	0.30	CS2*	No
S2-BH252 (s)	0.00	CS2*	No
~~S2-BH252 (d)~~	~~0.12~~	~~CS2~~	~~Yes~~
S2-BH261 (d)	0.07	CS2	Occasionally Flooded
S2-BH261 (s)	0.01	CS2*	Occasionally Flooded

*CIRIA 665 indicates that if carbon dioxide is recorded above 5%v/v, or methane is above 1%v/v then consideration should be made to increase to CS2 and at these locations CS1 has been upgraded to CS2 as a viable source of gas is considered to be present.

Grey shaded cells indicate flooded monitoring well and data has been excluded from the assessment

Based on the methodology provided in Section 8.4.6, the exploratory holes record GSVs corresponding to a CS2 (low risk). If flooded boreholes that have flows that are not considered to be representative were included (S1-BH102 and S1-BH105) two locations would be classified as CS3 (moderate risk). Although S1-BH102 and S1-BH105 were calculated as a CS3, this was due to elevated flow rates recorded when the monitoring wells were flooded which will not provide an accurate representation of the gas regime underlying the site.

CIRIA C665 indicates that if carbon dioxide is recorded above 5% v/v, or methane is above 1% v/v, then consideration should be made to increase to CS2. On this basis the characteristic situations for BH34, S1-BH113, S2-BH247, S2-BH248 (d), S2-BH250 (d) and S2-BH252 (d) have been revised up to CS2 ("low risk").

When a GSV is calculated using the maximum flow (7 l/hr) and gas concentrations (13.8% carbon dioxide) of the Washery data set a GSV of 0.97 l/hr, which equates to Characterisation Situation 3 (CS3), is calculated.

Maximum hydrogen sulphide concentrations (3 ppm) below both the short (5 ppm) and long term (10 ppm) exposure limits were recorded on one occasion following site works in S2-BH243 in the south-eastern section of the site. Maximum carbon monoxide concentrations (88 ppm) were recorded above the long term (30 ppm) exposure limit on one occasion following site works in S1-BH105, located east of the site's centre. The concentration was below the short-term limit (200 ppm).

Oxygen concentrations ranged between 1% and 21.30%. The majority of monitoring wells recorded reduced oxygen concentrations of below 17.5% during the monitoring period.

8.4.8 Conclusion & Discussion

Several historical mine workings have been identified beneath the site and within close proximity to the site. The site is therefore considered to be at risk from coal mining gas and ground gas, for the following reasons:

- The risk of gas migration is greatest from shallow workings, less than 30 m from the surface [42]. Mine workings have been identified beneath site at depths of 10-20 m bgl. Coal levels are inferred to sub-crop within the site's SWCM with a limited thickness of overlying Made Ground or superficial geology. The cut and fill planned as part of the development will locally increase and locally decrease the depth to coal horizons and mine workings. Generally reducing the depth in the south-east and increasing it in the west of the site;
- According to the Coal Authority a fault runs through the site, which could provide a pathway for mine gases to reach the surface from underground mining either beneath site or off-site;
- Two adits and a shaft have been identified in the north-east of the site, with a further shaft and two adits in sufficient proximity to the sites northern boundary that they also present gas migration pathways. A further two adits are present in the south of the site, with a shaft present 10 m south of the site boundary that is



within sufficient proximity to the site that it also presents a potential gas migration risk to buildings located within 50 m of its location. No evidence is available indicating that shafts and adits have been treated.

- On-site shaft 285210-026 is considered to pose a high risk from coal mine gas to buildings that would be located within 50 m of the shaft. Adits 284210-35 and 285210-26 are present in the east of the site and respectively extend south-west and south-east below the eastern site and off-site to the south;
- Off-site shaft 28210-29 is present approximately 15 m north, off-site shaft 284210-32 is present approximately 15 m south and considered to pose a high risk from coal mine gas to buildings that would be located within 50 m of the shaft. Off-site adits 284210-023 and 285210-001 are considered likely to respectively extend south and south-west below the site and then off-site to the south.
- Relatively thin superficial soils are present across the site, which are not anticipated to confine any underlying gas source in the SWCM. Made Ground on-site is primarily colliery spoil that was deposited in the 1900s onwards, this is also a potential source of ground gas;
- Methane, carbon dioxide and oxygen concentrations are such that there is a risk of explosion and asphyxiation present if the gas concentration encountered in monitoring wells were to be present within an enclosed space;
- Groundwater levels have been recorded at shallow depths (0.10m - 12.35 m bgl) across the site, indicating that the majority of mine workings are likely flooded, significantly reducing the likelihood of methane emissions, however SOP003 encountered air voids and there are therefore potentially some mine workings that are not flooded and present a greater risk; and
- Artesian conditions have been encountered in the west of the site and one borehole encountered sub-artesian conditions in the east of the site and there is a potential for degassing of dissolved methane or carbon dioxide where groundwater moves from confined to unconfined settings and associated pressure changes occur.

While mitigating factors are present, such as the age of the coal workings, evidence of elevated groundwater flooding workings across the majority of the site, and location of shafts away from the UKRRIN building, the factors above indicate historic mine workings represent a significant potential source of hazardous ground gases.

Due to the type, depth and age of coal mine workings on-site, nature of the development (absence of enclosed spaces where gas risk may occur) and site circumstances (water levels, geology and cover soils) it is considered that within the site, a **low risk** from coal mine gas is present where enclosed spaces (e.g. buildings) will not be present. A **moderate risk** is considered to be presented to any structures which have enclosed spaces such as the UKRRIN building and future structures such as train maintenance depot, electricity substation, maintenance sheds and Innovation Hub and Characterisation Situation 3 (CS3) is considered to be present. This represents a precautionary upgrade in protection requirements from CS2 due to the coal mine gas CSM and uncertainty about the site's true flow rates due to the presence of shallow groundwater levels flooding many monitoring wells.

Redevelopment of the site is not considered to pose an unacceptable risk to adjacent off-site residential and commercial land uses due to:

- The sites distance (56 m to 245 m) from receptors that are outside the footprint of the wider GCRE site;
- Age of workings and flooded nature of mine workings in the south of the site, and presence of considerable history of mine workings off-site to the south which is considered to pose a more plausible risk than on-site sources;
- On-site development is not considered to introduce a mechanism to drive off-site coal gas or ground gas migration;
- Ground gas monitoring data showing an off-site coal mine and ground gas source that is equivalent in potential to the on-site source; and



- Risks from other ground gas sources (peat and Made Ground) are considered to be lower than those presented by coal mine gas and to be adequately characterised by the by the conventional BS8485 risk assessment approach.

There is a potential for unacceptable risks to off-site receptors and on-site buildings to occur during the remediation of mine workings. Grouting workings has the potential to displace gases and groundwater that may then migrate and present a risk if not managed by appropriate working methodologies and risk assessment of the remediation works.

It should be noted that carbon monoxide exceeds its STEL in S1-BH05, while depleted oxygen levels are also present that would pose a risk of asphyxiation if present within confined spaces or on-site buildings. It is considered that gas protection installed to protect against coal mine gas risk will mitigate against this potential risk.

8.4.9 Gas Protection Recommendations

The following recommendations are made for gas protection:

- Coal mine gas and ground gas are not considered to present an unacceptable risk to the Earthworks as no enclosed spaces where gas could build up are contained within the Earthworks design.
- Mitigation measures for a CS3 level of risk will be required for the development based on BS8485:2015+A1:2019 [41] and the assessment of the coal mine gas risk. This represents a precautionary upgrade from CS2, taking account of the coal mine gas risk CSM and methane, carbon dioxide, oxygen and flow concentrations that were recorded on-site. Detailed design of ground gas protection measures within the site should be completed in accordance with CIRIA C801 [49] and CL:AIRE's Good practice in assessing mine gas emissions [42];
- Several shafts have been identified on-site and within close proximity to the site. Shafts pose a risk of ground gas migration where within 50 m of a structure and it is recommended that shafts locations are confirmed by GI, treated and / or buildings are not constructed within 50 m of any shaft locations. Figure 7-2 identifies the locations of mine shafts and adits recorded on-site and within sufficiently close proximity to pose a risk to on-site buildings.
- If piled foundation solutions are being considered, additional risk assessment will be required to assess the risks to future properties as the piling may result in direct pathways being created;
- BS8485 requires that ground gas monitoring datasets should include two readings from what are considered to be worst case conditions. These are conditions where pressure is falling rapidly and meets the requirements set out in TB17 [49]. Only one monitoring event undertaken coincides with worse case conditions. In order to increase confidence in the data set additional gas monitoring across the site is recommended to add a further instance of worst case ground gas generation conditions to the data set.
- Across the monitoring area, 20 out of 41 exploratory holes located within the site were flooded, and therefore flows and gas concentrations from these locations are not considered representative of the conditions underlying the Washery;
- With respect to mine gas risks specifically a key uncertainty in the site area is how groundwater levels change over the hydrogeological cycle and whether shallow mine workings identified will be flooded under all circumstances. The current assessment is precautionary and assumes that workings will not be permanently flooded due to the presence of two locations where unflooded voids were encountered. Data collected to date shows shallow groundwater (circa 0.1 m to 12.35 m bgl) between the months of November to August (recorded during three monitoring periods), but does not establish how groundwater levels vary with respect to seasonality and whether shallow mine workings will be permanently flooded (a lower risk scenario) or subject to seasonal inundation (a higher risk scenario). However, SOP003 encountered evidence that an adit within the Depot Area was not flooded and there is evidence that S2-BH262 is not completely flooded all the time, therefore a higher risk scenario has been considered to be present;

- Depleted oxygen levels (<17.5%) were recorded in BH29, BH30, BH31 (shallow), BH32, BH33, BH34 (shallow), BH34 (deep), S1-BH102, S1-BH103, S1-BH105, S1-BH113, SOP003.16, S2-BH239 (shallow), S2-BH239 (Deep), S2-BH240, S2-BH242, S2-BH243(Shallow), S2-BH244(Shallow), S2-BH244(Deep), S2-BH245, S2-BH246(Shallow), S2-BH246(Deep), S2-BH247(Deep), S2-BH247(Shallow), S2-BH248(Shallow), S2-BH249(Shallow), S2-BH249(Deep), S2-BH250(Deep), S2-BH250(Shallow), S2-BH252(Shallow), S2-BH261(Deep) and S2-BH261(Shallow). Appropriate health and safety measures should be implemented during any on-site works and a safe system of work must always be implemented to address risks of asphyxiation from elevated methane, carbon dioxide or reduced oxygen concentrations if entry to a confined space is required and unavoidable. Guidance issued by the HSE for working in confined spaces should be followed;
- Due to the flooding portions of the underground mine workings, artesian conditions in the east and sub-artesian conditions in the west of the site, dissolved methane may be present, which could potentially degas in significant quantities in the right conditions. Groundwater samples should be tested for dissolved methane, further GI completed and the gas risk re-assessed if buildings from Stage 2 and 3 works are planned in these locations;
- Once all monitoring works are complete, all boreholes and wells must be decommissioned through backfilling and sealed in a manner that prevents them acting as migration pathways for mine gas. Decommissioning on monitoring wells should be completed in line with the EA's Good practice in the decommissioning of redundant boreholes and wells [50];
- Where remediation of mine workings are proposed an assessment of the acute risks associated with the remediation measures e.g. grouting of workings and potential for displacement of mine gas will be required; and
- Further gas monitoring is recommended to reduce uncertainty and conservatism in the coal mine gas risk assessment with respect to Stage 2 and Stage 3 buildings in the south of the site.



9. Refined conceptual site model

The revised conceptual site model is based on the data provided to data and attention is drawn to the data gaps discussion in Section 8. The methodology followed is as presented in Section 5.1.5.



Sources	Pathway	Receptor	Probability	Consequence	Classification of Risk	Recommendations
<u>On-site</u> Made Ground associated with historic and current industrial activities (coal washery, former colliery, railway land, spoil heaps). Infilled ground associated with underlying historic mine shafts, quarries, and workings. Potentially contaminated surface water / road run-off from current Mineral Railway and Coal Washery. Loss of hydrocarbons / chemical from on-site AST. Localised spillages of hydrocarbons/fuels from current Mineral Railway activities. Historic contamination associated with historic industrial activities. Natural soils with a potential to generate ground gases (peat). Coal mine gas from Made Ground and shallow mine workings Possible contaminants include: - Asbestos; - Metals; - Phenols - Cyanides - PAHs; - Petroleum hydrocarbons; - VOCs/SVOCs; - PCBs; and - Ground gases and mine gas (methane, carbon dioxide, hydrogen sulphide or carbon monoxide) originating from Made Ground / shallow coal workings.	Inhalation, ingestion and dermal contact with contaminants in soil and soil derived dust.	<u>Human Health</u> future users of site: site workers and maintenance staff during the operational phase	Low	Medium	Moderate/Low Of the determinands tested, a single exceedance of the assessment criteria was recorded for lead and was located in S1-BH106 at a depth of 2.50 m bgl outside of the footprint of the Earthworks and stage 1 development. The remaining determinands were recorded at concentrations that are below the assessment criteria. There is a potential for unanticipated contamination to be present within the sites Made Ground between GI locations or in areas where access constraints have prevented GI works occurring. Risk from determinands other than asbestos are considered to be Moderate/Low.	Post-construction it is anticipated that ground cover at the site will predominantly comprise minimal areas of exposed bare soil due to the presence of ballast in areas of rail track, hardstanding (Building foundations) or areas of concrete / asphalt, with the remaining site subject to soft landscaping. Development will occur in a phased manner and a time gap will be present between earthworks / demolition occurring and the sites final development state. Additionally some trimming of the earthworks and a potential for erosion of the earthworks between its construction and construction of overlying rail track and buildings is anticipated. Bare soils may be exposed during construction, increasing the short-term potential of soil derived dust and dermal contact with soils. It is assumed that any potential risks to construction workers would be managed through robust risk assessments to identify appropriate PPE and working methods. Considerable Made Ground is present on-site and there is the potential to encounter contaminants during the excavation and reuse of this material a discovery strategy and verification testing is required to manage this uncertainty and demonstrate that soils intended for reuse on-site are suitable for use. This verification should be used to ensure the upper 1 m of the earthworks comprises of materials that do not pose an unacceptable risk to human health During earthworks construction verification testing and assessment should be undertaken if soils are to be re-used instead of remaining in-situ to demonstrate that they are suitable for re-use. A remediation strategy should be prepared, to include mitigation measures to ensure the risk posed by contaminants of concern is mitigated and to ensure reused material will be suitable for use. During construction works a watching brief is required to identify unanticipated contamination and to ensure that risks associated with a discovery are assessed and mitigated.
			Low	Severe	Moderate Asbestos was recorded in three of the samples tested and unrecorded asbestos may be present within the Made Ground and structures within the site that have not been demolished. There is a potential risk of undiscovered asbestos on-site and the consequent of exposure to asbestos is Severe, therefore the risk from asbestos is considered to be Moderate.	Two of the asbestos detects are located in areas outside of the Stage 1 works, the third is located within Made Ground underlying a Washery structure. Prior to demolition of any on-site buildings/structures, an asbestos demolition and refurbishment survey should be undertaken and its recommendations implemented. Additionally delineation of locations where asbestos has been detected in soil should occur in order to

						help manage the risks this material poses to construction workers during redevelopment and allow the Control of Asbestos Regulations (CAR) 2012 to be complied with. Earthworks should be constructed in a manner that ensures material that poses a risk to human health is overlain by 1 m of clean material. Specific requirements regarding asbestos risk mitigation can be included in a remediation strategy.
Migration of ground gases and vapours along preferential pathways such as permeable ground/services/mine workings/faults. Accumulation within enclosed spaces such as the UKRRIN building.. Inhalation/asphyxiation/explosion.		Low	Severe	Moderate Risk The shallow mine workings present beneath site are a significant potential source of ground gas / coal mine gas, with Made Ground on-site also posing a source with a lower potential for gas generation. Elevated methane, carbon dioxide and flow rates were recorded along with depleted oxygen levels. and the site was assigned as Characteristic Situation 3- Moderate Risk. Several aboveground storage tanks holding diesel or fuel oil are identified on-site. At the time of investigation these were still present. Soil analysis results (TPH CWG and BTEX), headspace readings and visual observations recorded in logs did not evidence a vapour source.		The proposed enclosed spaces should be designed with suitable gas protection measures for a CS3 site, with consideration of the correct building type, as defined by BS8485 [41] and CIRIA C801 [51] and calculated GSV. Further ground gas / coal mine gas / vapour characterisation work is recommended to inform the design of buildings proposed as part of the Stage 2 / 3 development. Gas protection verification. No entry into confined spaces without appropriate risk assessment, confined space training and appropriate mitigation during construction phase. Risk assessment and mitigation of gas risk due to potential displacement of gas/groundwater during mine working remediation if planned.
Migration of ground gas along strata and preferential pathways such as permeable ground/services/mine workings/faults leading to accumulation and explosion.	<u>Human Health</u> Wider Washery (areas outside of site): site workers and maintenance staff during the operational phase	Low	Severe	Moderate Risk Ground gas risk assessment has identified a viable source of coal mine gas and considers Characterisation Situation 3 to be likely to be present to receptors within the wider GCRE development footprint The risk to receptors that are outside of the GCRE planning redline is considered to be low due to the distances involved. Off-site receptors are considered to be at more significant risk from off-site ground gas sources. Piling may adjust the flow of mine gases on and off site and should be considered further if required.		Installation of gas protection to meet requirements of CS3 and the types of structures that are proposed is likely to be required within the wider Washery area. Gas protection verification in wider GCRE site footprint. No entry into confined spaces without risk assessment, confined space training and appropriate mitigation in wider GCRE development. Risk assessment and mitigation of gas risk due to displacement of gas / groundwater during on-site mine working remediation if planned. Additional development specific ground gas monitoring and further risk assessment in areas outside of earthworks footprint. Piling risk assessment to consider ground gas risks if piling designed.
	<u>Human Health</u> neighbouring residential properties, nearby commercial properties including the wider site	Unlikely	Severe	Low Risk The risk to receptors that are outside of the GCRE planning redline is considered to be low due to the distances involved. Off-site receptors are considered to be at more significant risk from off-site ground gas sources. Piling may adjust the flow of mine gases on and off site and should be considered further if required.		No unacceptable risks are considered to be posed by the site development to receptors outside of the GCRE planning boundary. · Risk assessment and mitigation of gas risk due to displacement of gas / groundwater during mine working remediation if planned.



						Additional development specific ground gas monitoring and further risk assessment in areas outside of earthworks footprint. Piling risk assessment to consider ground gas risks if piling designed.
Migration of ground gas along strata and preferential pathways such as permeable ground/services/mine workings/faults leading to accumulation and explosion.	<u>Property and Services</u> <u>On-site buildings and enclosed spaces</u>	Low	Severe	Moderate Risk Ground gas risk assessment has identified a viable source of coal mine gas and considers Characterisation Situation 3 to be likely to be present to receptors within the wider GCRE development footprint. Risk relates to explosion and damage to buildings. Piling may adjust the flow of mine gases on and off site and should be considered further if required.	Installation of gas protection to meet requirements of CS3 and the types of structures that are proposed. Gas protection verification in wider GCRE site footprint. No entry into confined spaces without risk assessment, confined space training and appropriate mitigation in wider GCRE development. Risk assessment and mitigation of gas risk due to displacement of gas / groundwater during mine working remediation if planned. Additional development specific ground gas monitoring and further risk assessment in areas outside of earthworks footprint. Piling risk assessment to consider ground gas risks if piling designed.	
Inhalation and ingestion of wind-blown dust. Plant uptake. Leaching of contaminants and migration within groundwater.	<u>Property (wider Washery)</u> <u>Grazing Land and Livestock</u>	Low	Mild	Low Risk Made Ground is present beneath the majority of the site, with colliery spoil extending off-site south and north and into the wider Washery where livestock are grazed. On-site contaminants may potentially migrate to grazing land and livestock beyond the site’s boundaries via leaching to groundwater and wind-blown dust. However wider Washery soils originated from colliery spoil tipping and poses a greater risk than migration from within the site. Risks are considered to be low	Additional investigation of wider Washery area when development in this area is planned.	
Inhalation and ingestion of wind-blown dust. Plant uptake. Leaching of contaminants and migration within groundwater.	<u>Human Health</u> Off-site adjacent to the site boundary	Unlikely	Severe	Moderate/Low Asbestos was recorded in three of the samples tested and unrecorded asbestos may be present within the Made Ground and structures within the site that have not been demolished. There is a potential risk of undiscovered asbestos on-site and the consequent of exposure to asbestos is severe and consequently the risk from asbestos to off-site receptors is Moderate/Low, with the risk mitigated following completion of the development and placement of earthworks and buildings. Of the remaining determinands tested, an elevated concentration of lead was recorded in S1-BH106 at a depth of 2.50 m bgl. The remaining determinands were recorded at concentrations that are below the long-term human health assessment criteria for commercial land use. Risk from determinands other than asbestos are considered to be low. It is assumed that site work will be completed in accordance with CDM 2015 and CAR 2012 and controls will be in place to	Post-construction it is anticipated that ground cover at the site will predominantly comprise clean cover or impermeable surfacing with minimal areas of exposed bare soil. Bare soils may be exposed during construction, increasing the short-term potential of dust derived soils. Further testing and assessment should be undertaken if soils are to be re-used instead of remaining in-situ to demonstrate that they are suitable for re-use as part of a Watching Brief, Discovery Strategy and Materials Management Plan. Additionally investigation of locations on-site where characterisation works have been limited by access constraints such as the presence of structures / live services is recommended either as a standalone investigation or as part of the construction phase of works.	



				manage dust, this is considered to reduce the likelihood of the risk occurring during construction works to a negligible level.	Prior to demolition of any on-site buildings/structures, an asbestos demolition and refurbishment survey should be undertaken and its recommendations implemented. During construction works a watching brief is required to identify unanticipated contamination and to ensure that risks associated with a discovery are assessed and mitigated.
Direct contact of foundations/services with aggressive soils and or groundwater. Chemical attack to buried structures.	<u>Property and Services</u> neighbouring residential and commercial properties.	Low	Mild	Low Risk Current and future below ground infrastructure (e.g. water supply pipes) is assumed to have been / will be constructed to appropriate standards for the site to withstand attack from soil chemistry.	Concrete design to take account of aggressive ground conditions in accordance with BRE SD1 (DS-1, AC-1) [51].
Leaching or dissolution of contaminants in unsaturated soils and subsequent migration Lateral and vertical migration through Made Ground, superficial deposits and bedrock, mine workings (with either voids or infilled material), faults and artesian water. Migration via preferential pathways e.g. existing drainage, foul sewer, proposed service pipes/trenches.	<u>Groundwater Controlled Waters</u> Secondary A Aquifer (bedrock) Secondary Undifferentiated Aquifer (superficial aquifer)	Low	Medium	Moderate/Low Risk The works are likely to result in disturbance of soils and colliery spoil during excavation and construction which may result in the release of contaminants with a potential to migrate to groundwater, in addition to leachate generation during the operational phase. Groundwater below the site is present at a shallow depth and classified as a Secondary A Aquifers (SWCM) or secondary undifferentiated aquifer (Superficial deposits). Leachate and groundwater testing to date has shown that on-site soils pose a limited environmental risk. Exceedances of WQS were intermittently recorded for anthracene, benzo(a)pyrene, cadmium, chromium, copper, cyanide (total), fluoranthene, lead, manganese, nickel, PAHs, pH, sulphate, and zinc in leachate, groundwater and surface water samples. For the majority of determinands, no adverse correlation between soil leachate exceedances and groundwater/surface water exceedances was recorded, however potential risks from on-site soils were identified with regards to manganese.	DQRA is recommended to derive site-specific reuse criteria to determine whether the on-site soils are suitable for re-use within the Earthworks or the wider site, particularly for manganese where exceedances have been recorded. Where soils are proposed to be re-used, further leachate tests (including manganese) should be undertaken to provide further information on the concentrations of these determinands within the on-site soils as part of a Watching Brief, Discovery Strategy and Materials Management Plan. Reuse of soils to be undertaken via a Watching Brief, Discovery Strategy and Materials Management Plan in accordance with details to be specified in a Remediation Strategy.
Leaching or dissolution of contaminants in unsaturated soils and subsequent migration. Lateral and vertical migration through Made Ground, superficial deposits and bedrock, mine workings (with either voids or infilled material), faults, and artesian water. Surface water runoff. Migration of contaminated water in drainage ditches to controlled surface waters.	<u>Surface Water Controlled Waters</u> Camnant (10 m to east of site) and Dulais (680 m west site))	Low	Medium	Moderate/Low Risk For the majority of determinands, no adverse correlation between soil leachate exceedances and surface water exceedances was recorded. However potential risks from on-site soils were identified with regards to manganese. Elevated concentrations of manganese were recorded in groundwater and some surface water samples.	DQRA should be undertaken to derive site-specific criteria to determine whether the on-site soils are posing a risk to controlled waters, and whether soils are suitable for re-use on the Washery or the wider site, particularly for manganese where a wide range of exceedances have been recorded. Where soils are proposed to be re-used, further leachate tests (including manganese) should be undertaken to provide further information on the concentrations of these determinands within the on-site soils. Where soils are proposed to be re-used, further leachate tests (including manganese) should be undertaken to provide further information on the concentrations of these determinands within the on-site soils. Reuse of soils to be undertaken via a Watching Brief, Discovery Strategy and Materials



						Management Plan in accordance with details to be specified in a Remediation Strategy.
	Lateral migration of contaminated water within the aquifer. Intake and uptake of contaminants in soil and soil-derived dust by flora and fauna	<u>Ecological</u> Onllwyn Gorsllwyn SSSI 150 m north-east of the site	Unlikely	Medium	Low Risk Limited exceedances of EQS have been identified for on-site soil-leachate, groundwater and surface waters, with the majority of on-site surface water draining to the west towards the Dulais. A portion of the eastern site surface water will drain to the Camnant, with the distance from the site of the SSSI such that risk is considered to be Low to ecological receptors. Risks to the surface water feature are considered separately above. .	DQRA should be undertaken to derive site-specific criteria to determine whether the on-site soils are posing a risk to controlled waters, and whether soils are suitable for re-use on the Washery or the wider site, particularly for manganese where a wide range of exceedances have been recorded. Where soils are proposed to be re-used, further leachate tests (including manganese) should be undertaken to provide further information on the concentrations of these determinands within the on-site soils
<u>Off-site</u> Historical landfill within 80 m of site. Contamination and Made Ground associated with historical and current mining and quarrying activities. Potentially contaminated surface water/run-off from historical and current mining activities in Nant Helen and wider Washery areas. Possible contaminants include: - Asbestos - Metals - PAHs - Petroleum hydrocarbons - VOCs/SVOCs - Ground and mine gases (methane, carbon dioxide, hydrogen sulphide or carbon monoxide)	Inhalation, ingestion and dermal contact with contaminants in soil derived dust.	<u>Human Health –</u> future users on-site	Unlikely	Medium	Low Risk Off-site land uses in the wider Washery are similar in nature to those identified on-site, historical contaminating uses that are located outside of the Washery are typically covered by vegetation and not exposed directly to atmosphere risks are therefore considered to be Low.	No further actions required.
	Migration of ground gases along preferential pathways such as permeable ground/services/mine workings/faults. Accumulation within confined spaces such as the proposed UKRRIN building. Inhalation/asphyxiation/explosion		Likely	Medium	Moderate Risk Off-site Made Ground, spoil tips and mine workings present a potential sources of ground gases, which may migrate to site via permeable strata. Mine workings are identified at depths of <30 m and shafts / adits are recorded off-site and within the wider Washery area. The majority of off-site mine workings to the north and south are associated with the Dulais and Onllwyn Collieries and were therefore last worked prior to 1982, shafts and adits are also recorded to the north and south of the site. Groundwater levels are considered to be shallow, with mine workings likely to be flooded. The proposed earthworks do not present confined spaces where gas will present a risk, however the UKKRIN building will contained enclosed spaces where vapours and ground gases could potentially accumulate. Later stages of development will introduced additional buildings to the site with additional GI planned to inform their design. Off-site shafts, adits and workings are identified within close proximity to the site and present a risk that is characterised as CS3.	Installation of gas protection to meet requirements of CS3 / calculated GSV and for the types of structures that are proposed. Gas protection verification. No entry into confined spaces without risk assessment, confined space training and appropriate mitigation. Risk assessment and mitigation of gas risk due to displacement of gas/groundwater during mine working remediation if planned.
	Leaching or dissolution of contaminants in unsaturated soils and subsequent migration Lateral and vertical migration through Made Ground, superficial deposits and bedrock, mine workings (with either voids or infilled material), faults, and artesian water. Migration via preferential pathways e.g. existing drainage, foul sewer, proposed service pipes/trenches.	<u>Groundwater</u> <u>Controlled Waters</u> Secondary A Aquifer (bedrock) Secondary Undifferentiated (superficial aquifer)	Likely	Mild	Moderate/Low Risk Potential off-site sources have been identified, however groundwater monitoring within the site by AtkinsRéalis and monitoring from the wider Washery completed by Arup has not shown an off-site source that presents an unacceptable risk.	Further ground investigation and interpretive reporting will be undertaken on other portions of the wider site.



10. Materials management

10.1 Introduction

The primary aim of the intrusive investigation was to gather data for a geo-environmental risk assessment for site; the investigation was not designed to provide sufficient data to characterise all waste / materials in accordance with Environment Agency's Guidance on the classification and assessment of waste (1st Edition v1.2GB) Technical Guidance WM3 [52] (known herein as WM3) for off-site disposal at a landfill or treatment facility.

It should be noted that material reuse will need to either comply with Waste Framework Directive [53] (WFD) (where soils / geology are natural or contain anthropogenic material that is not classified as mining waste) or the Mining Waste Directive (MWD) [35] (where soil / overburden consists of spoil from mining activities). Reduce under the WFD would be most likely to be achieved via the DoW:CoP. Both the DoW:CoP and MWD require collection of verification data demonstrating that their requirements have been complied with during construction works to avoid regulatory action.

The DoW:CoP requires a Material Management Plan (MMP) to be prepared then declared by a Qualified Person (QP), then submission of a MMP Verification Report to CLAIRE. The MWD requires that a Waste Management Plan (WMP) is prepared if mining waste is not classified as inert waste or unpolluted spoil.

Within the site Made Ground is predominantly reworked natural material originating from past below ground mining of the SWCM. These works predate the WMD and the material was deposited in an uncontrolled and unregulated fashion on the valley floor from the 1800s onwards. The originating collieries were located to the north and south of the site and workings the material originated from came from the coal levels that are to the north and south of the site and wider Washery rather than the more recent open cast workings. The material is therefore not considered to be within its original depositional environment and the WFD is considered to apply rather than the MWD.

Additionally non-mining related anthropogenic and natural material is present that would also fall under the WFD if considered to be a waste.

Preliminary WM3 waste classification was undertaken on the geo-environmental data, which is summarised below. It is intended to provide the Client with a preliminary assessment on the potential waste classification of the soils at the site, rather than to characterise all materials that may be reused / disposed of on-site as considerable thicknesses of Made Ground are present that is not practical to fully assess via an intrusive site investigation, further characterisation for reuse will require inspection during excavation works.

Material that the holder discards or intends or is required to discard, or material that has no legal mechanism for re-use either on- or off-site, is classified as a 'waste' and should be disposed of in accordance with the Waste Framework Directive [53] and the Waste Duty of Care Code of Practice [54]. It is the waste producer's legal responsibility to accurately classify any waste arising from their works.

To classify waste materials for disposal, a number of steps should be undertaken in accordance WM3 [52]. The initial steps are to identify:

- if the materials are waste and whether classification is required;
- whether the waste is required to be classified at all;
- the relevant List of Waste (LoW) codes;

- the chemical composition of the material; and,
- if the substances in the waste are 'hazardous substances' or 'Persistent Organic Pollutants'.

Waste classification in the case of soils and excavated materials is undertaken on laboratory soils analysis, with Waste Acceptance Criteria (WAC) testing often undertaken in tandem to inform the type of landfill which would be considered suitable for the waste. WAC analysis is therefore not suitable to use as a standalone analysis for the assessment of waste.

There are a number of potential systems available to legally manage the re-use of site-won materials if appropriate, such as CL:AIRE's Definition of Waste Code of Practice [55] through the production of a MMP, specific registered waste exemptions, and/or operating under environmental permits. These approaches all require further consultation and specialist advice, which is outside the scope of this assessment and should be sought by the Client if applicable.

10.2 Waste Classification

A preliminary waste assessment based on the 181 samples collected during the three phases of ground investigation has been undertaken using the online HazWasteOnline waste classification tool [56]. HazWasteOnline has been designed to assess various waste types including those falling under Chapter 17 of the List of Wastes (LoW) "Construction and Demolition Waste (Including Excavated Soil from Contaminated Sites)" [57].

Chemical data available at the time of this report were assessed to determine the potential hazardous properties of the tested soils using contaminants commonly encountered in similar materials. Where concentrations less than the LOD were recorded, the value of the LOD was inputted into HazWasteOnline. Where applicable, appropriate metal species were selected based on worst-case hazard statements, site history, ground conditions, and likely compounds present in similar soils.

Analytical results from the 181 samples analysed were uploaded into HazWasteOnline and the output of the tool is provided in Appendix L.

The results indicate that six of the 181 samples, located across the site would be classified as hazardous, as follows:

- S1-BH103 2.2 m bgl: granular Made Ground comprising coal;
- S1-BH106 2.5 m bgl: granular Made Ground comprising coal;
- TP01 0.2 m bgl: granular Made Ground comprising brick, metal, glass and timber;
- TP02 1 m bgl: granular Made Ground comprising coal and ash;
- S2-TP270 0.5 m bgl: granular Made Ground comprising concrete, brick and clinker; and
- S2-TP2110 0.2 m bgl: granular Made Ground comprising bituminous bound material and brick.

Waste Acceptance Testing (WAC) indicates that sample S1-BH103 2.20 m bgl failed the stable non-reactive and hazardous landfill limits due to the high total organic carbon content of the material, indicating that this material would need treatment prior to disposal to a landfill.

Additionally during site walkover suspected visually ACM was visually identified in an area of hardstanding that was targeted by S1-TP115 (intended to investigate asbestos presence) and in S2-WS01, however no samples tested positive for asbestos in these locations. If visually identifiable asbestos is identified it would render associated waste as hazardous material if it contained asbestos at >0.1%. This area is located outside the footprint of the Earthworks and Stage 1 works.

The remaining 175 samples analysed would be classified as non-hazardous for off-site disposal purposes. Twenty seven inert WAC tests were undertaken on the non-hazardous materials. From these, 23 samples failed the inert criteria: S1-TP114 (0.3 m), S1-TP115 (0.2 m), S1-BH107 (0.3 m), S1-BH108 (0.3 m), S1-BH109 (3.7 m), S1-BH112 (0.5 m), S2-TP276 (0.9 m), S2-TP2101 (2.9 m), S2-TP2112 (0.9 m), S2-TP294 (2.9 m), S2-TP261 (0.9 m), S2-TP263 (0.9 m), S2-TP262 (0.9 m), S2-TP2115 (2.9 m), S2-BH250 (0.2 m), S2-TP271 (0.2 m), S2-TP2100 (0.2 m), S2-BH252 (0.5 m), S2-BH252 (4.7 m), S2-BH240 (0.2 m), S2-TP2104 (0.9 m), S2-TP2107 (0.2 m) and S2-TP277 (0.2 m). Four samples passed the inert WAC criteria, S1-BH112 (3.7 m, Glacial Till), S1-BH114 (1.7m, SWCM), S2-TP260 (1.9 m, Made Ground) and S2-BH242 (0.9 m, Made Ground). However, the sample from S2-BH242 was not tested for TOC or LOI which is what the majority of samples failed for. S2-BH240 (0.2 m) did not exceed TOC or LOI but did exceed total dissolved solids.

If excavated material is required to be disposed of, different materials should be stockpiled separately, particularly those suspected of being hazardous. Different material types should not be mixed, and confirmatory testing would be required on the material prior to disposal, to fully characterise the waste. However, there may be the potential for re-using much of the material excavated on-site, which would be preferable to disposal.

10.3 Limitations

This assessment provides a preliminary waste classification only. Limitations associated with this assessment may be due to the number of samples scheduled for chemical analysis, the analysis suite utilised, the way the samples were collected, and other various characteristics which may indicate the sampling was not undertaken in line with current standards and guidance specifically applicable for the assessment of waste.

As such, the results above should be taken as a preliminary assessment only. Actual waste materials to be removed off-site are likely to be subject to further sampling with appropriate laboratory analysis, which can then be used for classification by the waste producer as the responsible party.

Should any material from the site be considered for off-site disposal, liaison with any receiving facilities should be undertaken prior to disposal. Copies of the laboratory analysis undertaken to date should be presented to the facility operator(s) alongside any further testing completed by the waste producer so they can confirm their acceptance requirements; certain types of facilities may require further WAC testing to be undertaken prior to acceptance.

In addition to not comprising a full WM3 waste classification, this assessment will not be sufficient to allow accurate estimation of disposal fees, and as such Atkins is not liable for any commercial implications of the above assessment being used in such a manner.

Any material – not solely excavated materials – that needs to be discarded during the project works is potentially waste and should be disposed of in accordance with the current relevant regulations, guidance and best practice.



11. Geo-environmental conclusions

11.1 Human health risks from soils

Results of the soil screening process recorded one asbestos detect within the sites boundary and two in the Campus Area to the south . Additionally an exceedance of lead at S1-BH106 (located 35 m north-east of the site in the wider Washery) at a depth of 2.50 m bgl, indicates that the soil at this location could pose a human health risk to future users of this portion of the wider Washery. S1-BH106 is located in an overgrown area, formerly used for disposal of colliery spoil and is considered to be a hotspot. If this material were to be excavated as part of the cut and fill earthworks, the risk associated with the lead exceedance will be removed from the eastern part of the site. The hotspot soils can be suitably re-used in the proposed fill in accordance with a remediation strategy as long as the location of permanent placement is at least 1m below finished formation level.

Suspected asbestos was visually observed in S2-WS01 during the GI, and suspected as being present in the area adjacent to S1-TP115 during the site walkover, however samples from these locations did not identify asbestos as being present. Asbestos was detected in three of the 162 soil samples scheduled for laboratory analysis. The locations of asbestos detects are:

- Stage 1 Development (Depot Area)
 - S2-TP268 at 1.9 m depth (trial pit excavated below slab level in the footprint of one of the Washery buildings and within Stage 1 development) quantification recorded <0.001% chrysotile fibres / clumps ;
- Stage 2/3 Development (Campus Area)
 - S2-TP2108 at 0.5 m depth (trial pit targeting a 1000 litres AST adjacent to a machine repair shop). Quantification recorded 0.001% chrysotile fibres; and
 - S2-TP2114 at 0.2 m depth (trial pit targeting the grease store located 23 m south-east of TP2108). Quantification recorded <0.001% chrysotile fibres / clumps

These quantifications ranging from <0.001% to 0.001% represent a trace to low concentrations of asbestos.

S2-TP2108 and S2-TP2114 are located outside of the area where the Stage 1 construction works are planned and are in an area which will, following completion of the Stage 3 redevelopment, be overlain by hardstanding in the form of buildings, yard areas, roads and car parking or will have soft landscaping comprising imported topsoil placed. These will all mitigate the asbestos presence for the proposed development once constructed and operational. Risks posed to construction workers should be managed via compliance with the Control of Asbestos Regulations (2012) and it is recommended that delineation of asbestos occurs to inform construction phase risk management. The asbestos concentrations detected would, subject to compliance with CAR 2012, be suitable for re-used in the proposed fill in accordance with a remediation strategy as long as the location of permanent placement is at least 1 m below finished formation level.

Cut and fill is intended to produce the earthworks / Stage 1 development and a remediation method statement in conjunction with a materials management plan should be developed, and suitable mitigation measures employed to mitigate the risks from unanticipated contamination and variability of the sites Made Ground.



There is a potential risk that further asbestos may be present in Made Ground, especially around areas of former buildings. Mitigation of further asbestos, if found, should be considered as part of the construction works design.

Access constraints have limited investigation of several structures and potential sources of contamination in land that is to the south of the proposed earthworks and would be developed during Stage 3. Additional characterisation, following demolition works, is recommended at these locations to ensure that risks to end users are appropriately managed. This further characterisation can be completed as verification sampling under the remediation method statement. Evidence collected to date indicates that characterisation of these locations after demolition / access being enabled and in parallel to Stage 1 development will not pose an unacceptable risk to off-site receptors or the wider Washery to the south.

11.2 Ground gas / coal mine gas and vapour risks

Geology mapping and mining records, confirmed by ground investigation, have identified the presence of South Wales Middle and Lower Coal Measures at shallow depths (<30 m) below the site. Within the site area CA records record coal extraction from the Bluers and Peacock workings intruding under limited areas of the west of the site, additionally adits and shafts are identified within the sites footprint and within close proximity to the sites border where they present a risk to confined spaces where intended to be present.

Based on site historical information, the ground conditions encountered, and monitoring currently undertaken, it is considered that harmful ground gases pose a moderate risk to the human health and property receptors identified within the site. It is considered that ground gas risk is likely to be CS3 (Moderate Risk). Unflooded mine workings were encountered at SOP003 and it is considered possible for S2-BH262 (locations where a series of boreholes were drilled with the intention of identify a suspected mine working) to not be flooded in times of low groundwater flow and the presence of unflooded workings in other parts of the site has been assumed when assessing risks from coal mine gas.

Gas protection measures that deliver the level of protection required for the CS3 risk scenario by BS8485 and CIRIA C801 should be incorporated into the UKRRIN building. It is recommended that further gas characterisation is completed to reduce uncertainty and inform the design of buildings within the site that would be completed during the Stage 2/3 development works. A Remediation Method Statement setting out what this gas protection will be, how it will be delivered and verification actions will require production and submission to the LPA for approval before development of buildings can commence.

Borehole and trial pit logs, headspace testing, and soil TPH CWG and BTEX analysis results do not provide evidence of a vapour risk on-site, however further investigation of locations where VOCs may be present should be completed prior to Stage 2 and 3 development.

Redevelopment of the site is not considered to pose an unacceptable risk to adjacent off-site residential and commercial land uses due to:

- the sites distance (56 m to 245 m) from receptors that are outside the footprint of the wider GCRE site;
- age of workings and flooded nature of mine workings in the south of the site, and presence of considerable history of mine workings off-site to the south;
- Ground gas monitoring data showing an off-site coal mine and ground gas source that is equivalent in potential to the on-site source; and
- Risks from other ground gas sources (peat and Made Ground) are considered to be lower than those presented by coal mine gas and to be adequately characterised by the by the conventional BS8485 [41] risk assessment approach.



Following a decision regarding mine working treatment (grouting / additional ground investigation / excavation) of shallow mining risks a standalone risk assessment will be required to address acute risks associated with the treatment of mine workings. Grouting workings has the potential to displace gases and ground water that may then migrate and present a risk if not managed by appropriate working methodologies and risk assessment of the remediation works.

Once all monitoring works are complete, all boreholes and wells must be decommissioned through backfilling and sealed in a manner that prevents them acting as migration pathways for mine gas, in accordance with the Environment Agency guidance for good practice for decommissioning redundant boreholes and wells, October 2012 [50].

11.3 Risks to controlled waters

The results of the leachate, groundwater and surface water testing mostly showed relatively limited and intermittent exceedances. For the majority of determinands, no apparent adverse correlation between soil-leachate exceedances and groundwater / surface water exceedances was recorded. No exceedances of TPH, or BTEX were recorded in the groundwater or surface water. Anthracene, benzo(a)pyrene, cadmium, chromium, copper, fluoranthene, lead, manganese, nickel, PAHs, pH, sulphate, and zinc were recorded at concentrations that intermittently exceeded water quality standards.

While generic WQS can be utilised for assessing reuse suitability a DQRA is recommended to derive site-specific criteria to determine whether soils are suitable for re-use on on-site or the wider GCRE development, particularly for manganese where a wide range of exceedances have been recorded. Undertaking a DQRA would reduce the quantity of material that is potentially unsuitable for use in the earthworks and reduce the quantities of material classified as a waste.

A remediation method statement should be developed, describing any proposed soil re-use alongside the derived acceptability criteria, and also detailing any remediation measures if deemed required. Where soils are proposed to be re-used during the earthworks construction, further leachate tests (including manganese) should be undertaken as part of the RMS / MMP requirements to provide further information on the concentrations of these determinands within the on-site soils. The leachate results should be compared to suitable acceptability criteria.

It is assumed that piled foundations are not required within the site. Should piled foundations be required the risk of creation of a preferential pathway should be assessed in a Piling Risk Assessment and the piles designed to mitigate the creation of a pathway for potential contamination.

11.4 Materials management

Materials reuse, where proposed, will need to comply with either the DoW:CoP [55], MWD [58] [59] or a relevant exemptions / permit. The DoW:CoP or MWD both require collection of verification data demonstrating that their requirements have been complied with during construction works to avoid regulatory action. Additionally, during earthworks a watching brief should be undertaken with screening of soils proposed for reuse and especially in areas of landscaping where exposure of future site staff to contaminants could occur.

It should be noted that material reuse will need to either comply with the DoW:CoP (where soils/geology are natural or contain anthropogenic material that is not classified as mining waste) or the MWD (where soil/overburden consists of spoil from mining activities). The DoW:CoP would require an MMP to be prepared then declared by a Qualified Person (QP), with verification activities undertaken during construction works, then submission of a MMP Verification Report to CLAIRE. The MWD requires that a



Waste Management Plan (WMP) is prepared if mining waste is not classified as inert waste. Within the site, geo-environmental verification sampling and analysis is needed to allow either approach to be followed.

Non-compliance with the waste regime exposes a developer or contractor to prosecution by the regulator and substantial fines, additional HMRC can require that landfill tax be paid on materials / wastes that they deem to have an incorrect waste classification or have been illegally landfilled.

11.5 Construction risks

Under current health and safety legislation, employers (i.e., the Contractor) are required to carry out their own appropriate health and safety risk assessments and mitigation actions to protect themselves and their employees, other human receptors and the environment from potential contamination. Such risks must be adequately mitigated by law, specifically The Construction (Design and Management) Regulations, 2015 (CDM) (Health and Safety Executive, 2015) which require that potential risks to Human Health and the environment from construction activities are appropriately identified and all necessary steps taken to eliminate/manage those risks.

The adoption of appropriate best practice environmental management during construction to mitigate potential risks to environmental receptors (e.g., minimisation of dust generation and migration, and controlled surface water run-off) should be incorporated in future site works.

Before demolition occurs it is recommended that refurbishment and demolition surveys are completed of all structures that may contain asbestos and if encountered asbestos will need to be removed in compliance with the Control of Asbestos Regulations (CAR) 2012.

Asbestos has been identified at low to trace concentrations in three locations with suspected visually identifiable asbestos noted in two further locations, but not confirmed by analysis. Asbestos data will need to be considered by the Principal Contractor / employer, an assessment made regarding the status of any works under CAR 2012 and, if CAR 2012 is considered to apply, an asbestos risks assessment and plan of works setting out mitigation such as asbestos controls, training requirements and what PPE/RPE is required will need to be prepared.

11.6 Geo-environmental recommendations

AtkinsRéalis has provided the following recommendations, these have been split into those that apply to Stage 1 development and those that apply to Stage 2/3:

Earthworks, trackbed and UKRRIN Building / Stage 1 Development

- A remediation method statement should be developed, and followed during construction, to ensure sufficient contamination mitigation measures are followed and the below bullet points are addressed;
- Completion of a controlled waters DQRA to further inform reuse of materials on-site. Currently an Earthworks formed of site won material is intended, but a portion of these soils exceed water quality standards. DQRA would enable derivation of site specific soil reuse criteria to avoid the direct use of over-conservative water quality standards as reuse standards where justifiable DQRA is envisaged as including those determinands that exceed EQS in soil-leachate or groundwater (anthracene, benzo(a)pyrene, cadmium, chromium, copper, fluoranthene, lead, manganese, nickel, sulphate, and zinc;
- Where soils are to be re-used options are under the MWD or WFD. Following completion of GI within the site it is considered that the most appropriate reuse option for the sites Made Ground is via an MMP which should be undertaken prior to any works or excavations taking place, with reuse



occurring in compliance with DoW:CoP. A watching brief and further verification testing for soils will be required where re-use is proposed;

- Not all buildings or structures within the Depot Area have been demolished (electricity sub-stations, Froth Building, Machine Repair Shop) and access constraints prevented access to some potential contamination sources. Additional investigation is required to characterise these locations before redevelopment of them occurs. It is considered that this additional investigation can be completed during the remediation phase or as additional characterisation works completed when further design information (building locations and outline design is understood);
- The UKRRIN building should be designed with suitable gas protection measures for a CS3 site and the identified coal mine gas risk, with consideration of the correct building type, as defined by BS8485 [41];
- The adoption of appropriate best practice environmental management during construction to mitigate potential risks to environmental receptors (e.g. minimisation of dust generation and migration, and controlled surface water run-off) should be incorporated in future site works, and recorded within a Construction Environmental Management Plan (CEMP);
- There is evidence for asbestos presence on-site specifically in the former Washery structures and as contamination present within Made Ground. A refurbishment and demolition asbestos survey should be undertaken by a suitably qualified person, prior to demolition of all on-site structures asbestos removal should be completed and verified during the demolition process. Groundworkers during the construction phase should be made aware of the possibility of encountering contaminated soils through toolbox talks and in particular the potential presence of asbestos. Appropriate risk assessments to mitigate exposure of the workforce and general public during development of the site will be required. The contractor will need to prepare a risk assessment which identifies a safe system of work to handle any Made Ground material including that which contains localised asbestos. The soil quality data recorded within this report should be recorded in the project risk register and health and safety file, and considered during any future sub-surface works;
- Completion of further groundwater sampling and monitoring, and ground gas / vapour monitoring to generate a site wide data set that is temporally contemporaneous and to inform further risk assessment and mitigation design.
- Following completion of additional monitoring an updated Coal Mining Risk Review and ground gas risk assessment should be completed;
- Where soils are proposed to be re-used, further soil-leachate tests (including manganese) should be undertaken as part of the RMS / MMP to determine whether they potentially pose an environmental risk. The leachate results should be compared to suitable acceptability criteria, and where the EQS / DWS are exceeded, DQRA may be required to derive site-specific criteria to determine whether the soils are suitable for use;
- Due to the inherent variability which can be expected, there is a possibility that previously unidentified contamination may be encountered. It is recommended that this uncertainty is considered within health and safety risk assessments and a watching brief / discovery strategy is provided during all excavation works in order to identify any unexpected, potentially contaminated ground conditions; and
- The geotechnical ground model and Earthworks design for the site is currently being developed. Once complete the ground gas risk assessment should be reviewed, in compliance with BS8485 [41], CIRIA C665 [40] and CL:AIREs Good Practice for Risk Assessment for Mine Gas Emissions [42];

Construction of further buildings, additional railway sidings and trackbed / Stage 2 and 3 Development

- Revision of ground gas risk assessment for proposed buildings based on additional monitoring data and the identified coal mine gas risk, with consideration of the correct building type, as defined by BS8485 [41];



- Not all buildings or structures on-site have been demolished and access constraints prevented access to some potential contamination sources. Additional investigation is required to characterise these locations before redevelopment of them occurs. It is considered that this additional investigation can be completed during the remediation phase or as additional characterisation works completed when further design information (building locations and outline design is understood);
- Once all monitoring works are complete, all boreholes and wells must be decommissioned through backfilling and sealed in a manner that prevents them acting as migration pathways for mine gas;
- A method to mitigate the potential risk of asbestos to human health should be designed based around proposed construction works. It is anticipated that placement of this material at least 1 m below finished formation level within the earthworks would remove this contaminant linkage and potential associated risk;
- Where soils are to be re-used, an MMP should be undertaken prior to any works or excavations taking place, in compliance with DoW:CoP. A watching brief and further verification testing for soils will be required where re-use is proposed; and
- A remediation method statement should be developed, and followed during construction, to ensure sufficient contamination mitigation measures are followed and the above bullet points are addressed.



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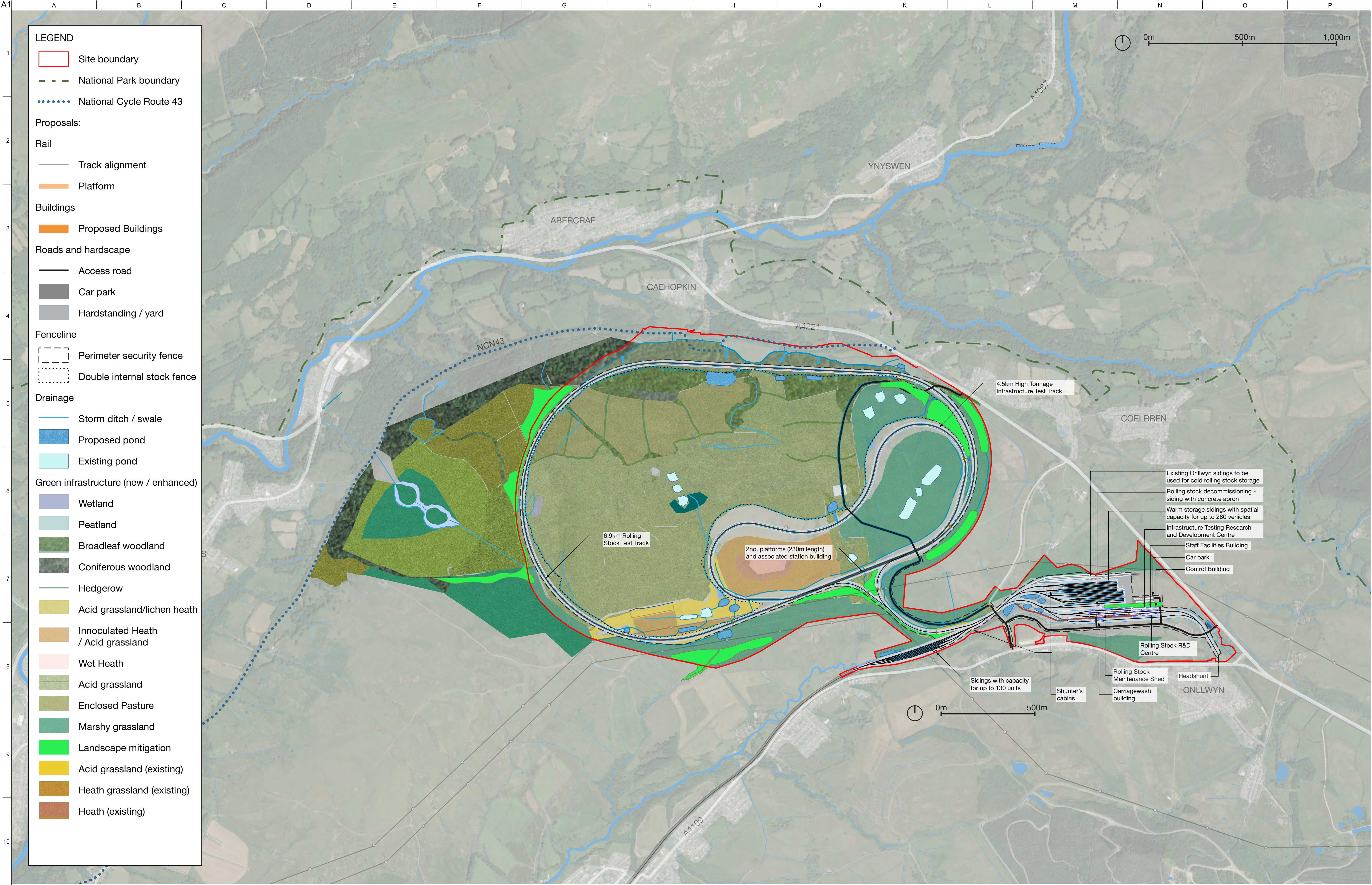


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APPENDICES



Appendix A. Drawings



02

25/05/21

BS

ER

DB

Issue

Date

By

Chkd

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Client

Welsh Government

Job Title

Global Centre for Rail Excellence

Drawing Title

Illustrative Masterplan

Scale at A1

1:10,000

Discipline

Planning

Job No

264904-00

Drawing Status

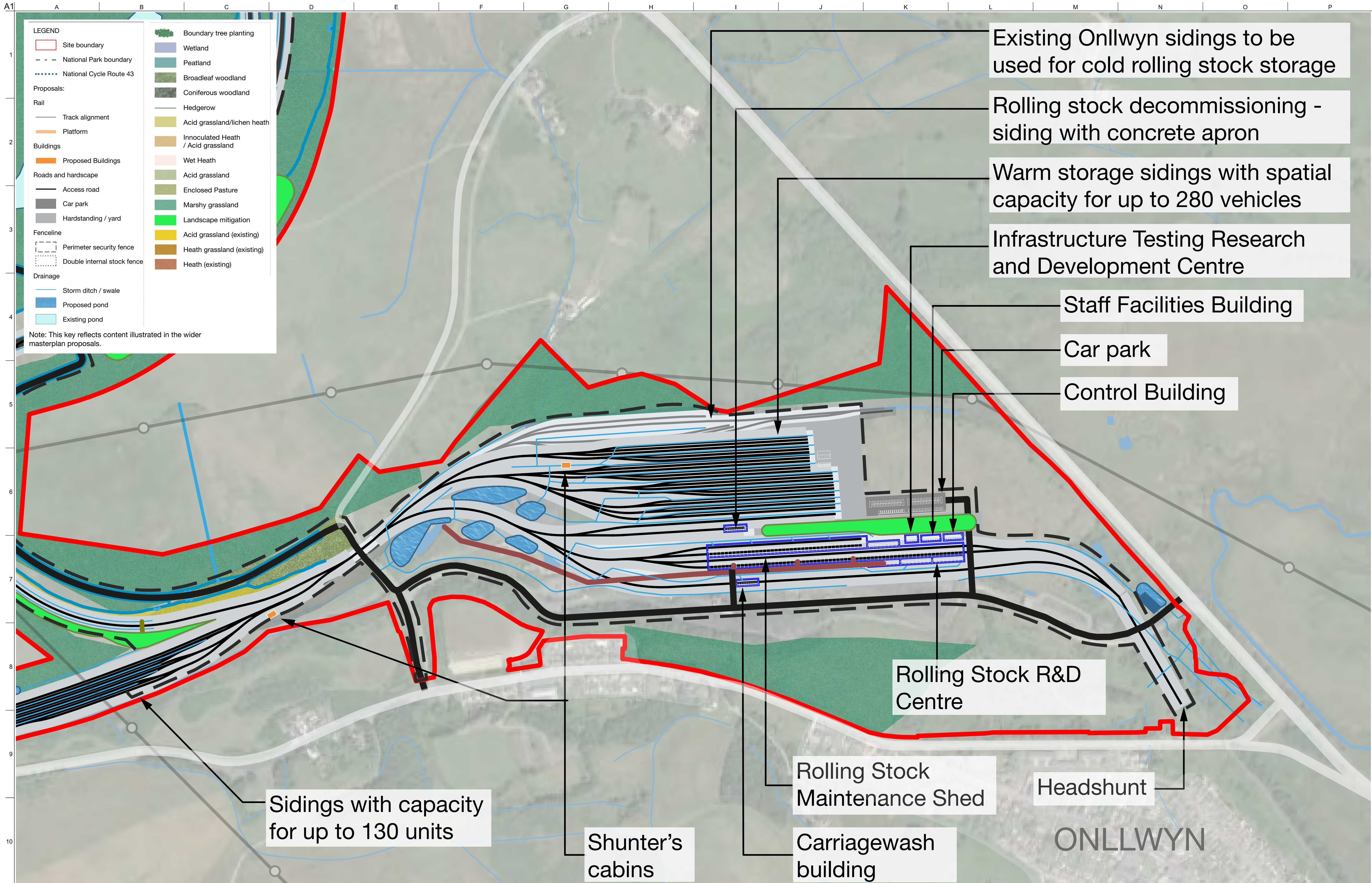
PLANNING

Drawing No

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Issue

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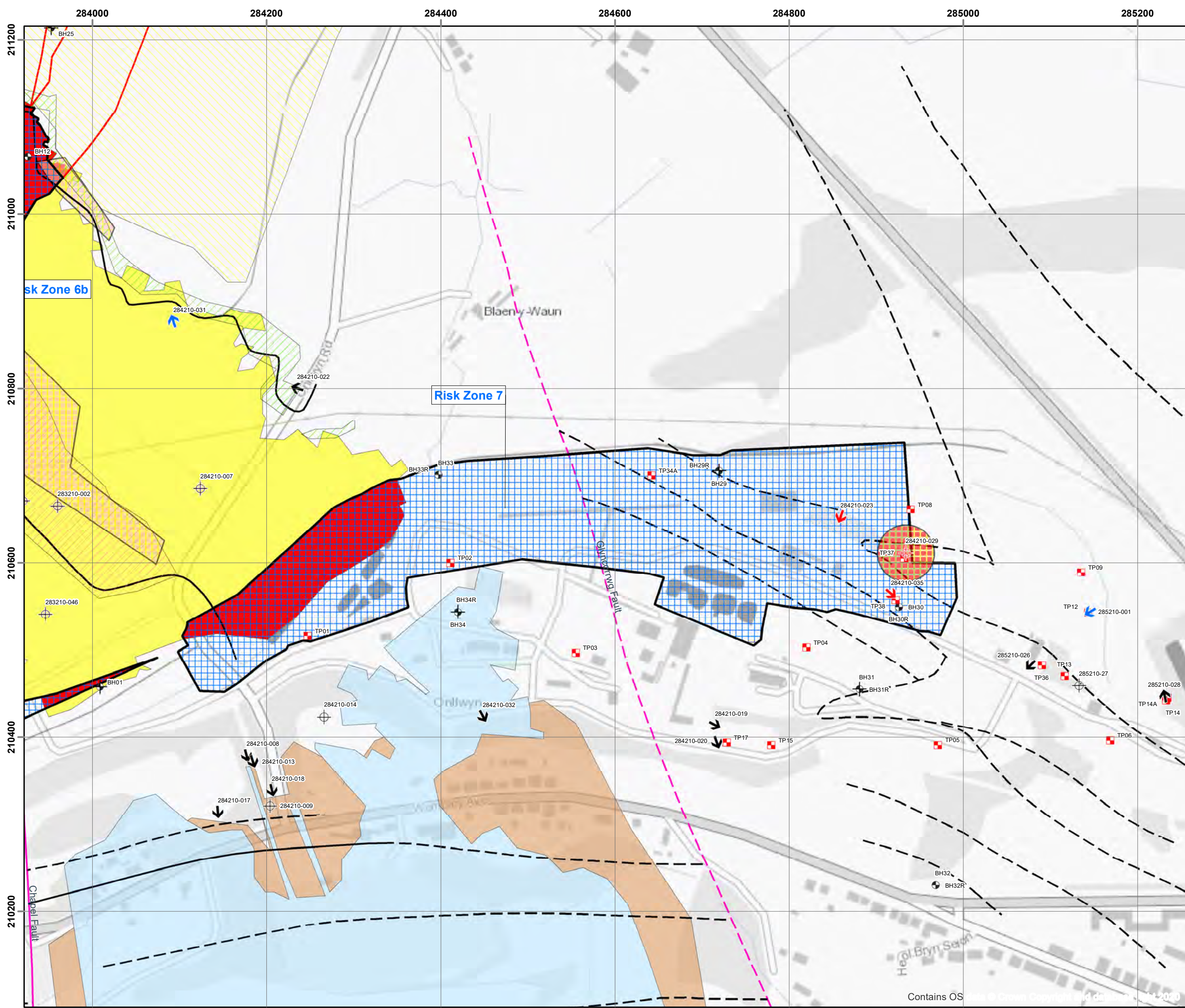
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Job Title
Global Centre for Rail Excellence

Drawing Title
Illustrative Masterplan -
Washery Proposals

Scale at A1 1:2,500	
Discipline	Planning
Job No	264904-00
Drawing No	003B
Drawing Status	PLANNING
Issue	02



Legend

Mining Risk Zones (MRZs)	Recorded shallow mine workings beneath the proposed alignment and Washery Area
Recorded adit	Abercrave Big underground working
Recorded adit entry point within the site	Onllwyn Bluers underground working
Recorded adit dipping beneath the site	Onllwyn Brass underground working
Recorded adit mouth likely extracted but roadway in-situ	Abercrave Black underground working
Recorded shaft	Abercrave Four Feet underground working
Recorded shaft within the site	Abercrave White underground working
Recorded shaft within 30 m of the site	Cwmtawe Bryn underground working
Rotary core borehole	Duffryn Bluers underground working
Rotary open borehole	Dulais Peacock underground working
Cable percussion borehole	International Four Feet underground working
Trial pit	Onllwyn - Peacock opencast (1946-1949)
Potential collapse risk zones for mine shafts	Onllwyn - Nine Feet opencast (1946-1949)
Coal seam, inferred (BGS)	Abercrave/Gwaunton opencast (1963-1973)
Coal seam, observed (BGS)	Onllwyn opencast (1972-1982)
Normal fault, inferred (BGS)	Nant Helen opencast (1986-1999)
Normal fault, observed (BGS)	Nant Helen Extension opencast (2002-2019)
Washery Area - Phase 1A Boundary (Arup, 2022)	
Proposed GCRC Alignment	
Evidence for bell pits	

NOTES

- Do not scale from this drawing.
- This drawing is not intended for design.
- The 'Washery Phase 1A Boundary' was derived from the Phase 1A Boundary shown on the 'Phase 1A Proposed Finished Levels' drawing by Arup (Drawing No. CG3500).

02550100

Metres

Coordinate System: British National Grid

1	DRAFT FOR ISSUE	HW	09/06/2022	PA	KP
VER	DESCRIPTION	BY	DATE	CHK'D	REVW AUTH
CLIENT: GCRC Co Ltd					
PROJECT: Global Centre for Rail Excellence					
TITLE: Overview of Mining Hazards (MRZ 7)					
SCALE: 1:4,000	ORIGINATOR: HW	CHECKED: PA	REVIEWED: KP	AUTHORISED: -	
SIZE: A3	DATE: 09/06/2022	DATE: 16/06/2020	DATE: 16/06/2022	DATE: -	
STATUS: DRAFT	DRAWING NO: 5209796-MRR-DWG005				VER: 1

KEY

Plan View

- Mining Risk Zones (MRZs)
- Washery Area - Phase 1A
- Boundary (Arup, 2022)
- Proposed GCRE Alignment

Recorded opencast Workings

- Onllwyn - Peacock opencast (1946-1949)
- Onllwyn - Nine Feet opencast (1946-1949)
- Abercrave/Gwaunton opencast (1963-1973)
- Onllwyn opencast (1972-1982)
- Nant Helen opencast (1986-1999)
- Nant Helen Extension opencast (2002-2019)

Recorded Mine Entries

- Adit
- Adit entry point within the site
- Adit dipping beneath the site
- Adit mouth likely extracted but roadway in-situ
- Shaft
- Shaft within the site
- Shaft within 30 m of the site

Exploratory Holes

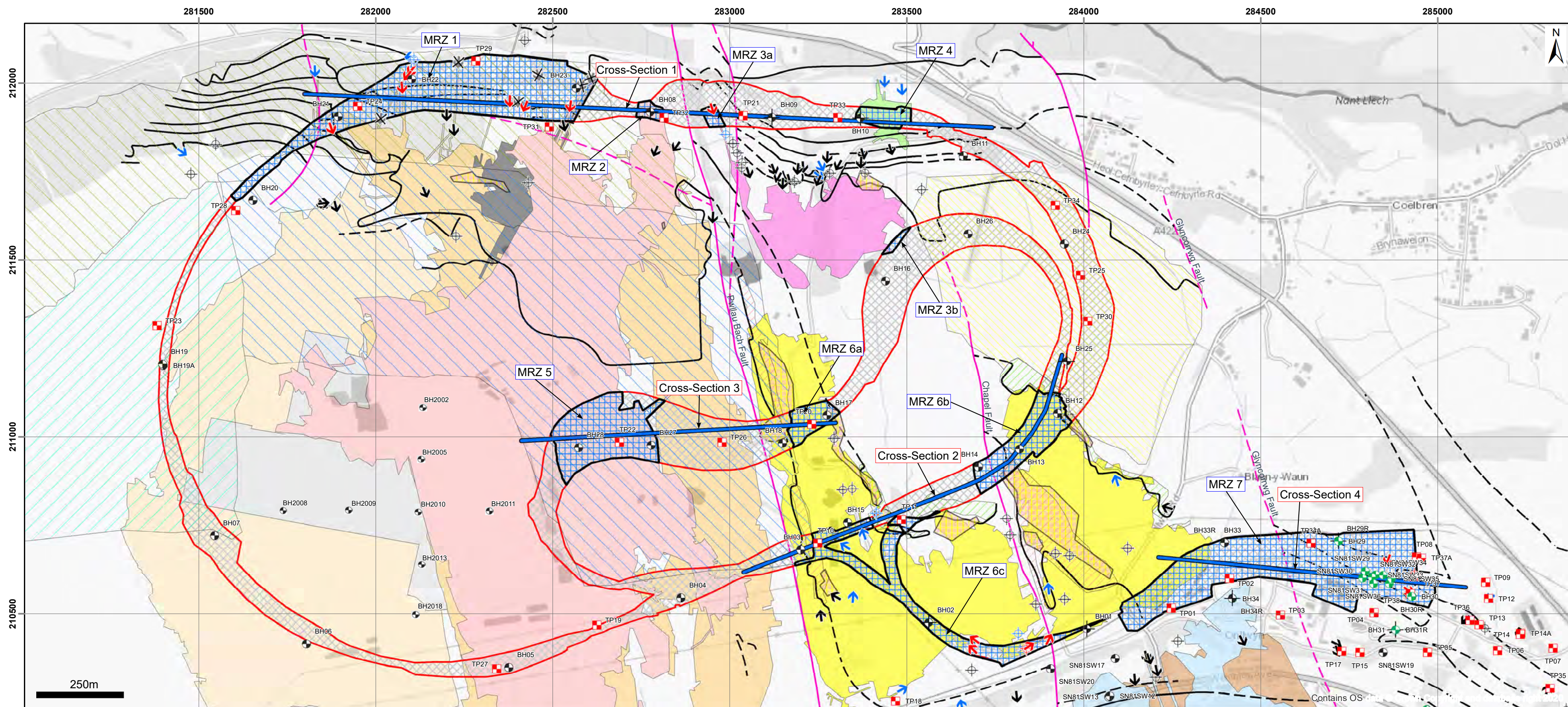
- Rotary cored
- Rotary open
- Cable percussion
- Trial pit

Cross Section

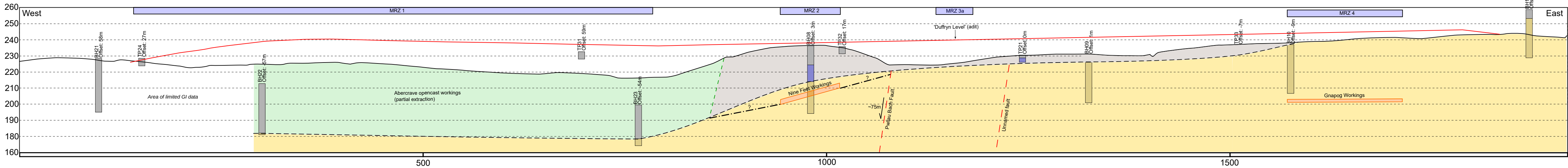
- Colours**
- Mining Risk Zones (MRZs)
 - Recorded opencast fill
 - Superficial cover (artificial and natural)
 - Interpreted bedrock
 - Peat
 - Made Ground
 - Glacial Till
 - Bedrock
 - Coal
 - Void
 - Recorded mine working
- Symbols**
- Existing ground surface
 - Proposed ground surface
 - Interpreted rockhead
 - Interpreted boundary of opencast area
 - Interpreted coal seam
 - Recorded fault
 - Recorded mine working
 - Fault displacement

NOTES

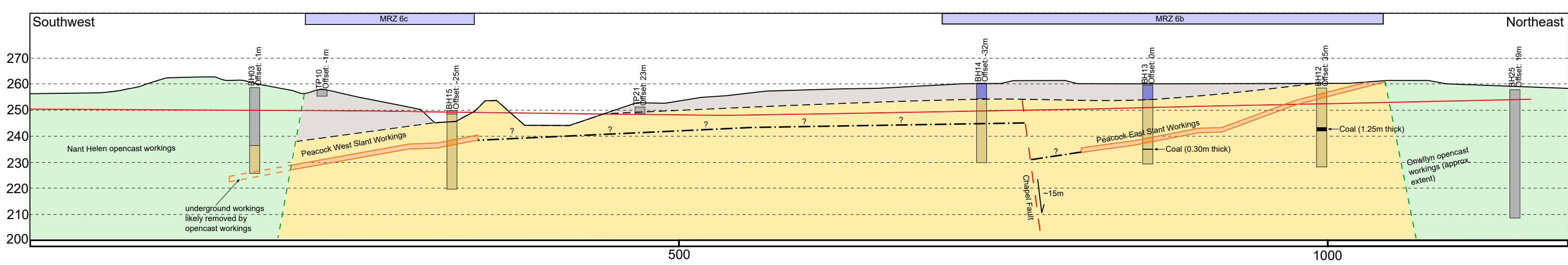
- This drawing and its contents have been prepared and are intended solely as information for GCRE Co. Ltd and use in relation to the Atkins GIR for the earthworks design and associated Mining Risk Review Document. Atkins Limited assumes no responsibility to any other party in respect of or arising out of or in connection with this drawing and/or its contents.
- Do not scale from this drawing.
- This drawing is not intended for design.
- This drawing and the cross-sections included therein represent an interpretation of the ground conditions on site from a limited ground investigation dataset. The true ground conditions may vary from those shown in this drawing.
- The levels of the recorded mine workings were approximated based on the mine abandonment plans available to Atkins at the time of origination. Atkins conservatively assumed that the levels shown on the mine abandonment plans represent the base of the mine workings.
- The ground investigation (GI) data includes the GI by Quantum Geotech (2021/22) and relevant holes provided by Celtic Energy and made available through the BGS Geotindex.
- The interpreted coal seam levels and interpreted rockhead levels are indicative only. The true levels of coal seams are likely to vary across the site in accordance with the variable dip of the bedrock.



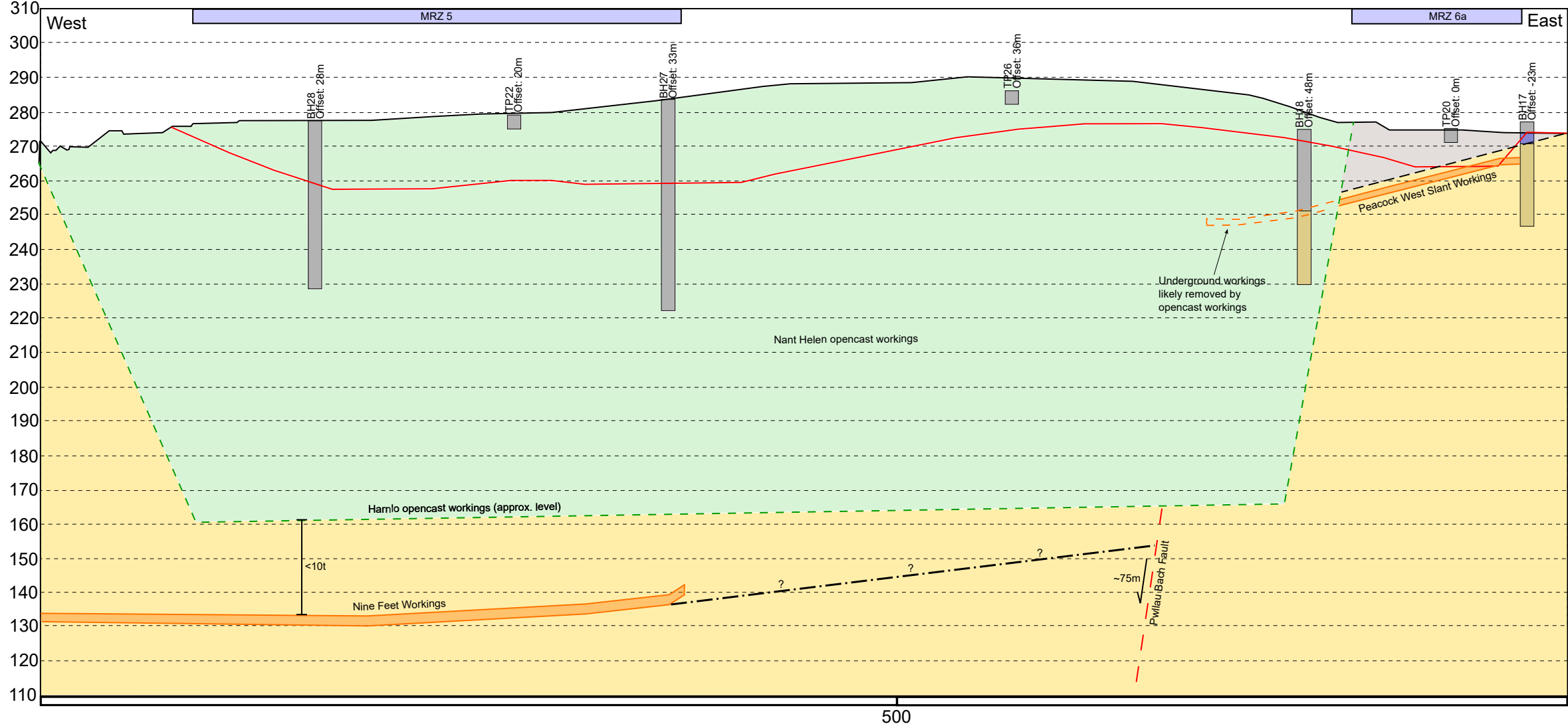
CROSS-SECTION 1



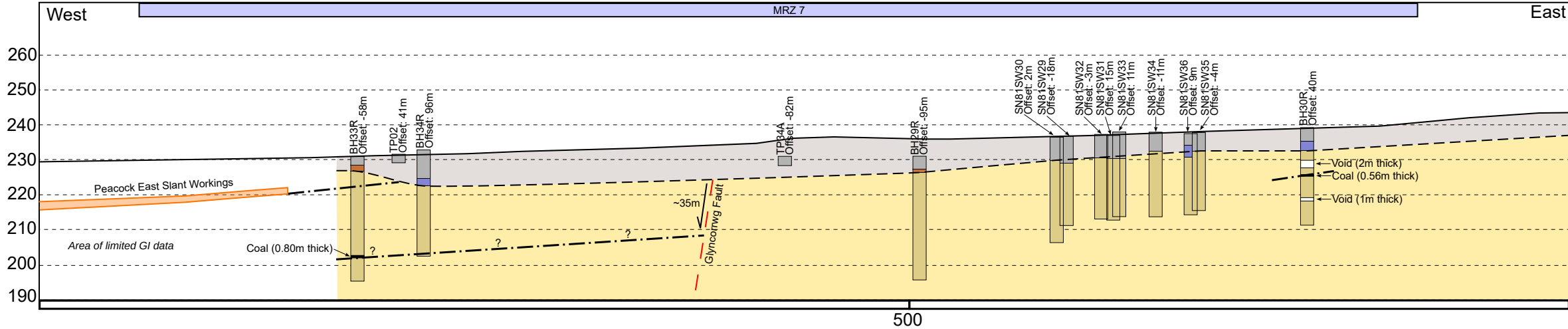
CROSS-SECTION 2



CROSS-SECTION 3

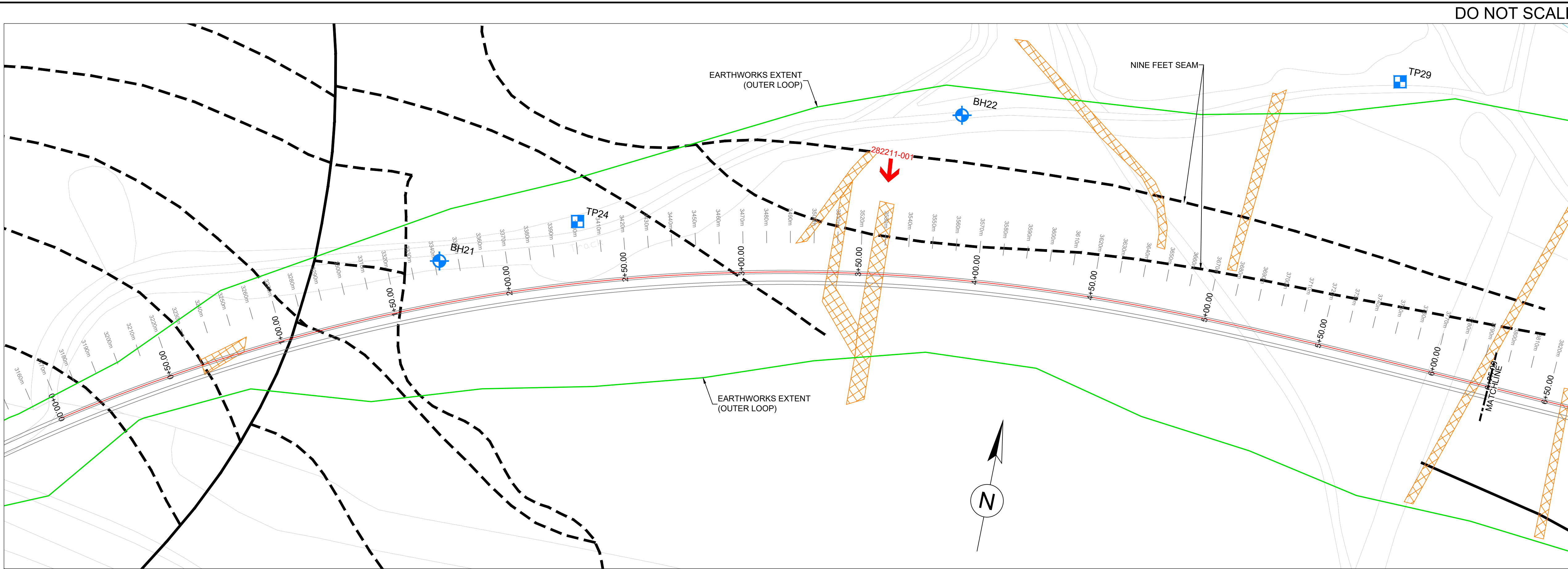


CROSS-SECTION 4



1	DRAFT FOR ISSUE	HW	16/06/2022	PA	KP	
VER	DESCRIPTION	BY	DATE	CHK'D	REV'D	AUTH
CLIENT:						
GCRC Co Ltd						
PROJECT:						
Global Centre of Rail Excellence						
TITLE:						
Mine Workings Cross Sections						
SCALE:	ORIGINATOR:	CHECKED:	REVIEWED:	AUTHORISED:		
N/A	HW	PA	KP			
SIZE:	DATE:	DATE:	DATE:	DATE:		
A1	16/06/2022	16/06/2022	16/06/2022			
STATUS:	DRAWING NO.:					VER:
DRAFT	5209796-MRR-DWG006					1

100
10
0
Millimetres



PLAN: OUTER LOOP NORTH EMBANKMENT
CHAINAGE 0+00 - 6+25m
1:1000

PROFILE LEGEND:

- EXISTING GROUND LEVEL
- EXISTING ROCKHEAD
- PROPOSED EARTHWORKS FORMATION
- APPROXIMATE BASE OF MINE WORKINGS
- ADIT (Estimated Location From Available Information)
- ADIT (Elevation Unknown - No Elevation Data)
- OVERBURN: OPENCAST FILL
- OVERBURN: MADE GROUND

BOREHOLE LEGEND:

- SUPERFICIAL AND ARTIFICIAL
- BEDROCK
- COAL
- NO RECOVERY

LEGEND:

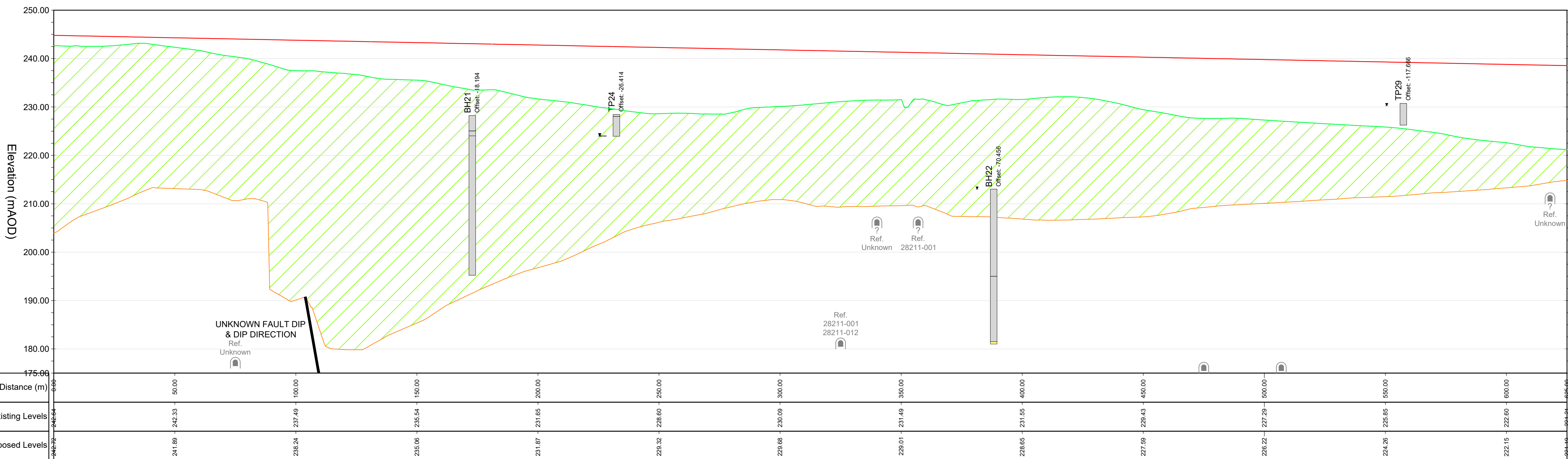
- MINE TREATMENT: DRILL AND GROUT
- MINE TREATMENT: EXCAVATE AND REPLACE
- ADIT PORTAL REQUIRING TREATMENT
- CENTRELINE OF LONGITUDINAL SECTION
- GEOLOGICAL FAULT
- COAL SEAM
- SHAFT NOT REQUIRING TREATMENT
- SHAFT REQUIRING TREATMENT

PRELIMINARY GROUND INVESTIGATION

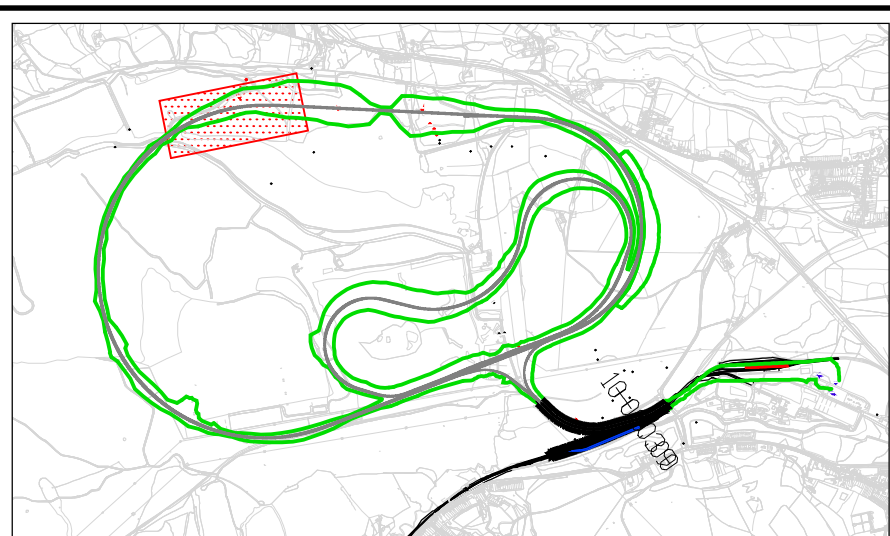
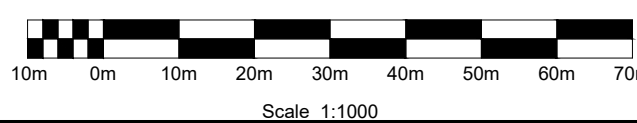
- BOREHOLE
- TRIAL PIT

COMPLETED ADDITIONAL GROUND INVESTIGATION - STAGE 1

- BOREHOLE
- TRIAL PIT



LONGITUDINAL SECTION: OUTER LOOP NORTH EMBANKMENT
CHAINAGE 0+00 - 6+25m
1:1000 HORIZ, 1:500 VERT



KEY PLAN

NOTES

- DRAWINGS TO BE READ IN CONJUNCTION WITH DESIGN INPUT STATEMENT INCLUDED IN THE GEOTECHNICAL DESIGN REPORT, MINE REMEDIATION PLANS (GCRE001-AWJV-00-XX-DR-GE-00021 TO 00028) AND THE SPECIFICATION FOR REMEDIATION OF WORKINGS.
- THE CONTRACTOR SHALL OBTAIN A COAL AUTHORITY PERMIT AND RELEVANT APPROVALS PRIOR TO UNDERTAKING WORKS.
- AN ARCHAEOLOGICAL WATCHING BRIEF WILL BE REQUIRED NEAR THE SCHEDULED MONUMENT AND MAY BE NECESSARY IN OTHER PARTS OF THE SITE.
- ECOLOGICAL APPROVAL SHALL BE OBTAINED FOR ANY VEGETATION CLEARANCE AT SURFACE REQUIRED TO FACILITATE WORKS.
- PROFILES COMBINE DATA FROM DIFFERENT SOURCES - THERE MAY BE DISPARITY BETWEEN BOREHOLE DATA AND ANTICIPATED BASE OF WORKINGS.
- THE 'APPROXIMATE BASE OF MINE WORKINGS' SURFACE WAS DERIVED USING ELEVATION ANNOTATIONS ON THE MINE ABANDONMENT PLANS. THESE VALUES ARE APPROXIMATE AND ASSUMED TO REPRESENT THE CURRENT PAVEMENT LEVEL OF THE MINE WORKINGS.
- COAL AND FAULT OUTCROP LOCATIONS ARE FROM THE BGS 1:10K DATA SERIES. FAULT DIP, DIP DIRECTION AND THROW ARE BASED ON PUBLISHED INFORMATION AND ARE APPROXIMATE ONLY.
- SCHEME-SPECIFIC EXPLORATORY HOLE RECORDS WERE CONDUCTED BY QUANTUM GEOTECH IN 2021/22 AND PROVIDED BY ARUP. THE OPEN ACCESS EXPLORATORY HOLE RECORDS WERE FROM THE BGS.
- ADIT LOCATIONS SHOWN ON THE LONG-SECTIONS WERE ESTIMATED FROM MINE ABANDONMENT PLANS AND ARE APPROXIMATELY ONLY. INDICATIVE ADIT ELEVATIONS ARE SHOWN WHERE NO ELEVATION DATA IS PROVIDED.
- AREAS PROPOSED FOR REMEDIATION TO BE REVIEWED AGAINST EXPECTED CHANGES IN EARTHWORKS FOOTPRINT PRIOR TO CONSTRUCTION.
- 0+00m ON LOCAL CHAINAGE SYSTEM RELATES TO CH 31+69m ON ARCADIS TRACK DESIGN MODEL (AUGUST 2022).
- ONLY THE ADITS REQUIRING TREATMENT OR THAT HAVE BEEN INVESTIGATED ARE SHOWN ON THESE PLANS; ALL OTHER ADITS WERE OMITTED FOR DRAWING CLARITY.
- FOR SOP001, SOP002 AND SOP00, ONLY THE PROBE HOLES THAT ENCOUNTERED EVIDENCE FOR MINE WORKINGS ARE SHOWN ON THE LONG SECTION. THE OTHER HOLES WERE OMITTED FOR CLARITY PURPOSES.

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following:

CONSTRUCTION

- Collapse of known mine-workings and/or mine entries.
- Collapse of unknown mine-workings and/or mine entries.
- Mine gas may be present within workings.
- Contaminated mine water may be present within workings.
- Ignition of coal seams.

MAINTENANCE/CLEANING

- Prior to each train test a track survey shall be undertaken to assess conditions and confirm any changes in track level.
- Visual inspection of voids and crown holes shall be undertaken in parallel
- Where evidence of voids or other collapse is identified train tests shall be suspended until remediation has been completed.

DECOMMISSIONING/DEMOLITION

It is assumed that all works will be carried out by a competent contractor working, where appropriate, to an approved method statement

Rev.	Date	Description	By	Chk'd	App'd
P01.01	---	PRELIMINARY	---	---	---

Drawing Status	Suitability
Initial non-contractual code	S0

WALTERS

ATKINS

Client

GCRE
Global Centre of Rail Excellence
Canolfan Fyd-Eang Rhagoriaeth Rheilffyrdd

Project Title
GLOBAL CENTRE OF RAIL EXCELLENCE

Drawing Title
MINING WORKINGS REMEDIATION
PLAN AND PROFILE
SHEET 1 OF 8

Scale 1:1000	Drawn ---	Checked ---	Approved ---	Authorised ---
Original Size A1	Date --/--	Date ---	Date ---	Date ---
Drawing Number GCRE001-AWJV-EW-XX-DR-GE-04001				Revision P01.0