

Client Name: Global Centre of Rail Excellence

Site: GCRE (Main Site)

Project No. 5209796

Photo No. SW-15 DP	Date: 12 July 2022	
Surface Water Feature SW-15 DP: Smaller lagoon, water storage area, probably lined with low permeability material, drainage/runoff from restoration area. No water flowing observed at the time. Approximate measurements 10m wide, 50m length. Measurements DO 134.57%, ORP 163.8 mV, Cond 1,602.50 ms/cm, pH 7.62, T19.55C The photo aspect is east.		

Photo No. SW-16 DP	Date: 12 July 2022	
Pump SW-16 DP: Pump present on northern boundary of SW16 CE holding lagoon. Pump not on at time of walkover. Connected to SW17 DP via pipes and presumed up to pumping uphill to this lagoon. The photo aspect is east		

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Photo No. SW-17 DP	Date: 12 July 2022	
Surface Water Feature SW-17 DP: Lagoon, water storage area, probably lined with low permeability material, drainage/runoff from restoration area. No water flowing observed at the time. Submersible pump working and pumping water to lagoon to north. Not able to access for water parameter measurements. Approximate measurements 30m wide, 55m length. The photo aspect is east.		

Photo No. SW-18 DP	Date: 12 July 2022	
Surface Water Feature SW-18 DP: Overflow / washout pond. Water observed to be silty. Measurements DO 92.29%, ORP 147.0 mV, Cond 199.29 ms/cm, pH 7.84, T22.79C. Approximate measurements 25m wide, 30m length. The photo aspect is south.		

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Photo No. SW-19 DP	Date: 12 July 2022	
Surface Water Feature SW-19 DP: Lagoon, water storage area, probably lined with low permeability material, drainage/runoff from restoration area. No water flowing observed at the time. Black and silty. Not able to access for water parameter measurements. Approximate measurements 20m wide, 40m length. The photo aspect is north.		

Photo No. SW-20 DP	Date: 12 July 2022	
Surface Water Feature SW-20 DP: Lagoon, water storage area, probably lined with low permeability material, drainage/runoff from restoration area. No water flowing observed at the time. Black and silty. Not able to access for water parameter measurements. Approximate measurements 26m wide, 80m length. The photo aspect is north.		

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Photo No. SW-21 DP	Date: 12 July 2022	
Surface Water Feature SW-21 DP: Lagoon, water storage area, probably lined with low permeability material, drainage/runoff from restoration area. No water flowing observed at the time. Black and silty. Approximate measurements 26m wide, 80m length. Measurements DO 39.87%, ORP 160.5 mV, Cond 680.60 ms/cm, pH 7.71, T20.00C The photo aspect is north.		

Photo No. SW-22 DP	Date: 12 July 2022	
Surface Water Feature SW-22 DP: Grassed ditch extending south from the holding lagoon area. No water flowing observed at the time. Stagnant standing water 25cm deep. Becomes vegetated along ditch. Tributary of Nany Ystalwyn, Approximate measurements 70m length, 1.20m deep 2.0 m wide. The photo aspect is south.		

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Photo No. SW-23 DP	Date: 12 July 2022	
Surface Water Feature SW-23 DP: Continuation of SW22-DP extending south. Rocky ditch No water flowing observed at the time. Standing water 20cm deep. Becomes vegetated along ditch. Labelled as Nany Ystalwyn, Approximate measurements 1.20m deep 2.0 m wide. Measurements DO 96.95%, ORP 164.8 mV, Cond 1,238.6 ms/cm, pH 8.17, T15.5C The photo aspect is south.		

Photo No. SW-24 DP	Date: 12 July 2022	
Surface Water Feature SW-23 DP: Dry grassed ditch No water flowing observed at the time. Extending south from the access track The photo aspect is south.		

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Photo No. SW-25 DP	Date: 12 July 2022	
Surface Water Feature SW-25 DP: Continuation of the east to west ditch to the north of the access track in the south of the site. The photo aspect is west.		

Photo No. SW-26 DP	Date: 12 July 2022	
Surface Water Feature SW-26 DP: Continuation of the east to west ditch to the north of the access track in the south of the site. Drop in elevation from the road, damp at base. The photo aspect is east.		

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Photo No. SW-27 DP	Date: 12 July 2022	
Surface Water Feature SW-27 DP: Rocky gully extending south from the access track. No water flowing observed at the time. Standing water 10cm deep. Becomes vegetated along ditch. Approximate measurements 2.20m deep 1.0 m wide. The photo aspect is south.		

Photo No. SW-28 DP	Date: 12 July 2022	
Surface Water Feature SW-28 DP: Continuation of SW27 DP, located north of the access track. Dry, grassy ditch. The photo aspect is north.		

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Photo No. SW-29 DP	Date: 12 July 2022	
Surface Water Feature SW-29 DP: Concrete lined spillway chute between SW31 and SW30. Approximately 20m long. The photo aspect is north.		

Photo No. SW-30 DP	Date: 12 July 2022	
Surface Water Feature SW-30 DP: One of two holding lagoon, water storage areas, probably lined with low permeability material, drainage/runoff from restoration area. No water flowing observed at the time. Approximate measurements 25m wide, 130m length. No access. The photo aspect is south west.		

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Photo No.	Date:	
SW-31 DP	12 July 2022	
Surface Water Feature SW-31 DP: Holding lagoon, water storage areas, probably lined with low permeability material, drainage/runoff from restoration area. No water flowing observed at the time. Approximate measurements 40m wide, 45m length. No access. Pump not operational during walkover. The photo aspect is north.		

Photo No.	Date:	
SW-32 DP	12 July 2022	
Surface Water Feature SW-32 DP: Holding lagoon, concrete lined drainage/runoff from restoration area. Possible wheel wash area. No water flowing observed at the time. Approximate measurements 10m wide, 5m length. No access. Pump not operational during walkover. The photo aspect is west.		

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Photo No. SW-33 DP	Date: 12 July 2022	
Surface Water Feature SW-33 DP: Black silty pond. Possible overspill from wheel wash area. Approximate measurements 5m wide, 10m length The photo aspect is west.		

Photo No. SW-34 DP	Date: 12 July 2022	
Surface Water Feature SW-34 DP: Overflow ditch, dry Approximate measurements 5m wide, 30m length The photo aspect is east.		

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Site: GCRE (Main Site)

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Photo No. SW-35 DP	Date: 12 July 2022	
Surface Water Feature SW-35 DP: Holding lagoon, water storage area, probably lined with low permeability material, drainage/runoff from restoration area. No water flowing observed at the time. Approximate measurements 25m wide, 20 m length. No access. Not accessible The photo aspect is north.		

Photo No. SW-36 DP	Date: 12 July 2022	
Surface Water Feature SW-36 DP: Holding lagoon, water storage area, probably lined with low permeability material, drainage/runoff from restoration area. No water flowing observed at the time. Approximate measurements 45m wide, 10 m length. No access. Not accessible The photo aspect is north.		

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Photo No. SW-37 DP	Date: 12 July 2022	
Surface Water Feature SW-37 DP: Rocky ditch with standing water, orientated east to west under road adjacent to the west. Approximate measurements 1m wide, 145 m length 0.6m deep. Measurements DO 96.25%, ORP 144.7 mV, Cond 344.20 ms/cm, pH 8.31, T16.5C The photo aspect is north.		

Photo No. SW-38 DP	Date: 12 July 2022	
Surface Water Feature SW-38 DP: Possible dry grassed ditch orientated north to south towards access track. The photo aspect is south.		

Client Name: Global Centre of Rail Excellence

Site: GCRE (Main Site)

Project No. 5209796

Photo No.
SW-39 DP

Date:
12 July
2022

Surface Water Feature SW-39 DP:

Steep rock gully, orientated north to south, dry with standing water in paces. Lows south towards River Dulais located 320 m south of photo location.

Measurements DO 95.5%, ORP 155.3 mV, Cond 412.5 ms/cm, pH 8.07, T15.4C
The photo aspect is north



Appendix E. Mining Risk Assessment

Global Centre of Rail Excellence (GCRE)

Coal Mining Risk Review

Walters Group

16/01/2023

GCRE001-AWJV-00-XX-RP-GE-00003



Notice

This document and its contents have been prepared and are intended solely as information for Walters Group and use in relation to GCRE.

Atkins Limited assumes no responsibility to any other party in respect of or arising out of or in connection with this document and/or its contents.

Document history

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Client signoff

Client	Walters Group
Project	Global Centre of Rail Excellence (GCRE)
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Executive Summary

Atkins Limited (Atkins), part of the SNC-Lavalin Group, 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 as the Global Centre of Rail Excellence (GCRE), a rolling stock and rail infrastructure testing facility.

The site is divided into two areas; the proposed GCRE track alignment at the 'Land at Nant Helen' and 'The Washery'. The proposed alignment surrounds and overlies the Nant Helen opencast workings (previously operated for extraction of coal by Celtic Energy and now in process of being restored) and covers an area spanning approximately 2.7 km by 1.9 km.

The site is within the influence of historic underground and more recent surface mining activities. Arup has previously completed a Geotechnical and Geoenvironmental Desk Study Report, Detailed Mine Workings Study and Ground Investigation Report to inform mining risks at the site.

Reinstatement of the open cast works and risks associated therein are discussed outside this report.

Arup completed the Desk Study in December 2019 and identified a number of mining risk zones across the proposed scheme area and recommended that a further assessment of the instability risk posed by coal mining was undertaken.

The Mine Workings Study, completed in June 2020, considered abandonment plans obtained from the CA to further refine the instability risk and make recommendations for GI.

A preliminary GI, incorporating positions to investigate mining risk, was completed between November 2021 and January 2022 with a GIR completed in May 2022, summarising the findings of the GI.

This work identified a significant instability risk to the proposed project from legacy coal mining activities within the Middle and Lower Coal Measures.

The risks posed can be summarised as:

- Shallow workings present within under the proposed alignment where rockhead cover is insufficient to prevent migration of voids to surface;
- Shafts with collapse zones that encroach on the proposed alignment;
- Adits and/or roadways present under the proposed alignment where rock head cover is insufficient to prevent migration of voids to surface; and;
- Presence of historical bell pitting.

Through this process Arup identified four Risk Zones (A, B, C and D) defined by the presence of underground workings. Atkins synthesised key information provided by Arup and reviewed this information against available mine abandonment plans from the Coal Authority, open cast completion plans from Celtic Energy and open-access information from both the BGS and the Coal Authority.

The results of this review generally agree with the four mining risk zones previously identified by Arup, with the zones sub-divided to ten areas. Nine MRZs are within the proposed track alignment and one MRZ in the Washery Area. The MRZ's are shown on Drawings GCRE001-AWJV-00-XX-DR-GE-00014 to GCRE001-AWJV-00-XX-DR-GE-00018.

In addition to the risks highlighted in the MRZs, Atkins considers there to be a high probability of unrecorded mine entries occurring across the entire site, but particularly within and surrounding the extents of recorded mine workings. Atkins also considers there to be high probability of unrecorded mine workings occurring across the site, similar to the apparently unrecorded workings identified in the Washery Area (MRZ 7).

To mitigate the risks it is considered that actions will be necessary to either 'dig out' or undertake drill and grout treatment of shallow mine workings where these are present below the 'earthwork formation' and where these have less than 20m of rock cover.

Further investigations, including a site walkover, are recommended to validate the results of the risk assessment and inform future pricing of the scheme.

Approval from the Coal Authority is required prior to any further intrusive investigation works.

Anecdotal evidence from the Celtic Energy indicates that the groundwater has been artificially depressed by pumping to prevent flooding of the opencast workings. Further anecdotal evidence from Celtic Energy indicates that pumping ceased in 2021 and it is anticipated that the hydrogeological regime is in the process of stabilising.

It is understood from communication with Celtic Energy that rebound has stabilised at between 100-120m AOD. Deep underground workings and adits draining to the River Tawe are believed to be responsible for maintaining the groundwater level at this elevation.

To satisfy regulatory requirements, a hydrogeological risk assessment will be required to show that the recommended stabilisation works will not cause any adverse effects to environmental receptors. It is recommended that further ground investigations and studies be carried out to inform the baseline hydrogeological conditions.

Ground gas monitoring has to date been targeted at the Made Ground and peat. As such the presence, or absence, and composition of mine gases is currently undefined. Further investigation and monitoring is required.

Remediation works will be required to mitigate the mining risk posed to the site. The treatment type will vary depending on the final arrangement and will be subject to the findings of the additional investigation. This will likely comprise either cut and fill for workings near surface or bulk infill stabilisation for deeper workings.

Remediation of mine entries is expected to comprise either bulk infill or concrete cap at surface. This will be reviewed once the entry arrangements and conditions have been confirmed. It is noted that a selection of entries are reported as having been remediated in the past. Information on the remediation strategy completed should be sought. Additional validation of the remediation may be required.

1. Introduction

1.1. Overview

Atkins Limited (Atkins), part of the SNC-Lavalin Group, 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 as the Global Centre of Rail Excellence (GCRE), a rolling stock and rail infrastructure testing facility.

The GCRE project entails the design and construction of a railway test track at the site of the former Nant Helen Opencast mine. High speed and low speed train tests will be undertaken at the proposed facility on two new test loops.

The site is understood to be within the influence of historic underground and more recent surface mining activities. Arup has previously completed a Geotechnical and Geoenvironmental Desk Study Report [1], Detailed Mine Workings Study [2] and Ground Investigation Report [3] for the site. This work identified a significant instability risk to the proposed project from legacy coal mining activities.

Atkins' commission includes the development of a Ground Investigation Report (GIR) in accordance with the Design Manual for Roads and Bridges (DMRB) CD622 managing Geotechnical Risk (CD622) [4], and the GCRE Employer's Requirements [5].

This document represents the Mining Risk Review (MRR) which will be included as an appendix to Atkins GIR.

1.2. Scope

The GCRE Employers Requirements [5] identify that workings are present in the Middle and Lower Coal Measures and that it will be necessary to either 'dig out' or undertake drill and grout treatment of shallow mine workings where these are present below the 'earthwork formation' and where these have less than 15-20m of rock cover. It is further noted that an intrusive Ground Investigation is required to refine the risk zoning and allow the areas of mineworking's that require treatment to be refined.

In support of these requirements a GIR is being produced for the overall scheme for which this Mine Risk Assessment is being prepared.

The objectives of this report are to:

- Provide a review and synthesis of the available previous reporting pertaining to mining for GCRE;
- Review existing datasets (see Section 1.4) pertaining to mining at the site;
- Provide an assessment of the current level of instability risk posed by mining activities,
- Present the instability risk to the proposed scheme due to previous mining activities with identification risk zones; and
- Recommend next steps, including preliminary recommendations with regards to remediation options.

This MRR does not cover the optioneering and remediation design.

1.3. Site Description

The site is located immediately south of the village of Abercraf, approximately 20 km northeast of Swansea, south Wales, as shown on Figure 1-1. The approximate centre of site is National Grid Reference SN 83290 11091.

The site is divided into two areas; the proposed GCRE track alignment and the Washery Area. The proposed alignment surrounds and overlies the Nant Helen opencast workings (previously operated for extraction of coal by Celtic Energy and now in process of being restored) and covers an area spanning approximately 2.7 km by 1.9 km.

The alignment comprises an inner loop test track and an outer loop test track with respective track lengths of approximate 4.0 km and 6.7 km respectively. The alignment construction will require earthworks in the form of cuttings and embankments as shown in Figure 1-1.

The Washery Area refers to the extension of the site to the southeast incorporating sidings, located between the villages of Coelbryn and Duffryn and immediately north of the A4109. Access to the wider UK rail network is through this area.

An extract of the project visualisation model of the proposed site is shown in Figure 1-2.

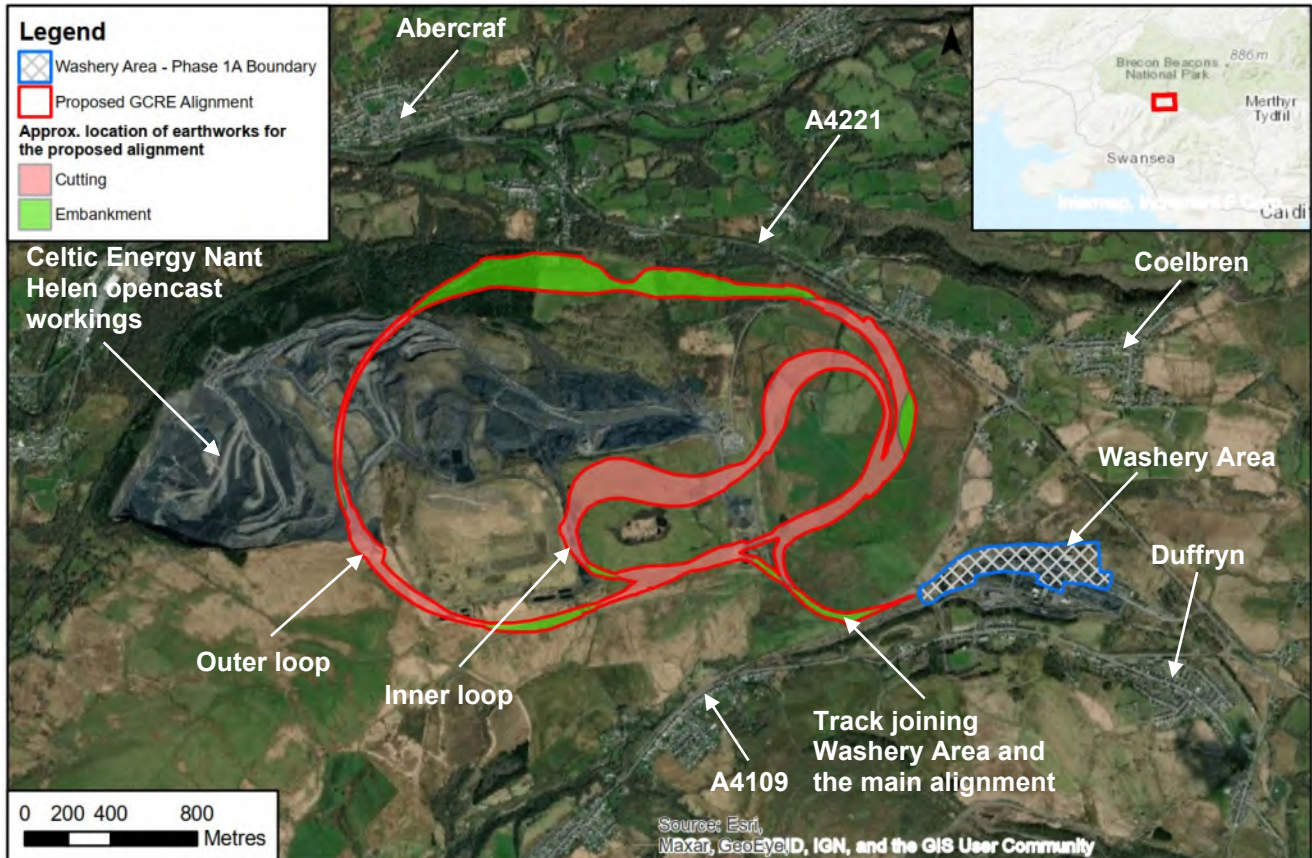


Figure 1-1 - Site map. The proposed earthwork locations were derived using Figure 8 from the Geotechnical and Geoenvironmental Desk Study Report by Arup [1] and are indicative only.



Figure 1-2 - Preliminary 3D model of the proposed scheme

1.4. Sources of Information

A combination of open-access resources from the Coal Authority (CA) and the British Geological Survey (BGS), datasets and reports provided by third parties (Arup and Celtic Energy) and purchased data from Groundsure have been used in compiling this review. Table 1-1 identifies the sources of information that were available to Atkins at the time of writing.

Table 1-1 - Sources of information

Owner	Type	Title	Status	Date
British Geological Survey	Online Interactive Map	GeoIndex [6]	Open-Access	N/A
	Geological Map	Merthyr Tydfil, Sheet 231, Solid Edition, 1:50:000 Series [7]	Published	1979
		Merthyr Tydfil, Sheet 231, Drift Edition, 1:50:000 Series [8]	Published	1979
The Coal Authority	Online Interactive Map	Interactive Map Viewer [9]	Open-Access	N/A
	Mine Abandonment Plans and Completion Plans [10]	<u>Abercraf and International Colliery</u>		
		12641_99 9999	Published	1939
		13040_99 9999	Published	1941/1954
		13041_99 9999	Published	1941
		SW203_99 9999_2 OF 2	Published	1953
		SW204_99 9999_2 OF 2	Published	1953
		SWA1077_22 8010	Published	1953
		SWA1077_22 8011	Published	1953
		SWA1077_22 8210	Published	1953
		SWA1077_22 8211	Published	1953
		SWA4053_22 8211	Published	1953
		SW198_99 9999	Published	1954
		SW341_22 8110	Published	1957
		SWR754_99 9999	Published	1967
		<u>Cwmtawe Anthracite Colliery</u>		
		10378_99 9999	Published	1929
		11122_99 9999_1 OF 4	Published	1933
		11122_99 9999_3 OF 4	Published	1933
		11122_99 9999_4 OF 4	Published	1933
		Tyn y Pant Colliery		
		SW2233_99 9999	Published	1901
		<u>Duffryn Anthracite Colliery</u>		
		6638_99 9999	Published	1916
		<u>Dulais Anthracite Colliery</u>		
		6784_99 9999_1 OF 2	Published	1918/1931
		8825_99 9999	Published	1926
		9796_99 9999	Published	1927
		11207_99 9999_1 OF 4	Published	1934
		11207_99 9999_3 OF 4	Published	1934
		11207_99 9999_4 OF 4	Published	1934
		<u>Onllwyn No.1 Colliery</u>		
		SW61_99 9999	Published	1949

Owner	Type	Title	Status	Date
		SW133_99 9999	Published	1951
		SW150_99 9999	Published	1953
		SWR750_99 9999	Published	1964
		<u>Ynyscedwyn Colliery</u>		
		12563_99 9999	Published	1939
		SWA1078_22 8010	Published	1953
		SWA4053_22 8011	Published	1953
Celtic Energy	Opencast Completion Plans [11]	Nan Helen Completion Plans	Issue	N/A
		Nan Helen Extension Completion Plans	Issue	N/A
		<u>Abercraf Gwaunton Opencast</u>		
		SWR2547_99 9999_1 OF 7 to 7 OF 7	Published	1981
		<u>Onllwyn Opencast</u>		
		SWR2909_99 9999_1 OF 2 and 2 OF 2	Published	1983
		SW164_99 9999	Published	1953
GCRE Co. Ltd	Employers Requirements	GCRE Earthworks – Volume 2 (C) GCRE Employers Requirements Document [5]	Issue	12 Sep. 2021
Arup	Desk Study	Land at Nant Helen and Onllwyn Coal Washery - Geotechnical and Geoenvironmental Desk Study [1]	Issue	18 Dec. 2019
	Mining Note	Detailed Mine Workings Study (Ref. 4-70) [2]	Issue	20 Jun. 2020
	GIR	Global Centre of Rail Excellence - Ground Investigation Report (Ref. 4-50) [3]	Draft	31 Mar. 2022
	Shapefiles	Risk Zones used in the Geotechnical and Geoenvironmental Desk Study. Areas of shallow mine workings used in the GIR. Nant Helen Geotechnical Borehole Locations. Location of underground workings. Mine entry location points; including the Easting, Northing, type, azimuth and Coal Authority ID.	N/A	N/A
Quantum Geotech	GI Factual Report	Global Centre of Rail Excellence Ground Investigation: Factual Report (Ref. Q0652/FR_01) [12]	Draft	7 Feb. 2022
	AGS data	Q0652 210222 [13]	Draft	24 Feb 2022
Pauley	3D model	'GCRE Scaled Assets' 3D model [14].	N/A	16 Dec 2021
Groundsure	Report	Groundsure Report (Ref: GSIP-2021-12345-10399) [15]	Issue	2022
	Shapefiles	Standard Groundsure reporting shapefiles, including but not limited to BGS geology, borehole locations and locations of opencast workings.	N/A	N/A

1.5. Assumptions and Report Limitations

This report has been prepared for use solely by GCRE Co. Ltd. Thereafter, this report shall not be relied upon, or transferred to any other parties without the express written consent of Atkins. If an unauthorised third party comes into possession of this report, they rely on its contents at their own risk.

Opinions and recommendations presented in this report are based upon information provided by third party sources. Atkins 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 Atkins' knowledge and belief, Atkins cannot guarantee the completeness or accuracy of any descriptions or conclusions based on supplied third party information.

The information presented in this report is geotechnical in nature. Any geological, geotechnical risk assessment considerations are based on an exploratory ground investigation and are subject to the 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/ground gas conditions vary seasonally. Therefore, unexpected ground conditions could occur between the sampling points and groundwater/ground gas conditions may differ from those encountered during the monitoring periods.

This review has been based on the current scheme at the time of writing, should the scheme proposals change as design develops or new information become available then a further review may be required.

1.5.1. Assumptions

The following assumptions and limitations are relevant throughout this report :

- This report relies on a variety of mine abandonment plans produced by former mine operators at the site (e.g., Celtic Energy). Atkins assumes these third party data are complete and that the details shown on the plans are accurate.
- A Site Walkover has not yet been undertaken to ground truth current conditions.
- The estimates of competent cover above conjectured workings consider the rockhead above seam pavement.
- Due to the limited data on the state of the workings, Atkins has assumed that all workings are open and have not collapsed at some point in the past. This is a conservative approach given that the subsidence above open workings is typically far greater than partially or fully collapsed workings.
- When calculating the potential collapse zones for the shafts, Atkins assumed a circular shaft geometry and an internal angle of shearing resistance of 25°. [19]
- Atkins was not involved in the scoping and supervising of the most recent GI (2021/22) and assumes that the factual data produced from the GI are accurate.
- Mine entry locations were received as a dataset from Arup, it is understood that Arup compiled the dataset based on Coal Authority records and information from Celtic Energy. Atkins assumes that these mine entries have been accurately plotted based on the datasets available to Arup. Atkins has reviewed these mine entry locations against the mine abandonment plans. Atkins notes that the spatial locations of mine entries are often inaccurately reported and therefore, Atkins expects at least some of the mine entry locations presented in this report to differ from the true locations on site.
- The location and extents of underground workings have been assessed from pdf mine abandonment plans. Arup provided some georeferenced mine abandonment plans, these were reviewed by Atkins. However, the remainder were provided in non-georeferenced format and were subsequently georeferenced by Atkins using landmarks and other features visible on the plans and aerial imagery for the site or against historical plans that themselves have been georeferenced. As such there may be some discrepancy between locations on mine entries and workings reported in this report and the actual locations on site.
- Based on correspondence with Celtic Energy, Atkins understands that all groundwater pumping has already ceased on site and that the groundwater has rebounded to the previous natural level of between 100-120m AOD. Atkins has not verified this as part of this report and assumes this information is correct as agreed in conversations with GCRE.
- Mining risk zones have been identified from the available information. Unknown workings may be present on site both within and outside the MRZ's that have not been identified during the desk study, ground investigation or during the due diligence review.
- This MRR does not cover wider hydrogeological or ground gas conditions which are reported in the main Atkins GIR and other reports.

2. Site History

2.1. Overview

This section provides an overview of the site history pertaining to mining, with key historic mining features and potential areas of risks being identified from historical mapping (1876-2019) as well as available aerial imagery (1945-2019), additional information is provided through peer-review of pre-existing technical reports [1] [2] [3].

2.2. Historical Maps

From the earliest maps on record, the site has been subject to extensive industrial activity revolving around the extraction of coal. These activities are initially recorded as a collection of underground workings in the 19th and 20th centuries before becoming an open cast colliery in the latter part of the 20th century.

Coal mining as an industrial activity in the South Wales valleys predates the 1876 maps, as such unidentified underground and surface workings from before this date may exist across the site.

The near 200-year mining history of the areas has created a legacy of potential risks and constraints, these are discussed in further detail throughout this report.

Table 2-1 provides an overview of known mine working both underground and surface working from the earliest known workings to present.

Table 2-1 – Known historical mine workings

Dates	Collieries	Type of mining
1840 - 1968	Hendre Ladis Colliery (located 1.4km to the western boundary)	Underground
1840 - 1964	Onllwyn Colliery	Underground
1864 - 1938	Gwaucnclawdd	Underground
1872 - 1964	Seven Sisters Colliery	Underground
1872 - 1967	Abercraf Colliery (also known as the Abercrave Colliery)	Underground
1893 - 1913	International Colliery	Underground
1905 - 1947	Dulais Colliery	Underground
1914 - 1978	Glynllech Colliery	Underground
Unknown	Cwm Tawe Colliery	Underground
1946 - 1949	Onllwyn	Opencast
1952 - 1953	Cefn Byrle	Opencast
1963 - 1973	Abercraf /Gwaunton 1	Opencast
1972 - 1982	Onllwyn (expansion in the east)	Opencast
1986 -1999	Nant Helen	Opencast
2002 - Present	Nant Helen Extension	Opencast

3. Synthesis of Previous Works

3.1. Overview

This section provides a review and synthesis of previous reporting and open-access data relevant to the project. This includes key information from the Geotechnical and Geoenvironmental Desk Study report [1], the Detailed Mine Workings Study [2], the GIR [3], BGS sources [6] [8] [7] and the Coal Authority [9].

Arup completed the Desk Study [1] in December 2019 to summarise published information, provide an initial conceptual site model, provide a preliminary engineering assessment and quantify expected risks.

The Desk Study [1] identified a number of mining risk zones across the proposed scheme area and recommended that a further assessment of the instability risk posed by coal mining was undertaken.

The Mine Workings Study [2], completed in June 2020, considered abandonment plans obtained from the CA to further refine the instability risk and make recommendations for GI.

A preliminary GI, incorporating positions to investigate mining risk, was completed between November 2021 and January 2022 with a GIR [3] completed in May 2022, summarising the findings of the GI.

Through this process Arup identified four Risk Zones (A, B, C and D) defined by the presence of underground workings, which are summarised and assessed in the following section.

3.2. Geology

A summary of the geology of the area is presented below based on a review of the BGS GeoIndex [6], BGS geological maps [7] [8] for the site and the opencast workings extents from Celtic Energy [11].

3.2.1. Made Ground

Several areas of artificial ground have been identified across the site identified as areas of backfilled opencast workings, as shown on Figure 3-1. The large area in the north of the main site is associated with the backfilling of the Abercraf/Gwaunton opencast coal mine. The area east of site is associated with the backfilling of the Onllwyn opencast coal mine and the area within the western portion of the cutting of the inner loop is associated with the backfilling on Nant Helen opencast coal mine. Made Ground is also shown beneath the Washery, which is likely associated with levelling of this area for the railway sidings and buildings.

3.2.2. Superficial Deposits

The BGS geological maps [7] show Glacial Till along the southern boundary of the outer loop, the western boundary of the inner loop and adjacent to the track leading to the Washery, as shown on Figure 3-2. Peat is also shown on the western edge of the inner loop and within the Washery (Figure 3-2). Most of this peat is likely to have been removed during the opencast workings in the centre of the site and the former construction in the Washery Area.

Glacial till typically comprises a heterogeneous mixture of clay, sand and gravel with large cobble and boulder inclusions of various sizes and shapes (diamicton). Peat typically comprises a partially decomposed mass of vegetation that has been deposited under largely anaerobic conditions, usually found in bogs or swamps.

3.2.3. Bedrock Geology

The bedrock beneath the site is part of the South Wales Middle and Lower Coal Measures. They are reported to comprise rhythmic sequences of mudstones (commonly containing pyrite), siltstones, sandstones, grits, fireclays, seatearths and coals; the coals found in these measures tend to be amongst the thickest and most economically significant in South Wales.

The geological mapping [7] indicates that dip angles for the bedding in the coal measures are typically between 5° and 15° in a west to south-westerly direction. However, there are localised variations to this, with a number of anticlines and synclines shown.

Three named normal faults are shown on the published geological maps [7] crossing the site with a NNW-SSE strike, there are two other parallel unnamed faults which extend into the northern boundary of the site. The three named faults: the Pwllau Bach Fault, the Chapel Fault, and the Glynccorwg Fault (ordered from west to east) divide the bedrock beneath the site into three fault blocks as shown on Figure 3-3. Unidentified faults are also likely to be present within the site boundary.

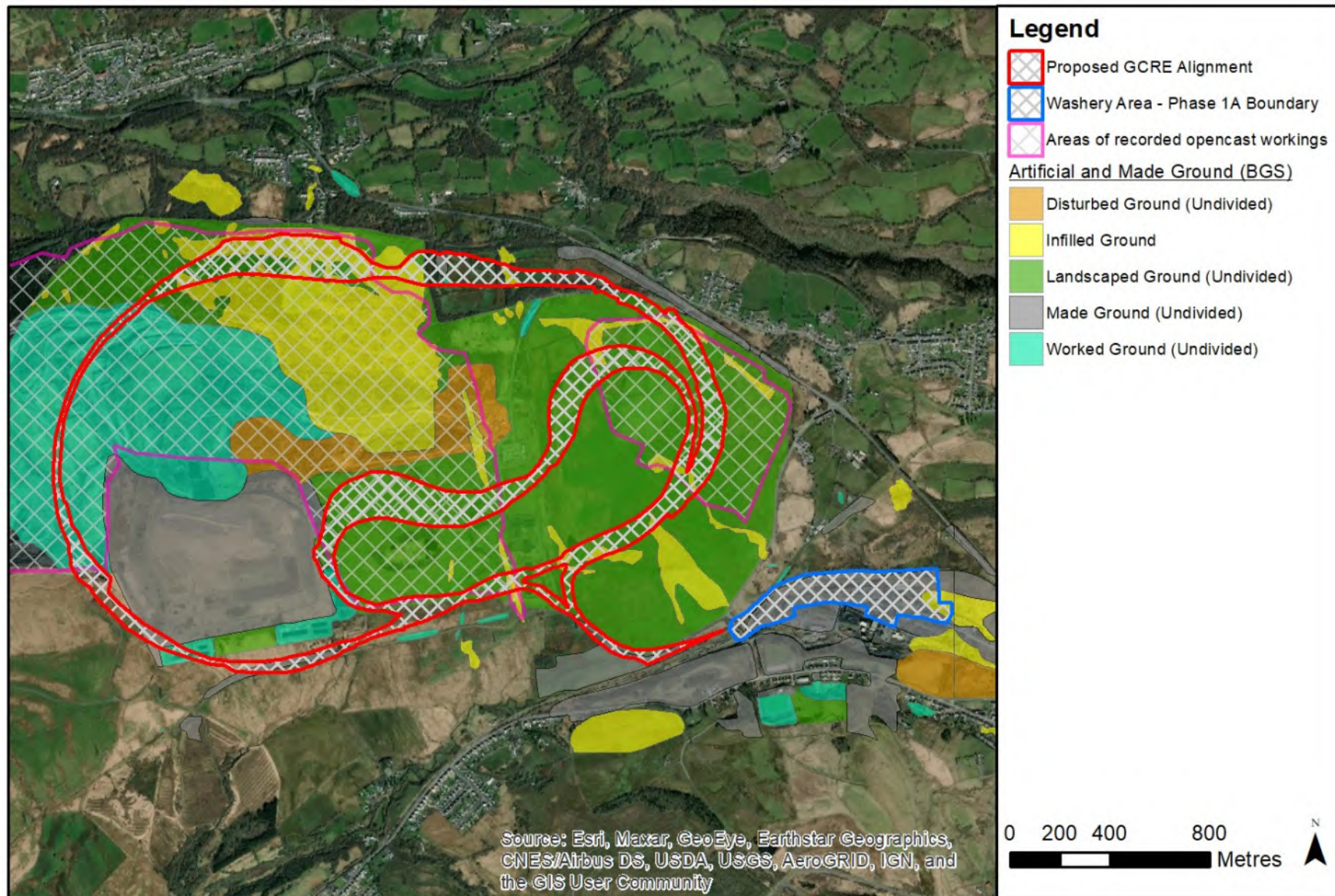


Figure 3-1 - Artificial and Made Ground.

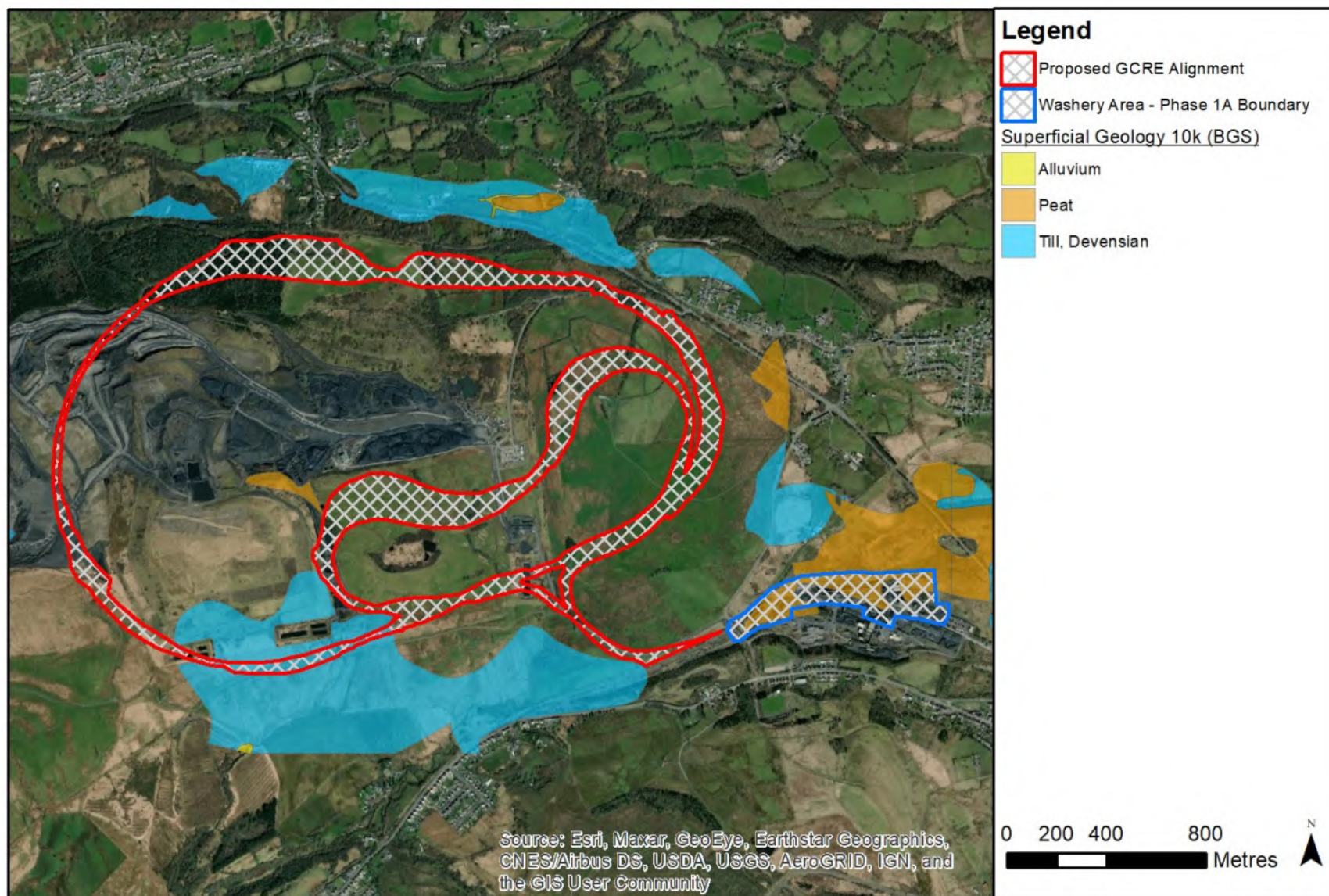


Figure 3-2 - Superficial geology.

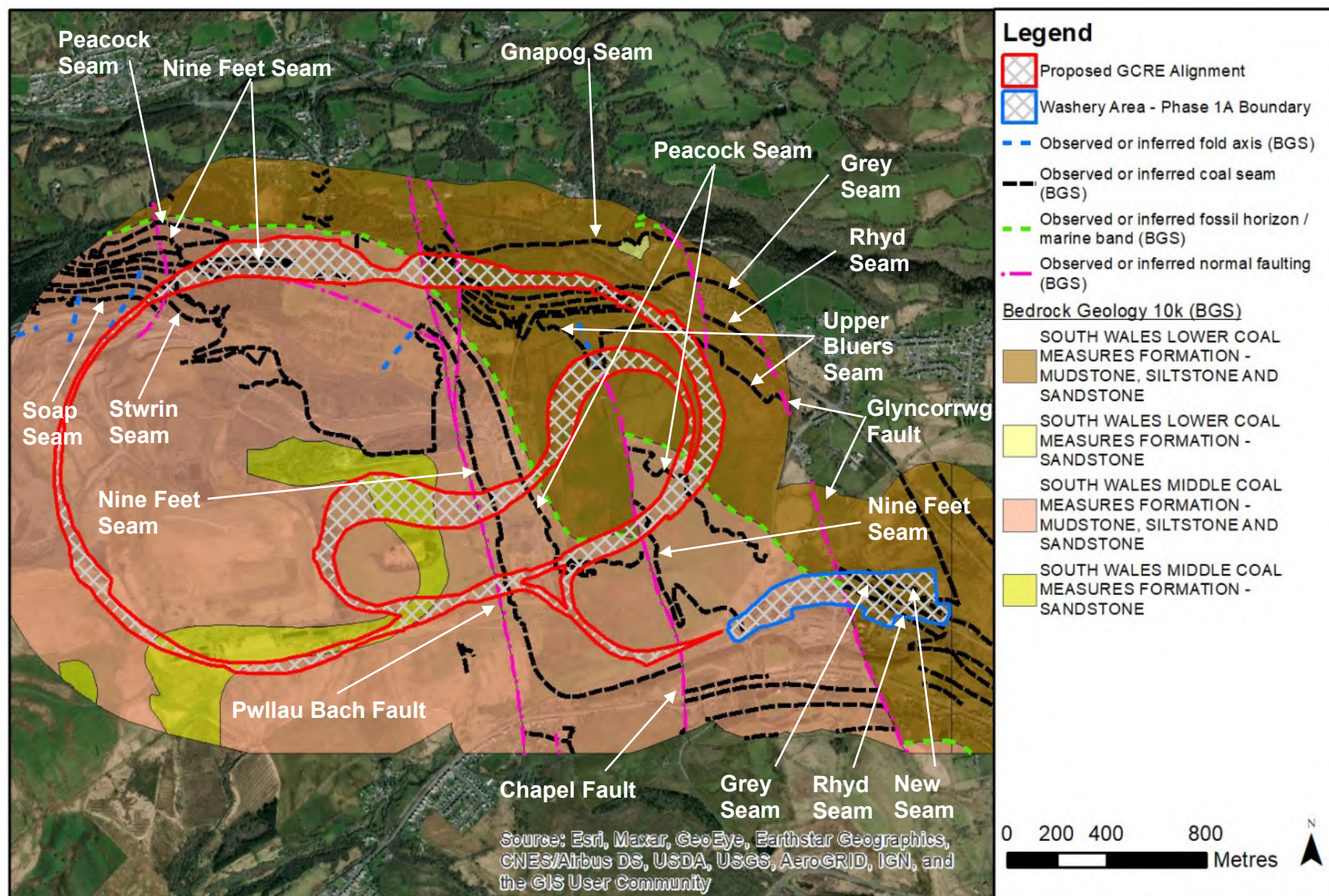


Figure 3-3 - Bedrock, faults and linear features.

3.3. Ground Investigations

A preliminary GI, incorporating positions to investigate mining risk, was completed between November 2021 and January 2022 with the findings captured in Arup's GIR [3]. A full review of this report and the GI findings is provided Atkins GIR.

Information, gained from the GI prevalent to the mining is discussed within this report. As an overview the recently completed GI comprised:

- 35 No. boreholes;
- 40. No trial pits;
- Insitu testing and soakaway tests;
- Geophysical surveys, and;
- Installations and monitoring.

The completed GI locations are shown in Figure 3-4.

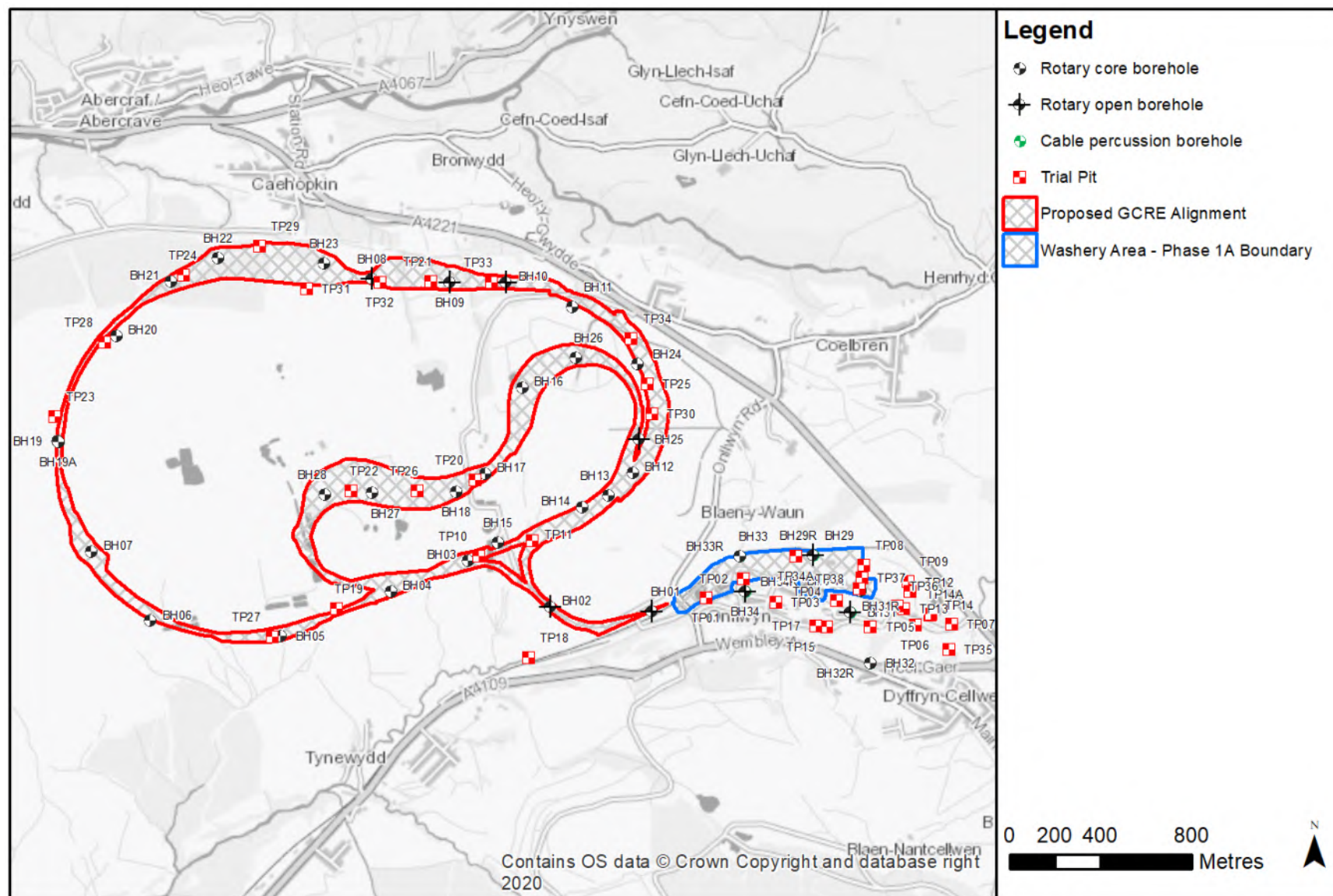


Figure 3-4 - Ground investigation location plan.

3.4. Mine Entries

The Desk Study [1] provided an initial assessment of known mine entries based on a review of the CA online viewer, opencast completion plans and abandonment plans provided by Celtic Energy.

This desk study identified a total of 95 mine entries within the site boundary. Arup identified clusters of mine entries in the northwest, northeast and south-central parts of the main railway alignment, and a cluster of mine entries around the Washery.

Arup suggested that the majority of the mine entries in the northwest of the site are likely to have been excavated during the opencast mining activities associated with the Abercraf/Gwaunton opencast site, and therefore may no longer be in place.

Arup also identified the potential for bell pitting across the north and south of the site based on satellite imagery from 1945 [16] and BGS inferred and observed coal outcrop locations [6] [7] [1] (bell pitting is discussed in detail in Section 334.2.3). A map showing the mine entries identified in the Desk Study is included in Section 3.6 (Figure 3-8).

The Detailed Mine Workings Study [2] refined the Desk Study [1] assessment of the mine entries through review of the available mine abandonment plans. Of the original 95 mine entries identified in the Desk Study [1], Arup identified seven mine entries within the proposed alignment and the Washery posing a risk to the site. This included four adits and two shafts in the south of the site, potentially extending beneath the inner loop, outer loop and access track, and one adit in the north of the site beneath the proposed location of an embankment.

Arup state the mine entries in the south of the site are associated with the Dulais Colliery West and East Slants [2]. The mine entry in the north of the site, called 'Duffryn Level', is associated with Duffryn Colliery, which is located approximately 90 m south of the proposed alignment.

Arup provided a summary of the mine entries identified on the mine abandonment plans, which is provided in Table 3-1.

Table 3-1 - Mine entry summary table from the Detailed Mine Workings Study [2].

Colliery	Entry name	Interpreted location		Arup Risk Zone	Shaft depth noted on abandonment plans
		Easting	Northing		
Dulais Colliery West Slant	"North Level" or "Cwm Mawr Level"	283373	210740	A	n/a
	"New Drift"	283684	210410		n/a
	"Air pit"	283414	210784		12ft (~4m)
Dulais Colliery East Slant	"East Slant"	283846	210410	A	n/a
	"Level to Big Vein"	283904	210436		n/a
	"Pumping Pit to Peacock Vein"	283838	210402		54ft (~17m)
Duffryn Colliery	"Duffryn Level"	282957	211907	B	n/a

The Detailed Mine Workings Study [2] recommended that the locations of mine entries in Table 3-1 should be investigated further in order to positively identify the entries locations and allow any mitigation or treatment measures which may be required to be developed.

3.5. Mine Workings

The entirety of the proposed site is situated within a CA 'Development High-Risk Area'. A Development high-risk area is defined as an "area which contains one or more recorded coal mining related features which have the potential for instability or a degree of risk to the surface from the legacy of coal mining operations" [9].

These "features" typically include mine entries (shafts and adits) and shallow coal workings (recorded and probable).

Table 3-2 sets out an interpretation of the stratigraphic sequences from shallowest to deepest of the known and named coal seams as well as the typical seam thickness. It is noted that within the provided information and literature there are some variations between names.

Table 3-2 - Interpreted coal seam sequence

Seam	Other name	Typical seam section thickness
South Wales Middle Coal Measures		
Soap	Two Feet-nine	-
Stwrin	Two Feet-nine	-
Four feet	Upper Four Feet, Lower Four Feet, White Four Feet, Wite, Stwrin	0.9m
Eight feet	Lower Eight Feet, Six Feet, Black	-
Cornish	Red Vein, Two Feet	0.76m
Harnlo	-	-
Nine feet	Big	2.7 - 3.0m
Brass	Bute, Peacock	0.9 - 1.4m
South Wales Lower Coal Measure		
Yard	Lower Peacock, Lower Brass	-
Bluers	Bluers, upper Bluers, lower, Seven Feet	0.6 - 0.85
Rhyd	Five Feet, Little Brass	0.75m
Grey	Gellideg	0.66m
Middle	Gellideg	0.63m
New	Lower	0.69m
Bryn	Gnapiog	0.5m

3.5.1. Underground Mining

Underground workings are distributed across the site, with more extensive workings located in the west working the thicker Nine Feet and Four Feet seams in the International and Abercraf collieries. These workings extend from north to south increasing in depth to the south due to the southerly dip.

Additional underground workings in the South Wales Middle Coal measures occur in the south of the site, predominantly working the Peacock (Brass) seam from the Dulais colliery. These workings extend from outcrop in the south to the north, these workings are offset by the north-south Chapel faults

Underground workings in the Lower Coal Measures (Cwmtawe Bryn Colliery) occur in the northeast of the site and adjacent to the southern boundary of the site, encroaching into the Washery. Figure 3-5 illustrates the known mineworking's.

Types of workings

It is understood from historic information and abandonment plans that room and pillar mining was used. This method of mining involves extraction of coal from specific areas of the seam (rooms) while leaving untouched

(pillars) to support the roof. A significant proportion of the coal may be left behind in pillars. These workings are commonly set out on a grid pattern and extend along a horizontal or shallowly dipping seam. Latterly, pillars may be 'robbed' to remove additional coal near to the end of life of the underground working to maximise seam yield, this may lead to insufficient coal being left in place to support the roof and cause collapse.

Previous Risk Assessment

Underground workings present on site with less than 20 m of overlaying bedrock were deemed to pose a stability serious risk to the proposed scheme, 20m was used by Arup as the minimum bedrock requirement by Arup to prevent void migration following the '10t rule' after CIRIA C758D [17] and assuming a maximum extraction thickness of 2m.

A number of risk zones related to underground mining were defined, see Section 3.6

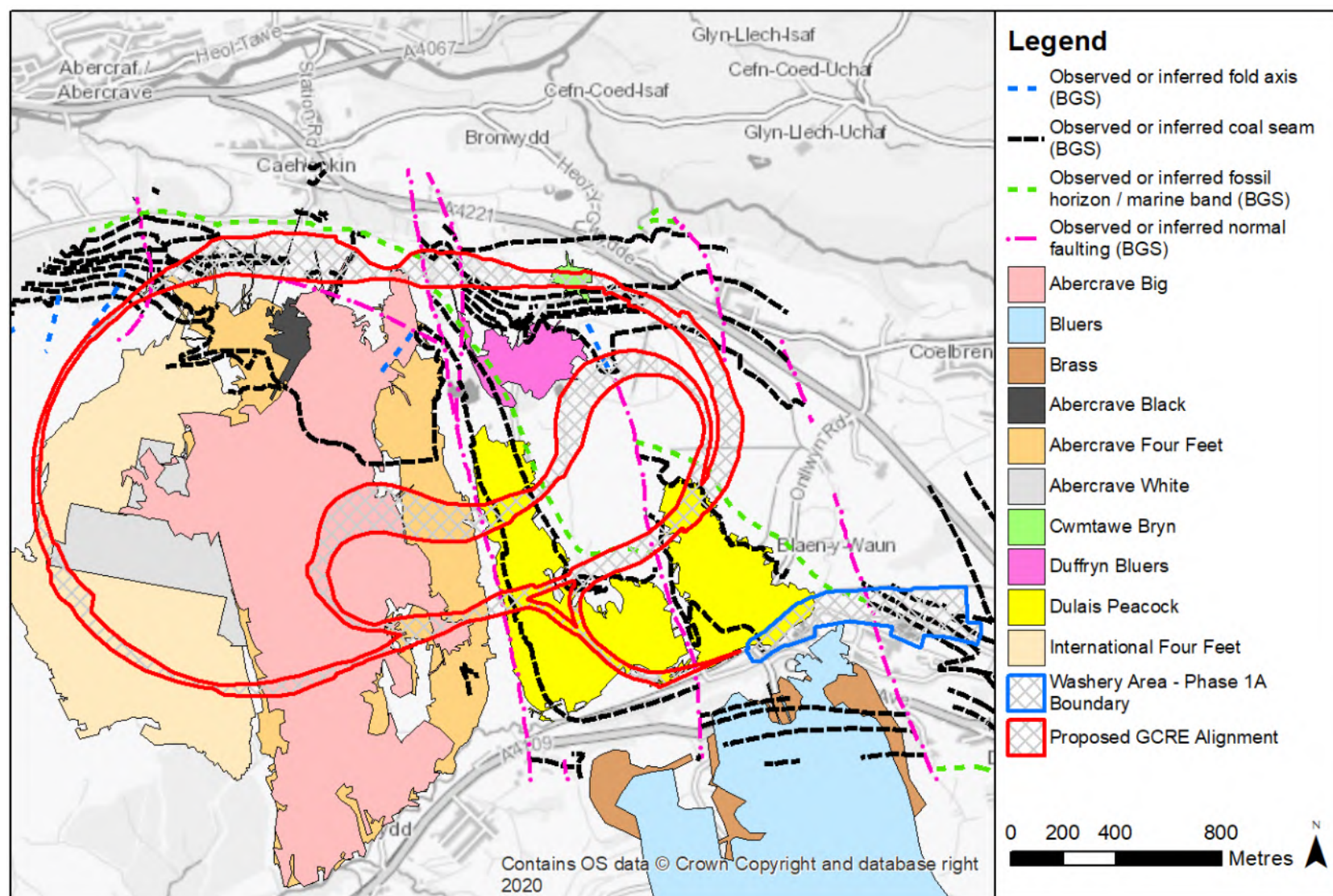


Figure 3-5 – Locations of recorded mine workings based on mine abandonment plans provided by the Coal Authority; data derived by Arup and Atkins, map generated by Atkins [3]

3.5.2. Surface Mining

Opencast mining was undertaken across the site. The most significant opencast workings are the Nant Helen workings located in the centre and north of the site as well as the later Nant Helen Extension to the west, as shown in Figure 3-6. It is understood that all extraction has now ceased with restoration now ongoing in accordance with regulatory requirements and the agreements with Powys County Council.

Aerial imagery [1] indicates that bell pitting was undertaken on site.

Open Cast Mining

Opencast mining is a form of bulk mining involving the removal of large quantities of overburden to access economic deposits (in this case coal) below the surface. This method of mining targets all of the seams in a location, stripping one before lowering the base of the pit to target the next. This method of mining is still economic in areas that have historical room and pillar mining due to the high proportion of resources that are left in situ, for example the Nant Helen and Abercraf opencasts that have reworked seams historically worked via underground mining.

Previous Risk Assessment

Backfill of opencast workings was considered to present a risk to the proposed scheme due to expected large settlements occurring within this material likely to cause subsidence at surface, this is addressed in the main Atkins GIR and not considered further in this report.

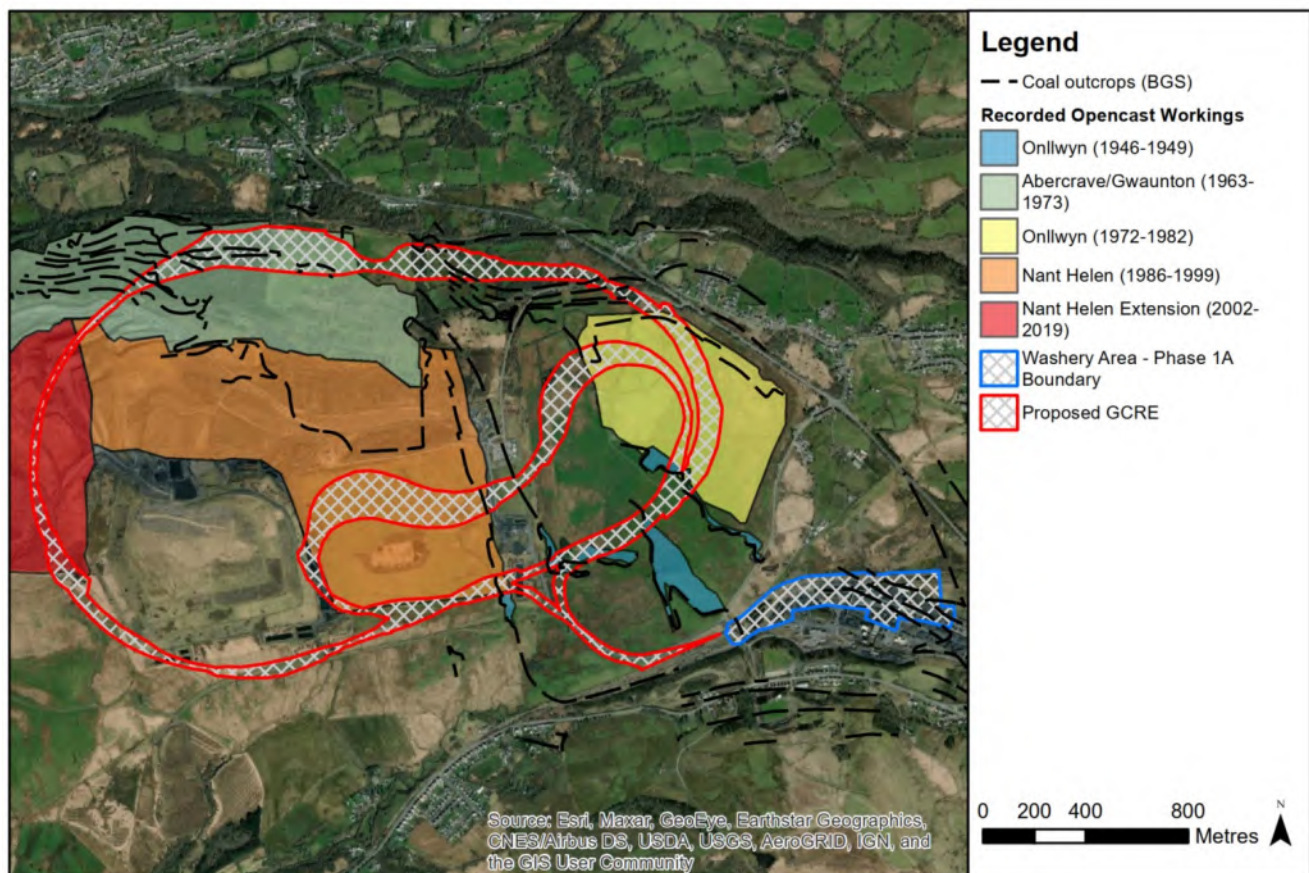


Figure 3-6 - Recorded opencast workings.

Bell Pitting

Bell pitting is a historic method of extracting shallow coal resources from narrow shafts opened into small caverns (bells) once coal is encountered. Coal was extracted by hand to a point the bell became unstable at which point a new, adjacent bell pit could be opened. Bell pit locations are generally unrecorded, poorly backfilled and a common source of mining related instability at surface.

Previous Risk Assessment

Evidence of bell pitting onsite was observed in aerial imagery [1] as open bell pits or crown holes, these occur predominantly in the south of the site (Figure 3-7).

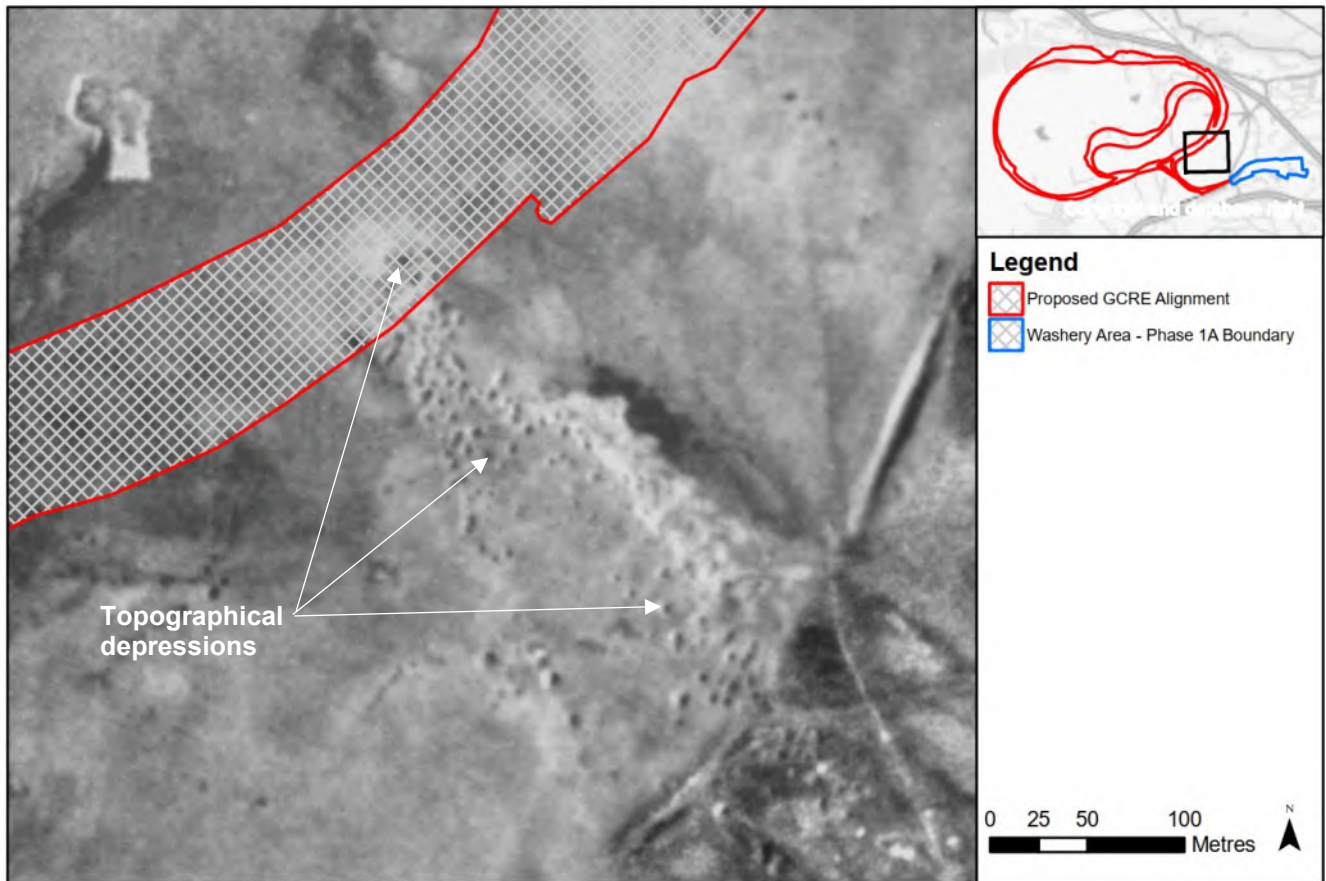


Figure 3-7 - Example of potential evidence for bell pitting in the southeast of the alignment.

3.6. Arup Risk Zones

Taking cognisance of all information, Arup identified four Risk Zones (A, B, C and D) defined by the presence of underground workings, as shown in Figure 3-8. Evidence of known workings beneath the proposed alignment was found within these zones, which therefore have a greater probability of being impacted by mining related instability.

3.6.1. Risk Zone A

Risk Zone A covers the south-eastern section of the outer main rail loop and the central section of the inner loop along with the section of rail that will connect the testing loop to the stabling yard and wider rail network. There was deemed to be a stability risk to the track due to:

- Shallow workings (within 10t of rockhead) in the Peacock (Brass) seam; and
- Shallow workings (within 10t of rockhead) in the Nine Feet seam.

Both being worked from the Dulais colliery. The stratigraphically higher Peacock also shows signs of having been worked from the surface by bell-pitting as evident from the earliest aerial photographs [16].

Deeper workings relating to the working of the Four Foot Seam from the Abercraf Colliery are anticipated to be at depths of approximately 80m bgl and therefore considered to pose a negligible instability risk.

The GI records evidence of suspected workings within the Peacock (Brass) seam from the Dulais Colliery (West and East Slants) were encountered within BH02, BH12, BH15, BH17 and BH18 at <20 m from proposed track level (except in BH12 and BH17).

Arup's GIR [3] provides a further update to the risk zones. Risk Zone A remains largely unchanged following the GI.

3.6.2. Risk Zone B

Risk Zone B covers the northeastern section of the loop. There was deemed to be a stability risk to the track due to:

- A number of shafts and adits in proximity to the track;
- Outcropping Bryn, Lower, Middle and Upper Bluers seams were shown to be present in the area and were assessed to have a high likelihood of containing unknown workings within the 10t limit; and
- Shallow workings within the Bryn seam from the Cwmtawe Colliery, within 10t of rock head.

The seams in this area dip predominantly north to south, the topography rises to the south increasing the relative depth of the seams below ground level and bedrock.

There are workings within the Bluers seam from the Duffryn Colliery, whilst the main workings do not directly interact with the track, an adit has been shown to be located on the north side of the proposed embankment.

Whilst no direct evidence of mine workings had been found during the 2021 ground investigation it is considered that underground workings are present in the area, due to the high concentration of adits and shafts in the vicinity of the proposed rail line.

3.6.3. Risk Zone C

Risk Zone C is located in the southwest of the site between the Nant Helen and Nant Helen Extension open casts. There was deemed to be a stability risk to the track due to:

- Lack of data coverage in the area, workings were identified within the Nine Feet and Brass; and
- Open-access data provided by the Coal Authority indicates that the stratigraphically higher “Four Feet” (Cornish), “Black” and “White” (Four Feet) seams were all worked in the areas, but to an unknown extent and are therefore considered a risk.

Workings within the Nine Feet and Brass Seams were at considerable depth and far greater than the 20 m of bedrock cover required to provide stability. Similarly, workings within the Four Feet and White Seams were found to be at a great depth (~80-115 m bgl) and therefore do not pose a significant risk.

Arup concluded that further ground investigation is required targeted around the location of BH05 to confirm that a zone of ‘core loss’ in BH05 does not represent unrecorded workings within the Soap Rider seams.

3.6.4. Risk Zone D

Risk Zone D covers the southeast section of the site in what will be the stabling yard and Washery. There was deemed to be a stability risk to the track due to:

- Lack of data coverage in the area;
- Shallow workings from the Dulais Colliery East Slant in the Peacock (Brass) seam, cross from Risk Zone A into the footprint of the Washery, within 10t of rockhead.
- Numerous mine entries relating to the Onllwyn Colliery; and
- The inferred presence of the “New”, “Grey”, “Rhyd” and “Upper Bluers” seam outcrops as shown on the Coal Authority Online Viewer [9].

No abandonment plans exist for workings in these inferred seams, but if worked can be expected to be shallow.

The GI encountered voids in this area which are interpreted as unrecorded mine workings potentially related to working of the New/Lower and Grey/Middle seams. Arup's recommendation was to carry out further intrusive investigations in the area to confirm the extent of the interpreted workings.

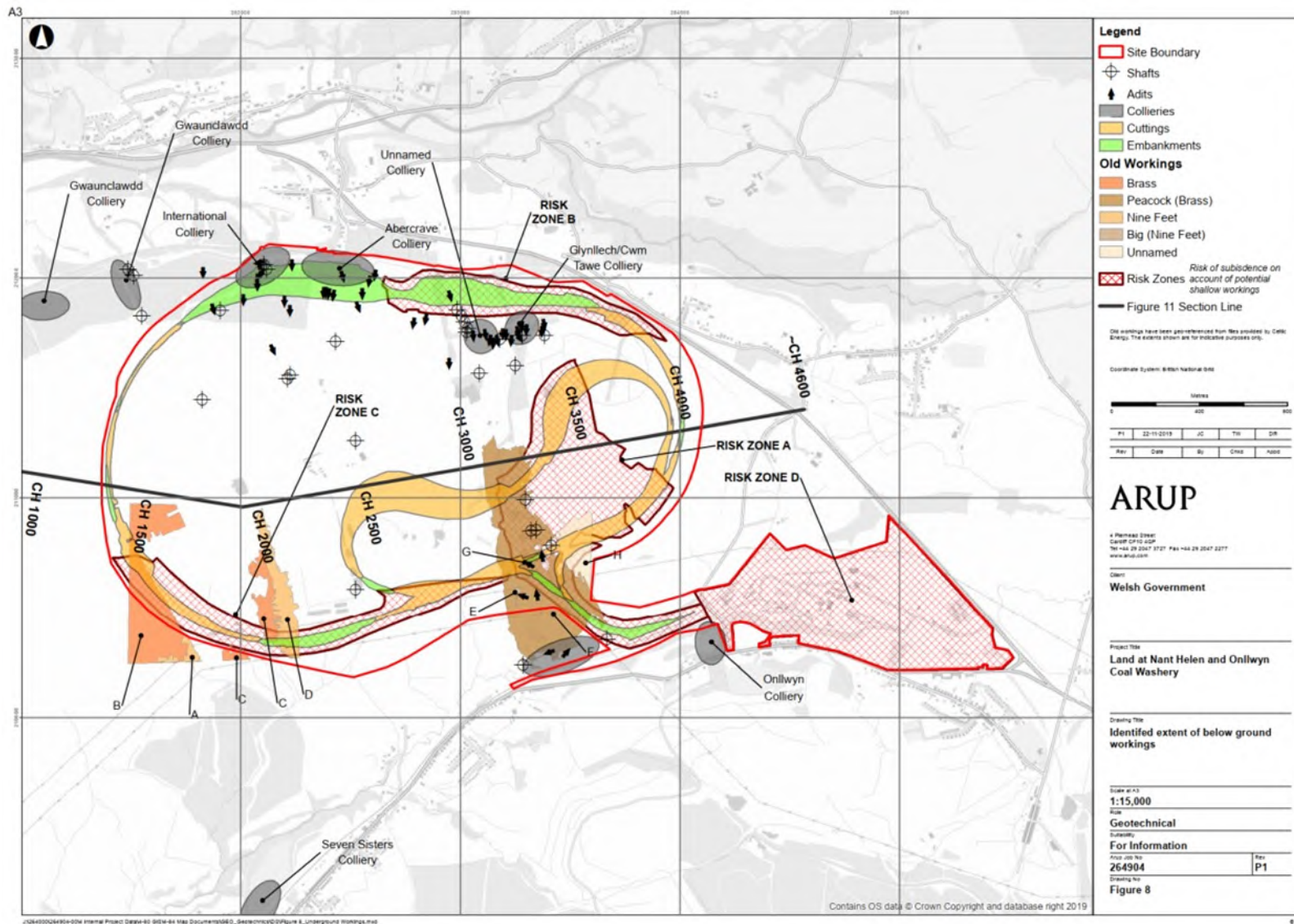


Figure 3-8 - Map of Arup risk zones from the Geotechnical and Geoenvironmental Desk Study by Arup [1].

3.7. Review of Preliminary Ground Investigation

A preliminary GI to investigate mine workings and entries, scoped by Arup was undertaken in between November 2021 and January 2022 by Quantum Geotech. The GI included cable percussive, sonic and rotary boreholes, trial pits and geophysical testing. Full details of the completed works are presented in the Arup GIR [3] and Quantum Factual Report [12] with a review provided in the main Atkins GIR.

3.7.1. Mine Entries Investigation

The GI investigated a select number of mine entries in the Washery and surrounding area, as shown on Figure 3-9. The investigation comprised magnetic, electromagnetic and microgravity geophysical surveying by Terradat, which identified a series of geophysical anomalies.

The works identified two geophysical anomalies (Z1-6 and Z1-9) in close proximity to the recorded locations of an adit (284210-035) and a shaft (284210-029) in the Washery (Figure 3-10). Both geophysical anomalies were subsequently investigated by trial pitting (TP37 and TP38), however, the intrusive investigations did not encounter any evidence of mine entries.

One additional adit is also recorded within the Washery (284210-023), however, this is beyond the extents of the geophysical survey area and has not been investigated by intrusive investigations.

The mine entries in vicinity of the main alignment were not targeted during the 2021/22 GI [12]. Conversations with Arup suggest this was due in part to limitations of proposed geophysical investigation techniques over thick sequences of fill material. Areas of bell pitting were also not investigated.

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 Factual Report [12].

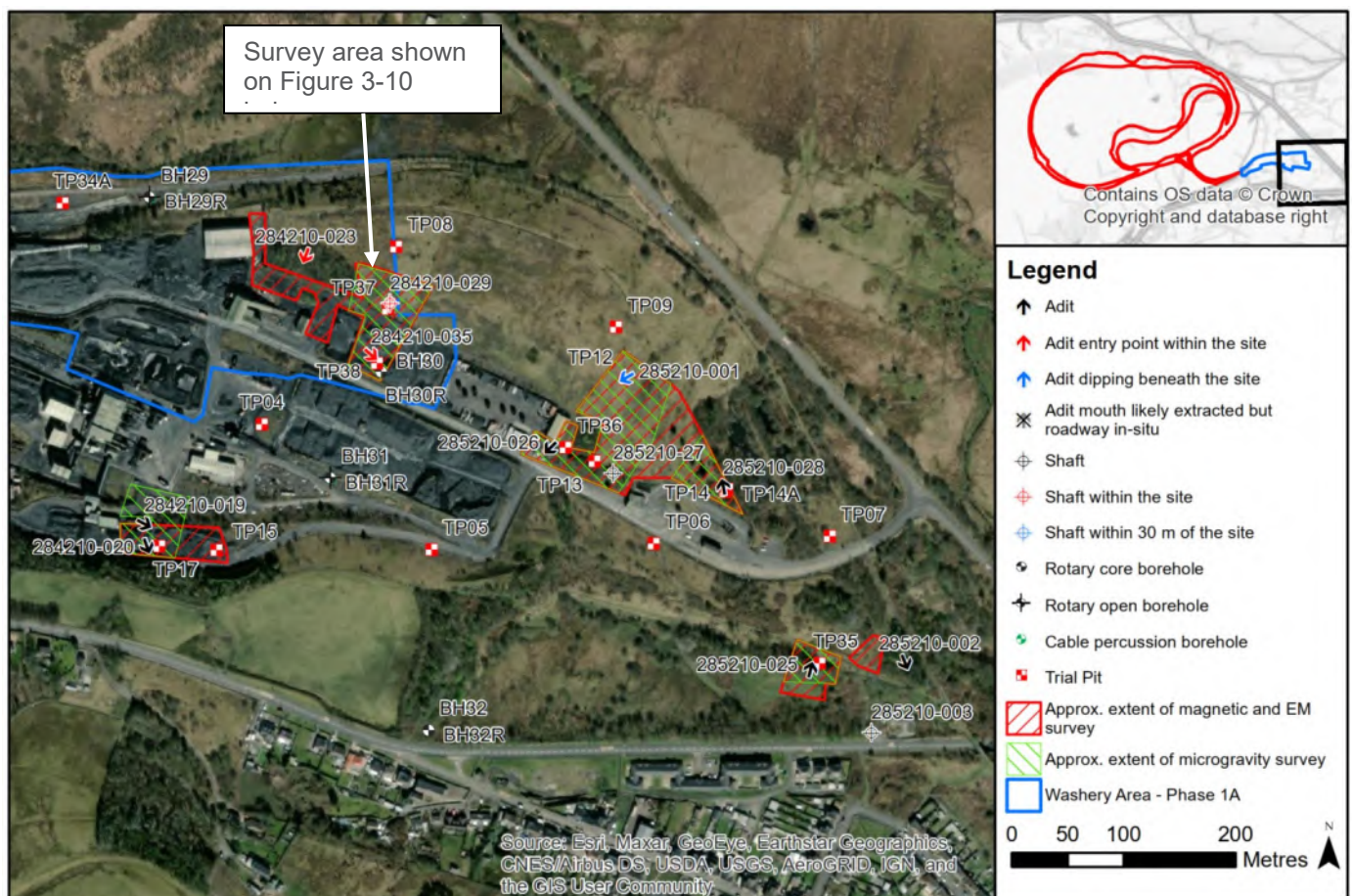


Figure 3-9 - Overview of geophysical survey conducted by Terradat.

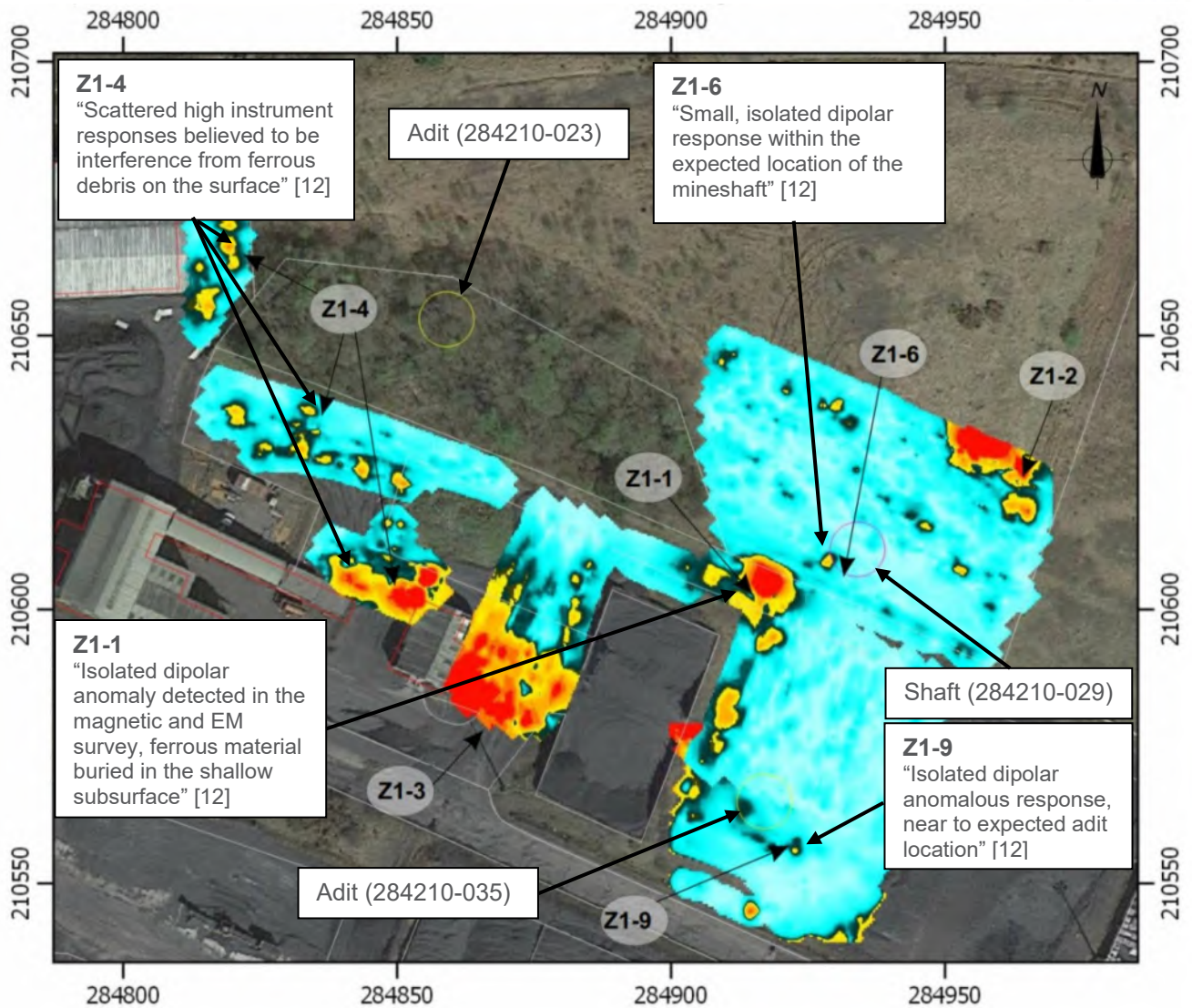


Figure 3-10 - Magnetic analytical signals indicative of significant ferrous metal anomalies, image taken from the Terradat Geophysical Survey Report [12].

3.7.2. Sub-surface Mine Workings

Sub-surface mine workings, as identified in the Desk Study [1] were targeted by the GI to better understand their extents, location and condition.

Table 3-3 and Table 3-4 indicate where coal and voids were encountered in the GI and interpretation of these features. For clarity boreholes where coal/voids are absent are not included in the tables. Borehole locations are shown on Figure 3-4 and in Drawings GCRE001-AWJV-00-XX-DR-GE-00014 to GCRE001-AWJV-00-XX-DR-GE-00018 in Annex A.

A number of boreholes did not reach target depth across the site due to difficult drilling conditions. A number of the borehole logs have limited geological descriptions due to drilling methods employed, there is therefore a reliance on drillers descriptions

The voids found in BH30R within the Washery were interpreted as unrecorded workings and would require further intrusive investigation to define the extent of workings. BH05 contains a “Zone of Actual Core Loss” in an area of the site where no known underground ground workings have occurred. BH18 “Zone of Actual Core Loss” has been attributed to potential mine workings relating to the Brass/Peacock Seam this is also the case for BH02, BH12 and BH17. BH15 has a small 0.3m section of core loss that has been attributed to potential workings within the Peacock (Brass) seam.

The preliminary GI confirms the presence of coal seams and open mine workings underlying the site within 10t of rockhead, thus posing a stability risk to the proposed scheme. It is concluded that further investigation to quantify the risk and define the remediation works are required.

Table 3-3 - Coal seams encountered in ground investigation

Borehole ID	Depth (m bgl)	Depth below rockhead (m bgl)	Thickness (m)	Log Description	Seam Interpretation
BH01	13.2	8.2	1.7	Weak coal (drillers description)	Nine Feet
BH04	17.0	13.1	0.2	Weak black coal, highly weathered to fine to medium gravel	Soap Rider
BH05	20.1	9.1	0.6	Weak to medium black coal with one discontinuity set	Soap Rider
BH06	27.0	25.0	0.8	Coal (drillers description)	Soap Rider
BH07	22.0	17.8	1.5	Coal (drillers description)	Soap Rider
BH10	24.0	23.3	1.2	Coal (drillers description)	Bryn/Gnapiog
BH11	10.7	5.3	0.6	Weak black coal	Grey/Middle
BH12	15.0	12.3	1.3	Coal (drillers description)	Peacock (Brass)
BH13	24.2	19.0	0.3	Weak black coal, highly weathered to fine to coarse angular gravel and cobbles	Peacock (Brass)
BH16	12.1	8.1	0.6	Weak black coal, highly weathered to fine to coarse angular gravel	Bluers
BH16	14.0	10.0	0.3	Weak to medium strong black coal	Bluers
BH26	36.2	1.0	1.0	Weak black coal	Rhyd
BH30R	13.7	7.1	0.6	Weak to medium strong black coal	Unnamed inferior seam
BH31R	16.0	5.6	1.1	Coal (drillers description)	Grey/Middle
BH31R	25.5	15.1	1.0	Coal (drillers description)	New/Lower
BH32R	11.8	7.5	3.2	Weak black coal, highly weathered to fine to coarse angular gravel and cobbles	Bluers
BH33R	28.1	23.2	0.8	Coal (drillers description)	Peacock (Brass)
BH34R	22.1	12.2	1.9	Weak coal (drillers description)	Peacock (Brass)

Table 3-4 - Summary of Evidence of Encountered in Ground Investigation

Borehole ID	Depth (m bgl)	Depth below rockhead (m bgl)	Thickness (m)	Log description	Seam/Working interpretation
BH02	19.7	15.8	0.7	Cavity (Drillers Description)	Brass/Peacock Dulais Colliery
BH02	20.4	16.5	9.6	Hard Drill - Loss of Returns (Drillers Description)	n/a
BH05	24.1	13.1	0.6	Actual Zone of Core Loss	n/a
BH12	5.7	3	1	Actual Zone of Core Loss - No recovery between 5.7 and 6.7mbgl. SPT sample grey gravelly Clay. Gravel is fine angular weak Mudstone	Brass/Peacock Dulais Colliery
BH12	7.9	5.2	0.3	Actual Zone of Core Loss	n/a
BH15	3.9	1.2	0.3	Actual Zone of Core Loss	Possible Brass
BH17	12.9	6.5	0.4	No Recovery	Brass/Peacock Dulais Colliery
BH18	30.7	6.7	1.2	Actual Zone of Core Loss - Recorded between 30.7 and 31.9mbgl very soft, no recovery, loss of returns	Brass/Peacock Dulais Colliery
BH18	35.4	11.4	2.9	Hard Drill - Drillers Description, No returns	n/a
BH18	38.3	14.3	0.7	Soft Drill - Drillers Description, No returns	n/a
BH18	39	15	2.3	Hard Drill - Drillers Description, No returns	n/a
BH18	41.3	17.3	1.1	Soft Drill - Drillers Description, No returns	n/a
BH18	42.4	18.4	2.8	Hard Drill - Drillers Description, No returns	n/a
BH30R	9.7	3.2	2	VOID	Grey/Middle [SWLCM]
BH30R	20.1	13.6	1	VOID	New/Lower [SWLCM]
BH30R	21.1	14.6	0.9	Soft Drill (Drillers Description)	n/a
BH30R	22.0	15.5	5.8	Hard Drill (Drillers Description)	n/a

3.7.3. Surface Mining

The GI targeted areas of known surface mining to assess the nature and competency of the backfill and inform the settlement risk. The information collected from these boreholes and the assessment is detailed within the main Atkins GIR.

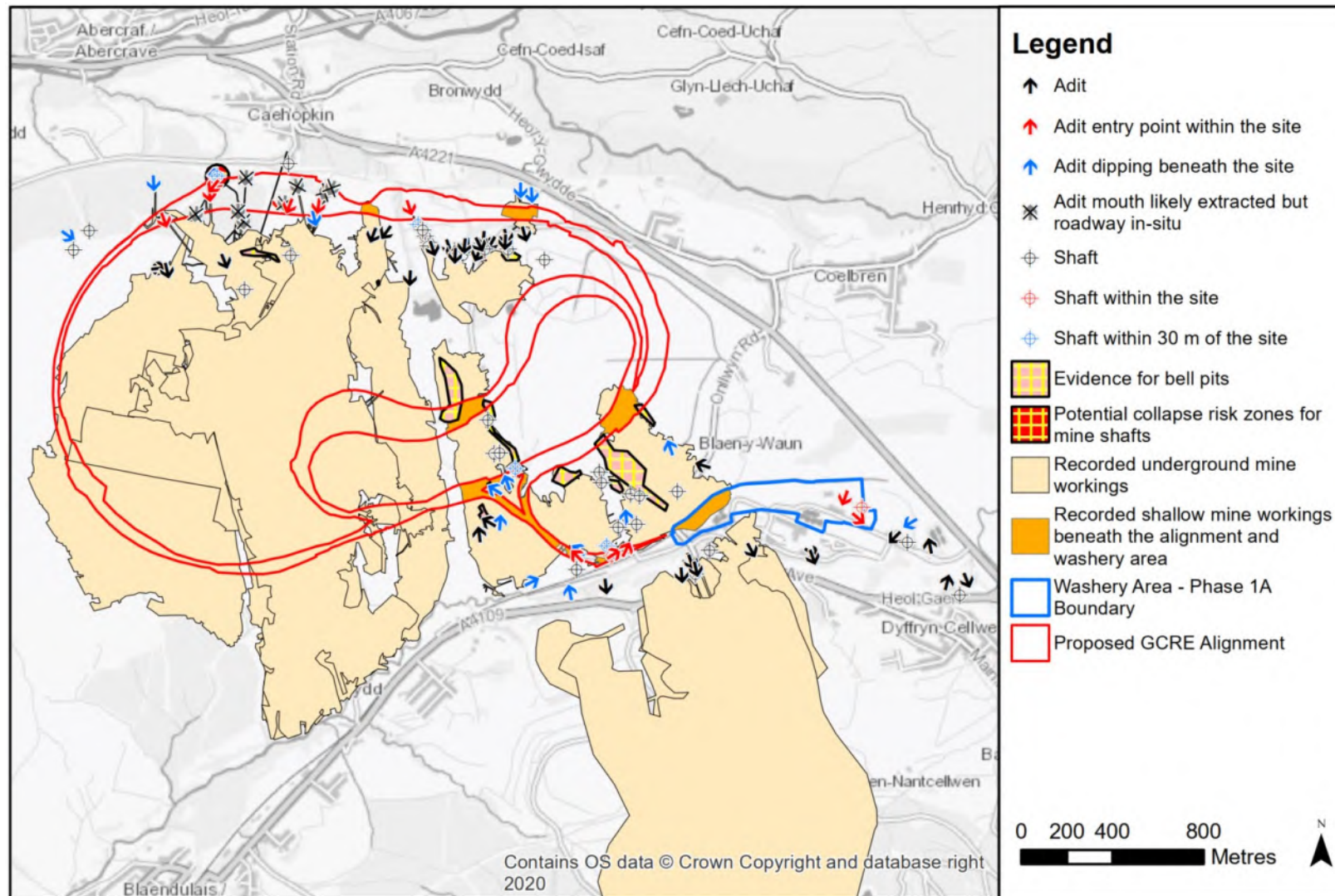
4. Assessment of Current Mining Risk

4.1. Overview

Drawing upon the information made available this section outlines Atkins' current understanding of the mining risks across the site at the time of writing and methodology for assessing the mining-related risks on site.

This information is then utilised to update and refine the Risk Zones identified by Arup to provide Atkins' 'Mining Risk Zones' (MRZ), with nine MRZs identified across the alignment and a further MRZ covering the Washery.

Drawings showing the mine entries and conjectured shallow workings across the site are included in Annex A and are discussed in detail throughout this Section (Drawings GCRE001-AWJV-00-XX-DR-GE-00014 to GCRE001-AWJV-00-XX-DR-GE-00018). A simplified hazard map (Figure 4-1) is included for reference.



* Refer to Drawings 5209796-MRR-DWG001-005 in Annex A for a more detailed illustration of the mining risks.

Figure 4-1 - Simplified overview map of the key mining risks.

4.2. Methodology used for Assessing Mining Risks

4.2.1. Assumed Height (Extraction Thickness) of Mine Workings

In line with the GCRE Employers Requirements [5] an assumed maximum extraction thickness of 2 m within workings (roadway height) is assumed. The required bedrock cover above all recorded workings and roadways to prevent void migration to surface is assumed to be 20 m based upon a cover equal to ten times worked seam thickness (10t rule) to prevent void migration after CIRIA C758D [17].

This assumption does not apply to the Nine Feet Seam, which is estimated to have a maximum extraction thickness of 3 m and therefore requires at least 30 m of bedrock cover under the 10t rule.

The design seam thickness shall be reviewed further as part of the remediation design process

4.2.2. Site Walkover

Atkins have prepared a proposed walkover plan to investigate surface features expected to be evidence of mining related instability and locate mine entries. At the time of writing this walkover has not yet been completed. The works will be completed as part of the remediation design process.

4.2.3. Mine Entries

The risk from mine entries was assessed using the following datasets.

- Purchased data from Groundsure [15]; key information including but not limited to historical borehole locations, historical OS maps and surface ground working extents
- Data provided by Arup; including mine entry locations in shapefile format, mine abandonment plans originally from the Coal Authority [12] and completion plans originally from Celtic Energy [13].
- Open-access data; including the Coal Authority interactive map [7], BGS GeoIndex [4], BGS historical maps [6] [5] and historical imagery [10], to corroborate the data and findings provided by Groundsure and Arup.
- GI data from the 2021/2022 investigation.

Shafts

Initially, all known or suspected shafts within 30m of the GCRE alignment or Washery were considered on the basis that their collapse zones may interact with the proposed permanent works. This was then expanded to include any additional locations to review all shafts.

The potential collapse zone for the shafts of interest was then assessed using guidance from CIRIA C758D [17] comprising the following equation:

$$C = z \tan(90 - \phi) + S + D$$

C = Potential collapse zone

ϕ = Internal angle of friction of overlying superficial deposits

z = Thickness of overlying superficial deposits

S = Shaft radius

D = Departure (location uncertainty)

A visual representation of a potential collapse zone for a shaft is shown in Figure 4-2. A summary of the parameters that were used to assess the potential collapse zone, and the rationale and assumptions for the chosen values, is included in Table 4-1.

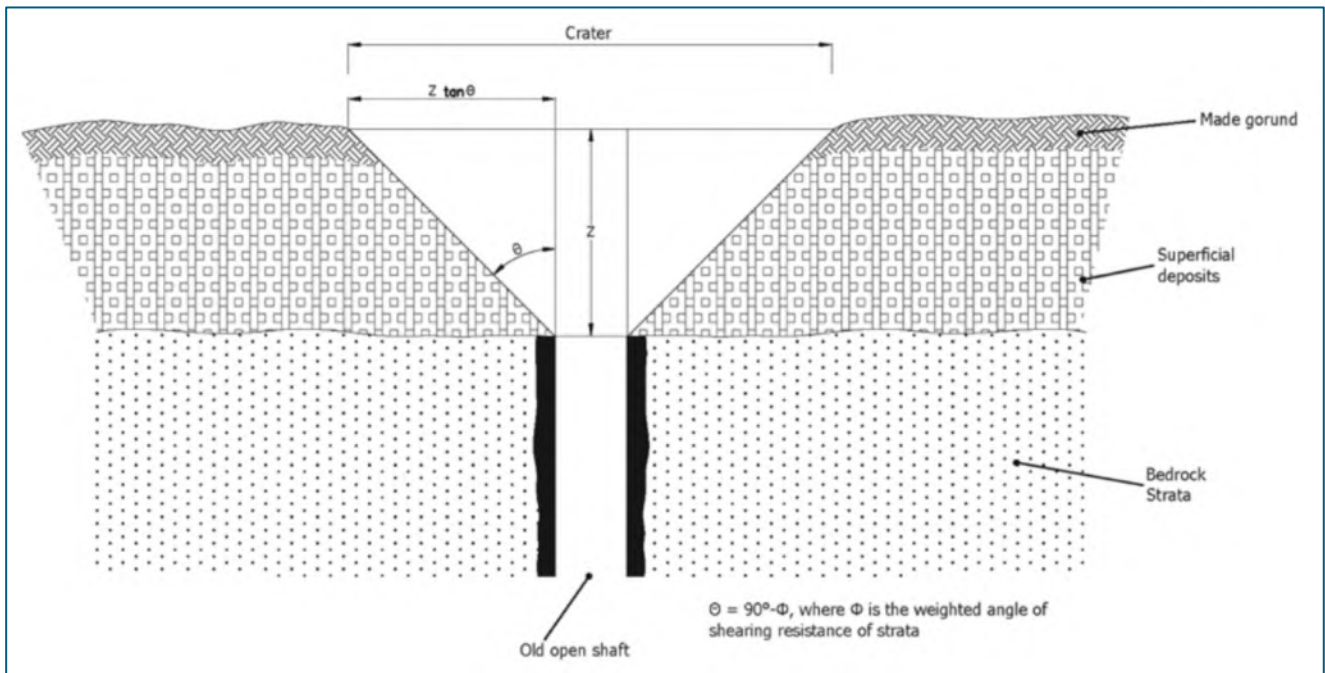


Figure 4-2 - Possible diameter of a crater due to shaft collapse (after Bell, 1978) [17].

Table 4-1 - Summary of parameters used in assessing the potential zone of collapse for shafts.

Parameter	Value(s)	Rationale and assumptions
Angle of shearing resistance (ϕ')	25 °	No strength testing was conducted as part of the GI by Quantum Geotech [13]. Atkins conservatively assumed a characteristic phi value of 25° this is less than that has been assumed in the main Atkins GIR (30° for cohesive Made Ground and 34° for granular). The value has been selected to reflect the unknown location of shafts.
Thickness of superficial deposits	2.60 – 34.00 m	The thickness of superficial deposits was assessed individually for each suspected shaft location based on the GI data from Quantum Geotech [13] and records of backfilling across the site [11]. Greater thicknesses of superficial deposits were typically associated with backfill material in the northwest of the site.
Shaft diameter	2.50 – 4.00 m	Atkins used the 'Assumed Shaft Diameter' and 'Actual Shaft Diameter' values from the Coal Authority Interactive Map to estimate the diameter of each shaft.
Shaft shape	Circular	No available information on the shape of the shafts on site was available, therefore, Atkins assumed a circular shaft shape for all shafts.
Departure	0 – 10 m	Atkins used the 'Departure' values from the Coal Authority Interactive Map to estimate the uncertainty in the location of the mine shafts. The values provided by the Coal Authority typically vary depending on the data source used to derive the mine entry locations; ranging from definitive positioning (0 m) to 1/2500 OS plans (5 m), mine abandonment plans (8 m) and geological plans (10 m).

Adits

Initially, all known or suspected adits within 30m of the GCRE alignment or Washery were considered. Adits represent a risk in the event of collapse of the adit portal, but also in the event of the collapse of the underground portion, or roadway, of the adit.

This assessment was expanded to include a review of all adits that are beyond the alignment but dip towards the alignment. Although located away from the alignment, roadways emanating from these adits are likely to extend beneath the alignment and therefore present an instability risk.

Atkins estimated the risk from these adits based on an assessment of the anticipated bedrock cover above the roadways at the point they pass under the alignment using available mine abandonment plans and GI data [12]. Finally, Atkins assessed the likelihood of the adits having been excavated and removed during past open cast mining activities. This assessment was based on a review of the opencast completion plans for the site and a comparison of this data against the levels for the adits shown on the available mine abandonment plans.

Bell Pits

Atkins assessed the risk from bell pitting by returning to the 1945 historical satellite imagery [16] as, included in the Desk Study (Figure 4-3) [1].

Atkins re-mapped the satellite imagery that showed evidence for bell pitting and then compared it against coal outcrops mapped by the BGS [6]. It was found that bell pits occurred where outcrops were mapped suggesting a correlation between this basic historical coal mining method and shallow coal seams.

This relationship was then used to infer additional locations where historical bell pitting may have occurred based on the presence of mapped outcrops. Using an approximate seam dip of 8 degrees SW [7] and an assumed maximum depth for bell pits of 12 m from CIRIA C758D [17]. The estimated distance down-dip of the coal seams in the south of the site where bell pitting could have occurred was then derived.

Collated information was then reviewed against the recorded opencast workings across the site to anticipate whether the bell pits have been extracted or remain in situ.

As shown in Figure 4-3, many of the bell pits overlap with the areas of opencast workings and expected to have been removed, however, some bell pits likely remain in situ, particularly in the northern part of the inner loop.

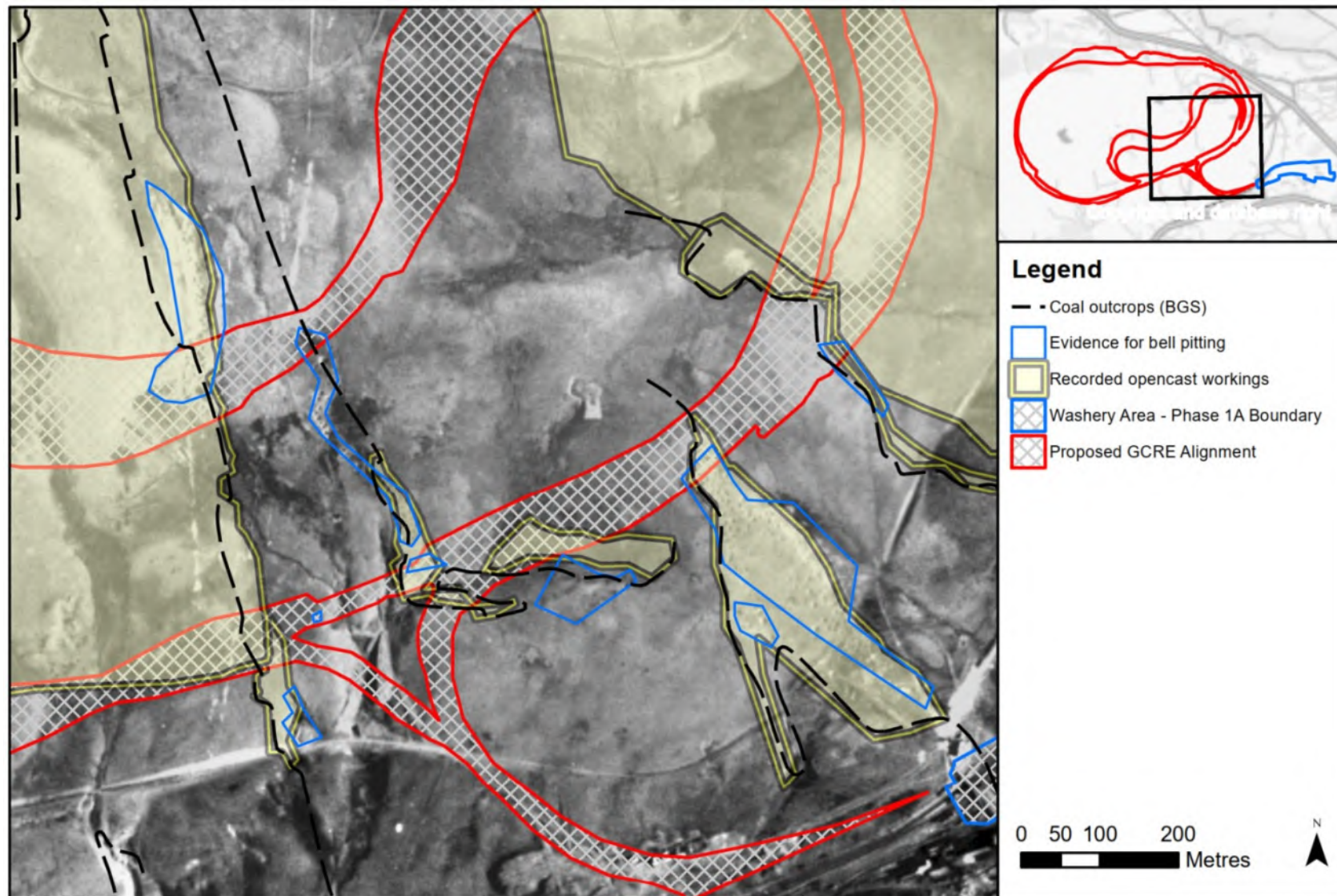


Figure 4-3 – Areas of potential evidence for bell pits shown on the 1945 historical satellite imagery compared against BGS coal outcrops and areas of recorded opencast workings.

4.2.4. Sub-surface Mine Workings

Assessment of risk posed by mine workings was completed by reviewing abandonment plans from underground workings and opencast working completion plans on site and in close proximity to the site. The topographic information from the abandonment plans were cross referenced to assess if and how the different methods of mining interacted, in order to determine to what degree underground workings have been removed due to opencast extraction. Where underground workings remain, there remains a risk of collapse causing subsidence at surface.

Atkins has also considered the likelihood of unknown workings occurring across the site, focusing on areas of known adits with no attached abandonment plans as well as evidence of voids, actual core loss and interpreted mine working from the GI.

Risk attached to the backfilling of the opencast workings on site will be covered in the main GIR.

4.3. Mining Risk

4.3.1. Mine Entries

The mine entries on site are generally clustered around the northern embankments of the outer loop, the junction in the southeast, the track leading to the Washery, and the Washery itself. Within these areas, Atkins has identified a total of four shafts with potential collapse zones that interact with the site and 29 adits that either lie within the proposed alignment or Washery (14 No.) or adits with roadways dipping beneath the proposed alignment or Washery (15 No.). Some of these mine entries can be observed from satellite imagery [18]

Of the 29 adits, Atkins identified six adits that are likely to have been removed during the operation of the Abercraf Opencast Colliery in the northwest. However, the underground adit roadways associated with these adits are likely to remain in place with insufficient bedrock cover. A summary table of shafts calculated to pose a stability risk to site is provided in Table 4-2, a full table of all shafts assessed is included in Annex B. A summary table of adits assessed to pose a stability risk to the site is provided in Table 4-3, a full table of all adits assessed is included in Annex B. A series of drawings showing the risk from shafts and adits across the site are provided in Annex A (Drawing 5209796-MRR-DWG001-005).

4.3.2. Underground Mine Workings

Abandonment plans indicate that the site was extensively worked from the 19th century until the early to mid 20th century with the majority of the underground workings being located to the south-west, south and south-east and smaller workings located in the northeast. A total of eight underground collieries are recorded on site working a number of coal seams, the most extensively worked are the Four Feet, Nine Feet and the Peacock (Brass) seams. A summary of these workings is included in Table 4-4.

An assessment of where opencast workings have removed sufficient bedrock to bring deep underground workings within 20-30 m of the base of the opencast and as such pose a risk of potential collapse and void migration following the 10t rule was also undertaken. This assumes that voids would migrate through the overlying backfill in the restored opencast without bridging or other wise stopping before reaching surface.

A series of drawings showing the risk from underground workings across the site are provided in Drawings 5209796-MRR-DWG001-005 in Annex A. Four east-west trending geological cross-sections through the recorded mine workings are provided in Drawing 5209796-MRR-DWG006 in Annex A.

4.3.3. Opencast Mine Workings

Opencast working of coal has been undertaken via the Abercraf, Onllwyn and Nant Helen pits across the site. Backfill placed in reclaimed opencasts is likely to experience settlement, as already recorded on site and documented in the Arup GIR [3]. Settlement of backfill in opencasts is considered in the main Atkins GIR, therefore it is not assessed here. Although it is noted that differential settlement is likely across the transition between unexcavated natural ground and backfill.

CIRIA C758D [17] states that instability of the opencast excavation highwall due to loosening of natural deposits during excavation and over steepening of faces may lead to later failure in the area of the former highwall. It is expected that further GI will be recommended in the main Atkins GIR where the alignment crosses the transition from natural ground to backfill.

4.3.4. Mine Gas

Ground gas monitoring was undertaken over a three-month period from January to April 2022, following the completion of the most recent GI [12]. This comprised monitoring 13 locations, including seven locations along the inner/outer loop and six locations within and around the washery area.

The ground gas assessment in the GIR by Arup [3] generally considered gas from Made Ground, peat and combusting strata and did not focus on the risks from mine gasses. As such the presence, or absence, and composition of mine gases is currently undefined.

Mine gas may migrate through underground mine workings towards surface. Where cuttings proposed as part of the scheme expose or nearly expose mine workings there is a risk of any mine gas present migrating into these cuttings. This should be assessed during any further investigation and/or remediation works. Mitigation measures should be followed to reduce the risk from mine gas migration in accordance with Coal Authority guidance and industry standards.

4.3.5. Minewater

To allow for opencast mining, the groundwater has been artificially depressed by pumping to prevent flooding of the opencast workings. On completion of the workings, it is understood that the pumps were switched off allowing the groundwater to naturally stabilise.

It is understood from communication with Celtic Energy that rebound has stabilised at between 100-120m AOD. Deep underground workings and adits draining to the River Tawe are believed to be responsible for maintaining the groundwater level at this elevation.

No boreholes were advanced deep enough to measure groundwater during the GI, therefore it has been assumed in agreement with the client, that groundwater will remain at this level (100-120m AOD).

Further review of hydrogeological data is to be included as part of the main Atkins GIR, a more detailed assessment of the risk due to minewater is required during remediation design.

Table 4-2 - Summary of mine shafts calculated to pose instability risk to the site.

Mine Entry ID	Easting (m)	Northing (m)	Distance from alignment/ washery area (m)	Estimated thickness of superficial deposits (m)	Phi (°)	Shaft diameter (m)	Departure (m)	Estimated potential collapse radius (m)	Does the estimated potential collapse zone overlap with the proposed development?	Treatment Records
282212-009	282108	212066	7	34	25	1.25	8	82	Yes	Treated, no further details.
283210-005	283838	210401	0 (below)	5	25	2	0	13	Yes	Treated 09/03/1987, no further details.
283210-029	283414	210785	5	2.7	25	1.25	8	15	Yes	Treated, no further details.
284210-029*	284934	210611	0 (below)	10	25	1.25	10	33	Yes	No records of treatment.

* Noted that geophysical anomalies in proximity to this mine entry were investigated by intrusive ground investigation, the location could not be confirmed

Table 4-3 - Summary of adits expected to pose instability risk to the site, ordered by location from northwest to southeast.

Mine Entry Ref.	Easting	Northing	Azimuth	Approximately distance from alignment (m)	Direction relative to alignment / Washery Area	Adit Portal Level (mAOD)	Adit Level below alignment/ washery area (mAOD)	Track Level Above Adit (mAOD)	Anticipated Status of Adit Mouth	Risk Comments
281211-008	281453	211804	126	185	Towards alignment	N/A	N/A		Unknown	Directed towards the alignment. May intersect the Nant Helen extension area of opencast. No mine plans are available to inform location/level/extent of this adit. Risk of subsidence / void migration below the alignment.
281212-009	281829	212034	178	118	Towards alignment	N/A	N/A	235*	Unknown	Directed towards the alignment. Mine plans shown that is located within an opencast area, but no levels are indicated for this adit on the mine plan. Risk of subsidence / void migration below the alignment.
281211-061	281875	211872	160	Below	N/A	226.00		240*	In situ	Located below the alignment. Opencast working plans suggest the adit has not been extracted. Risk of subsidence / void migration below the alignment.
282211-009	282014	211899	188	Below	N/A	219.14		236*	Extracted	Located below the alignment. Opencast working plans suggest surface extraction to below the elevation of the mouth of the adit, suggesting the adit mouth has been extracted but the adit roadway may remain in-situ. Risk of subsidence / void migration below the alignment.
282211-001	282075	211987	175	Below	N/A	208.25		208*	In situ	Located below the alignment and beyond known opencast working areas. Risk of subsidence / void migration below the alignment.
282212-012	282090	212020	219	Below	N/A	200.48		205*	In situ	Located below the alignment. Opencast working plans suggest that the mouth of the adit is likely to have been excavated by the roadways likely remain in place. Risk of subsidence / void migration below the alignment.
282212-001	282101	212035	219	Below	N/A	N/A		207*	Unknown	Located below the alignment. No mine plans are available to inform location/level/extent of this adit. The adit is within the Nant Helen opencast area. Risk of subsidence / void migration below the alignment.
282212-006	282097	212073	266	15	Parallel to alignment	N/A	Not dipping below the alignment	N/A	Unknown	Orientated parallel to the alignment approximately 15m from the alignment. Adit located in an opencast working area but no levels are available on plans to inform if the adit has been extracted. Risk of subsidence / void migration below the alignment due to uncertainty of the area of influence of the adit / accuracy of mine plan.
282212-002	282233	212059	186	Below	N/A	199.59		203*	Extracted	Located below the alignment. Opencast working plans suggest surface extraction to below the elevation of the mouth of the adit, suggesting the adit mouth has been extracted but the adit roadway may remain in-situ. Risk of subsidence / void migration below the alignment.
282211-004	282379	211948	180	Below	N/A	N/A	N/A	230*	Unknown	Located below the alignment. No mine plans are available to inform location/level/extent of this adit. Risk of subsidence / void migration below the alignment.
282211-005	282403	211946	187	Below	N/A	217.10		229*	Extracted	Located below the alignment. Opencast working plans suggest surface extraction to below the elevation of the mouth of the adit, suggesting the adit mouth has been extracted but the adit roadway may remain in-situ. Risk of subsidence / void migration below the alignment.
282211-006	282422	211934	201	Below	N/A	N/A		229*	Unknown	Located below the alignment. No mine plans are available to inform location/level/extent of this adit. Risk of subsidence / void migration below the alignment.
282212-003	282459	212023	165	Below	N/A	185.93		195*	Extracted	Located below the alignment. Opencast working plans suggest surface extraction to below the elevation of the mouth of the adit, suggesting the adit mouth has been extracted but the adit roadway may remain in-situ. Risk of subsidence / void migration below the alignment.

Mine Entry Ref.	Easting	Northing	Azimuth	Approximately distance from alignment (m)	Direction relative to alignment / Washery Area	Adit Portal Level (mAOD)	Adit Level below alignment/ washery area (mAOD)	Track Level Above Adit (mAOD)	Anticipated Status of Adit Mouth	Risk Comments
282211-008	282550	211934	188	Below	N/A	217.10		227*	In situ	Located below the alignment. Opencast working plans suggest the adit has not been extracted. Risk of subsidence / void migration below the alignment.
282211-010	282582	211994	210	Below	N/A	201.17		208*	Extracted	Located below the alignment. Opencast working plans suggest surface extraction to below the elevation of the mouth of the adit, suggesting the adit mouth has been extracted but the adit roadway may remain in-situ. Risk of subsidence / void migration below the alignment.
282212-004	282609	212014	204	Below	N/A	207.31		208*	Extracted	Located below the alignment. Opencast working plans suggest surface extraction to below the elevation of the mouth of the adit, suggesting the adit mouth has been extracted but the adit roadway may remain in-situ. Risk of subsidence / void migration below the alignment.
282211-016	282951	211927	162	Below	N/A	222.70		231.71*	Unknown	Located below the alignment. No opencast working plans are available for this area to assess if this adit was extracted or remains in-situ. Risk of subsidence / void migration below the alignment.
283211-017	283252	211738	129	137	Towards alignment	254.81	252.07	261	Unknown	Directed towards the alignment. Abandonment plan shows the roadway intersecting with the site. If adit extends into base of cutting then expected <10m of bedrock cover below the alignment which posing a risk of subsidence / void migration.
283211-043	283257	211765	153	109	Towards alignment	N/A	N/A	261	Unknown	Directed towards the alignment. No mine plans to inform location/level/extent of this adit are available. Risk of subsidence / void migration below the alignment if running parallel to adit 283211-043.
283211-037	283376	211800	165	75	Towards alignment	N/A	N/A	261	Unknown	Directed towards the alignment. No mine plans to inform location/level/extent of this adit are available. Risk of subsidence / void migration below the alignment.
283211-040	283487	211981	177	45	Towards alignment	216.21	204.78	230*	Unknown	Directed towards the alignment. Abandonment plan shows that intersects at the end with the alignment. Potential for <20m of bedrock cover below the alignment which may pose a risk of subsidence / void migration.
283210-026	283325	210691	302	19.5	Towards alignment	243.84	243.84	249	In situ	Directed towards the alignment. Shown on mine abandonment plan, but no indication of depth beneath alignment is available. Expected <20m of bedrock cover below the alignment which may pose a risk of subsidence / void migration.
283210-013	283379	210725	341	7.9	Towards alignment	241.84	241.84	249	In situ	Directed towards the alignment. Expected <20m of bedrock cover below the alignment which may pose a risk of subsidence / void migration.
283210-012	283348	210547	4	70	Towards alignment	N/A	N/A	247	In situ	Directed towards the alignment. No mine plans to inform location/level/extent of this adit are available. Located out of opencast working areas of Onllwyn opencast. Risk of subsidence / void migration below the alignment.
283210-032	283686	210400	315	Below	N/A	234.31		239	In situ	Located below the alignment. Located outside of working areas of Onllwyn opencast.
283210-015	283691	210426	307	6/ Below	N/A	232.64		239	In situ	Shown below the alignment on the mine abandonment plans. Located outside the working area of Onllwyn opencast. Risk of subsidence / void migration below the alignment.
283210-033	283488	210287	62	178	Towards alignment	N/A	N/A	234	In situ	Mine abandonment plan shows the roadway dipping beneath the alignment. Located beyond the opencast working areas of Onllwyn opencast. Risk of subsidence / void migration below the alignment.
283210-036	283654	210242	349	145	Towards alignment	N/A	N/A	236	In situ	Directed towards the alignment. No available mine plans to inform location/level/extent of this adit are available. Located out of opencast

Mine Entry Ref.	Easting	Northing	Azimuth	Approximately distance from alignment (m)	Direction relative to alignment / Washery Area	Adit Portal Level (mAOD)	Adit Level below alignment/ washery area (mAOD)	Track Level Above Adit (mAOD)	Anticipated Status of Adit Mouth	Risk Comments
										working areas of Onllwyn opencast. Risk of subsidence / void migration below the alignment.
283210-022	283846	210408	56	Below	N/A	228.73		228*	In situ	Located below the alignment. Located out of opencast working areas of Onllwyn opencast. Risk of subsidence / void migration below the alignment.
283210-023	283902	210428	26	Below	N/A	194.26		227*	In situ	Located below the alignment. Located out of opencast working areas of Onllwyn opencast. Potential for <20m of bedrock cover below the alignment which may pose a risk of subsidence / void migration, risk of subsidence / void migration below the alignment.
283210-003	283900	210571	355	128.3	Towards alignment	N/A	N/A	250	Unknown	Directed towards the alignment. Onllwyn completion plans shows that the adit may dip towards opencast working areas, but no mine plans are available to inform location/level/extent of this adit. Risk of subsidence / void migration below the alignment, although possible that adit ends before reaching alignment.
284210-031	284093	210877	341	220	Towards alignment	N/A	N/A	253	Unknown	Directed towards the alignment. Onllwyn completion plans shows that the adit may dip towards opencast working areas, but no mine plans are available to inform location/level/extent of this adit. Risk of subsidence / void migration below the alignment.
284210-023	284859	210653	200	Below	N/A	N/A	N/A	Assume current ground level	Unknown	Located below washery area. No mine plans are available to inform location/level/extent of this adit. Risk of subsidence / void migration below the washery area.
284210-035	284917	210565	131	Below	N/A	N/A	N/A	Assume current ground level	Unknown	Located below the washery area. No mine plans are available to inform location/level/extent of this adit. Risk of subsidence / void migration below the washery area. Noted that geophysical anomalies in proximity to this mine entry were investigated by intrusive ground investigation, the location could not be confirmed
285210-001	285145	210544	239	155	Towards washery area	N/A	N/A	Assume current ground level	Unknown	Directed away from the washery area but potential for adit roadway to pass beneath washery area. No mine plans are available to inform location/level/extent of this adit. May pass to south of The Washery area.

*Elevation at base of embankment at nearest point

Table 4-4 – Summary of Mine Workings Below Track

Colliery	Workings	Atkins Mining Risk Zone Number	Assumed Extraction Thickness (m)	Approximate level of workings below track from abandonment plans (m AOD)	Rockhead level	Approximate track level above mine workings (m AOD)	Required bedrock thickness [10t] (m)	Expected Bedrock Thickness	Workings occur within 10t of bedrock	Opencasting	Risk comment
Abercraf	Four Feet (Old Workings)	MRZ1	2	Unknown, nearest level is 197 (estimated)	Not proven, log of BH21 suggests 195 m AOD (base of opencast backfill)	236 (base of embankment)	20	~0	Possible	Opencasting taken place to 217m AOD	Potential risk from Four Feet Old Workings where these underlie the track. Discrepancy in level information across mining plans however possible that these old workings remain in place just below rock head level.
	Four Feet	N/A	2	217	N/A	N/A	20	N/A	N/A	Opencasting has likely removed these workings which occur in the centre of the site	Main workings are located outside of the alignment footprint. Adits used to access these workings do pose risk, covered in Table 4-3
	Cornish			190							
	Nine feet			192							
	Brass			Unknown							
	Nine Feet	MRZ2	3	206	214m AOD (proven in BH08)	232 - 237	30	8	Yes	None undertaken	Nine Feet workings underly track, recorded levels on mine plans indicate that there is risk of void migration to surface due to mine workings being within the 10t zone. BH08 did not encounter coal or workings to 194m AOD.
	Nine Feet	MRZ5	3	Between 120 - 135	Not proven by GI, fill proven to 220m AOD. Rockhead assumed to be at base of opencast (159m - 190 AOD)	260	30	29 - 55	Yes	Opencasting undertaken to between 159 – 190 m AOD (Nant Helen Main)	Opencasting to extract the Harnlow seam has pushed rock head down to within 10t of Nine Feet seam, potential for void migration to occur. Due to variability in elevation of worked Harnlow and Nine Feet seams this may not occur across the entirety of the seam. 10t limit increased to 30m for this seam as extraction thickness recorded to be 3m in seam. Assume void migration through >100 of overlying fill occurs.
International	Four Feet	N/A	2	Unknown	Not proven by GI, BH21 indicates that workings extend down to a depth of 195m AOD	235 - 241	20	N/A	N/A	Opencasting appears to have removed workings	No perceived risk based on reviewed information
	Nine Feet		2	Unknown	Unknown	235 - 237	20	N/A	Unknown	N/A	Limited information available, no GI coverage or abandonment plans covering this area.
	Brass										
Duffryn	Bluers	MRZ3b	2	240	238m AOD proven in nearby BH26 (~125m away)	280 (top of cutting)	20	~0	Yes	None	Workings recorded occur at or coincident with rock head level, therefore within 10t limit. BH26 indicates coal immediately below rock head.

Colliery	Workings	Atkins Mining Risk Zone Number	Assumed Extraction Thickness (m)	Approximate level of workings below track from abandonment plans (m AOD)	Rockhead level	Approximate track level above mine workings (m AOD)	Required bedrock thickness [10t] (m)	Expected Bedrock Thickness	Workings occur within 10t of bedrock	Opencasting	Risk comment
Cwmtawe	Bryn	MRZ4	2	200 - 204	236m AOD proven in BH10	233 (base of embankment)	20	32 - 36	Potential	None	Although depths of workings and rockhead indicate sufficient rock head cover coal was encountered at 213m AOD in BH10 very close to 10t, this area should be further investigated.
Dulais West Slant	Brass/Peacock	MRZ6a	2	244 (west side of workings) 268 (east side of workings)	Proven at 251m AOD in BH18 (west) Proven at 270m AOD in BH17 (east)	262 – 264 west to east (base of cutting)	20	6 - 7	Yes	None	Abandonment plan records indicate that workings likely to be exposed in cutting in the east and within 10t limit in the west. Zone of core loss recorded in BH18 at 244m AOD (coincident with recorded working depth in the west), between 229-239m AOD no recovery was possible. BH17 encountered zone of no recovery between 263.5-264m AOD.
	Brass/Peacock	MRZ6c	2	Levels vary from 224 to 234. Large number of old workings recorded without levels.	Proven at 247m AOD in BH15 (north) Proven at 234m AOD in BH02 (south) Proven at 223m AOD in BH01 (east)	226 – 255 (base of embankment)	20	~0 - 23	Yes	None	Workings recorded to occur within 10t limit – risk of void subsidence. BH15 – actual zone of core loss at 246m AOD BH02 – cavity at 218m AOD, no recovery down to 208m AOD BH01 – coal recorded at 215m AOD
Dulais East Slant	Brass /Peacock	MRZ6b	2	236 (west side of workings) 257 (east side of workings)	Proven at 254m AOD in BH14 (west) Proven at 254m AOD in BH13 (centre) Proven at 246m AOD in BH12 (east)	251 – 253 west to east (base of cutting)	20	~0 - 18	Yes	None	Abandonment plan records indicate that workings likely to be exposed in cutting in the east and within 10t limit in the west. Noted that levels of workings from plans in east exceed current bedrock level. Coal encountered at 243m AOD in BH12 Coal encountered at 235m AOD in BH13
		MRZ7	2	204 (west side of workings) 226 (east side of workings)	Proven at 226m AOD in BH33R (west) Proven at 223m AOD in BH34R (south), 25m south of area Proven at 232m AOD in BH30R (east) Proven at 226m AOD in BH29R (east)	230	20	~0 – 22m	Yes	None	Workings recorded to occur within 10t limit – risk of void subsidence. No GI undertaken within these workings BH33R encountered coal at 202m AOD BH34R encountered coal at 210m AOD
Unknown Workings	New / Lower		2	No plans available – unknown workings			20				No records of workings on plans, potential conjectured from outcrop. BH30R encountered coal at 225m AOD and void at 220m AOD Potential for voiding within 10t limit

4.4. Revised Mining Risk Zones (MRZs)

This section outlines the updated MRZs based on Atkins' understanding of the key mining risks across the site at the time of writing this report.

Atkins identifies a total of nine MRZs across the track alignment and one MRZ covering underlying the Washery. Some of the MRZs detailed in this section are similar to the 'Risk Zones' outlined in the previous reporting by Arup [1] [3].

Table 4-5 - Comparison of mining risk zones

Atkins MRZ	Arup Risk Zone	Comment
MRZ 1	N/A	Assessed that mine workings and entries have not been removed by opencasting
MRZ 2	Risk Zone B	Refinement of Risk Zone B
MRZ 3a	Risk Zone B	Refinement of Risk Zone B, for the adit called 'Duffryn's Level' in the north of the outer loop
MRZ 3b	Risk Zone A	Refinement of Risk Zone A, along the northern extent of the inner loop to highlight risks of shallow workings in the Duffryn Colliery.
MRZ 4	Risk Zone B	Refinement of Risk Zone B
MRZ 5	N/A	Assessed that opencast workings has pushed rockhead level to within 10t of expected workings, along the west of the inner loop to highlight risks from deep workings of the Abercraf Nine Feet Seam, which were raised relative to rockhead during opencast workings of the Harlow Seam
MRZ 6a	Risk Zone A	Refinement of Risk Zone A
MRZ 6b	Risk Zone A	Refinement of Risk Zone A
MRZ 6c	Risk Zone A	Refinement of Risk Zone A
MRZ 7	Risk Zone D	Refinement of Risk Zone D

The MRZs for the project are presented in Table 4-6. Drawings 5209796-MRR-DWG001-005 in Annex A illustrates the Mining Risk Zones across the site. Geological cross-sections through the mine workings are provided in Drawing 5209796-MRR-DWG006 in Annex A.

Table 4-6 - Mining Risk Zones.

Mining Risk Zone (MRZ)	Description of Extents and Overview of Risks	Details on Mine Workings	Details on Mine Entries
1	MRZ 1 is located in the northwest of the outer loop and extends for approximately 1 km along the track, from the potential interaction with Mine Entry 281211-008 in the west to the Mine Entry 282212-004 in the east. There is a stability risk posed by adits, shafts and shallow mine workings.	Older workings of the Four Feet Seam from Abercraf Colliery with limited level information recorded as underlying this risk zone. Opencast working may have removed Four Feet workings based on the depth of backfill encountered in BH21 Nearest level indicator for old workings is 197m AOD, base of backfill is 195m AOD suggesting that workings may have been removed but could also be present at or around rockhead level, therefore within 10t limit and present risk of void migration.	Total of 14No. adits within 30 m. 6 No. adits are believed to have been removed by opencast workings and 8 No. adits are believed to be in-situ. Numerous adit roadways lie beneath the site, some of which were likely not removed during the open cast workings and therefore may remain in-situ. The elevations of these roadways are not shown on the mine abandonment plans and may have < 20 m of bedrock cover beneath the alignment. An additional 2 No. adits located 118 m and 185 m northwest of the alignment have recorded dips towards the alignment but have no associated mine abandonment plans. As such it has not been possible to determine if these extend under the alignment but there is potential for this. One shaft is within 30 m. This shaft's potential collapse zone is estimated to have an 80 m overlap with the embankment in the north of the site. This shaft was treated at some point in the past but there is no available information on the date of treatment [7].
2	MRZ 2 is located in the north of the outer loop and extends for approximately 75 m along the track and is defined by the extents of the shallow workings of the Abercraf Colliery. There is a stability risk posed by shallow mine workings.	Underground workings are expected to be present in this location relating to the working of the Nine Feet seam from the Abercraf Colliery Records indicate mine workings at 206m AOD within 10t limit of rock head at 214m AOD presenting risk of void migration. Noted that BH08 drilled in this area did not encounter coal or evidence workings to 194m AOD.	No mine entries are recorded within 30 m of MRZ 2.
3	a	MRZ 3a is located in the north of the outer loop and extends for approximately 45 m along the track. This risk zone includes one SE-dipping mine entry, which is associated with the Duffryn Colliery 90 m southeast. There is a stability risk posed by adits and underground roadways with <20 m of bedrock cover.	1 No. adit (annotated as 'Duffryn level') beneath the alignment and dips southeast towards the Duffryn Colliery, which lies approximately 90 m south of the alignment boundary in this area. The elevations of the roadway associated with this adit are not shown on the mine abandonment plans and are likely to have < 20 m of bedrock cover beneath the alignment based on the location of the adit mouth. 1No. shaft is recorded approximately 22 m south of the site boundary but is not estimated to have a potential collapse zone that overlaps with the embankment in this region. This shaft has no records of treatment.
	b	MRZ 3b is located in the north of the inner loop and extends for approximately 110 m along the outside cutting of the bend. This risk zone includes the edge of the shallow workings of the Duffryn Colliery. There is a stability risk posed by shallow mine workings.	No mine entries are recorded within 30 m of MRZ 3b.
4	MRZ 4 is located in the northeast of the outer loop and extends for approximately 150 m along the track. This risk zone is defined by the extents of the shallow workings of the Cwmtawe Colliery. There is a stability risk posed by adits and shallow mine workings.	Underground workings are expected to be present in this location relating to the working of the Bryn seam from the Cwmtawe Colliery Recorded levels of workings (220-204m AOD) and rockhead encountered in BH10 (236m AOD) would indicate sufficient bedrock cover to prevent void migration. BH10 encountered coal at 213m AOD – edge of 10t limit. BH10 is the only borehole drilled in location and is located at the edge of risk zone.	2No. adits are recorded approximately 70 m and 50 m north of the embankment and dip beneath the rail loop embankment. Roadways associated with this adit are expected to be at 205 m AOD when they pass under the alignment with a level of 230 m AOD (base of embankment) with rockhead at 225 m AOD. Applying the 10t rule, there is a comparatively low risk of void migration from the workings to track level. No shafts are recorded within 30 m of MRZ 4.
5	MRZ 5 is located in the west of the inner loop and extends for approximately 300 m along the track. It is defined by the extent of the workings of the Abercraf Nine Feet Seam beneath the opencast workings of the Harlow Seam. There is a stability risk posed by deep workings.	The Abercraf colliery worked the Nine Feet seam from underground workings below the later Nant Helen opencast, in this are the opencast did not work the Nine Feet seam, opencast workings extended down to the overlying Harnlow seam. Open cast workings have brought the base of the pit within 20-30 m of the Nine Feet seam, resulting in insufficient bedrock cover.	No mine entries are recorded within 30 m of MRZ 3b.

Mining Risk Zone (MRZ)		Description of Extents and Overview of Risks	Details on Mine Workings	Details on Mine Entries
			Nine Feet seam recorded as being extracted to a thickness of 3m, increasing 10t from 20m to 30m. Rockhead assumed to be at base of opencast (159-190m AOD), not proven by GI, Nine Feet seam recorded at 120-135m AOD within 10t limit and presenting risk of void migration. Approximately 100 m of backfill has been place above the lowest workings to formation level, assume that a void migrates through the full thickness of this back fill	
6	a	MRZ 6a is located in the north of the inner loop and extends for approximately 150 m along the track. This zone is defined by the extents of the Nant Helen opencast and the bell pit workings. Much of this risk zone is also underlain by the shallow workings of the Dulais Colliery (Peacock Seam). There is a stability risk posed by shallow mine workings and bell pitting.	Shallow underground workings are expected to be present in this location relating to the working of the Peacock seam from the west slant of Dyffryn Colliery. The shallowest workings in the east at 268m AOD are likely to be exposed during construction of the proposed cutting to 264m AOD. Following the 10t rule, there is a risk of void migration from workings likely to occur very near surface beneath the track in west. Workings recorded at 244m AOD, proposed cutting depth of 262m AOD. Noted that the above cutting will be partially into rock (below current rockhead of 270m AOD in east Zone of core loss recorded in BH18	No mine entries are recorded within 30 m of MRZ 6a. 1945 satellite imagery indicates that bell pitting has been undertaken within MRZ 6a.
	b	MRZ 6b is located in the southeast of both the inner loop and outer loop and extends for approximately 350 m along the track. This risk zone is defined by the extent of possible bell pitting in the west and shallow workings of the Dulais Colliery (Peacock Seam) and evidence for bell pitting in the east. There is a stability risk posed by shallow mine workings, potential underground roadways with <20 m of bedrock cover and bell pitting.	Shallow underground workings are expected to be present in this location relating to the working of the Peacock seam from the east slant of Dyffryn Colliery. Evidence of suspected shallow underground workings was encountered in BH12 (actual zone of core loss), coal was encountered in BH12 and BH14 thought to be the Peacock seam. Coal and core loss are within 20m of rockhead. The levels of the workings are expected to be between 219 and 241 mAOD, track formation level is 249 m AOD with rock head at 255 m AOD (cutting in rock). Hence, following the 10t rule, there is a risk of void migration from the workings to track level.	No mine entries are recorded within 30 m of MRZ 6b. However, 2No. adits are located approximately 140 m and 220 m southeast of the alignment. The roadways associated with these adits are not shown on the mine abandonment plans, therefore, there is a risk these may pass beneath the alignment with < 20 m of bedrock cover. 1945 satellite imagery indicates that bell pitting has been undertaken within MRZ 6b.
	c	MRZ 6c is located in the south of both the inner loop and outer loop and extends for approximately 180 m along the main track and an additional 1 km along the track leading to the washery area. This risk zone is defined by extent of the Nant Helen opencast in the west and the extent of shallow workings of the Dulais Colliery (Peacock Seam) and evidence for bell pitting in the east. There is a stability risk posed by shafts, adits, shallow mine workings with <20 m of bedrock cover and bell pitting.	Shallow underground workings are expected to be present in this location relating to the working of the Peacock seam from the west slant of Dyffryn Colliery. Recorded workings expected between 224m AOD 234m AOD in this area Proven rockhead level varies form 223m AOD to 247m AOD, proposed track level between 226m AOD and 255m AOD Workings can be expected at or just below rock head, within 10t limit and therefore presenting a void migration risk. Evidence of the suspected shallow underground workings was encountered in BH02 and BH15 (void and zone of core loss), within 10t limit	Total of 2 No. adits are recorded within 30 m of the alignment, of which 4 No. lie directly under the alignment and 2 No. are adjacent to the alignment. Of 2 No. adjacent to the alignment: 1 No. roadway is expected to be at 242 m AOD when it passes under the alignment with a level of 250 m AOD with rockhead at 250 m AOD. Hence, following the 10t rule, there is a risk of void migration from the workings to track level. 1 No. roadway does not have any details on the mine abandonment plan to indicate the depth beneath the alignment. However, this adit is close to the other adit, and therefore there is a risk that this adit may also pass beneath the alignment with < 20 m of bedrock cover. The three adits underlying the alignment are expected to be near/at surface. A further 3 No. adits have roadways that dip beneath the alignment with <20 m of bedrock cover. The elevations of these roadways are not shown on the mine abandonment plans and may have < 20 m of bedrock cover beneath the alignment. A total of 3 No. shafts are within 30 m, comprising: 1No. shaft is within the site and was treated in March 1987. 1No. shafts potential collapse zone is estimated to have an approximately 8 m overlap with the earthworks in the north of MRZ 6c. This shaft was treated at some point in the past but there is no available information on the date of treatment [9]. 1No. shaft is located approximately 20 m north of the site. This potential zone of collapse for this shaft is estimated to not overlap with the alignment and this shaft was treated in August 1973.

Mining Risk Zone (MRZ)	Description of Extents and Overview of Risks	Details on Mine Workings	Details on Mine Entries
7	MRZ 7 includes all of the land within the Washery Area Phase 1A Boundary. There is a stability risk posed by shafts, adits and shallow mine workings.	Shallow underground workings are expected to be present in this location relating to the working of the Bluers seam and the brass seam from the Dulais East Slant and Onllwyn Colliery. Bedrock is proven by GI between 223m AOD and 232m AOD, workings are recorded between 204m AOD and 226m AOD within 10t limit and therefore presenting a risk of void migration. A 1 m void found in BH30R at a depth of 220m AOD has been interpreted as unrecorded mine workings, possibly of the New and Grey seams. Further evidence of void migration risk.	1945 satellite imagery suggests bell pitting within MRZ 6c. A total of two adits are within 30 m. Both adits underlie the alignment. The GI findings suggest that the two adits underlying the alignment may be buried with 4-10 m of Made Ground. 1No. mine shaft is located within the site and has an estimated potential collapse radius of 33 m, there are no historical records of treatment [7]. One adit and the shaft were investigated during the most recent geophysical survey by Terradat. Geophysical anomalies were identified in the vicinity of both mine entries, but the trial pitting at these locations found no evidence for mine entries There is a risk that these mine entries are present in other locations within the Washery. The second adit was not investigated and remains a risk.

5. Conclusions and Recommendations

5.1. Summary

Atkins Limited (Atkins) has been commissioned by GCRE Co. Ltd to complete the design of the earthworks (cuttings and embankments) for the Global Centre of Rail Excellence (GCRE) Project in South Wales. The project entails the design and construction of a railway test track at the site of the former Nant Helen Opencast mine. High speed and low speed train tests will be undertaken at the proposed facility on two new test loops.

The site is divided into two areas; the proposed GCRE track alignment and the Washery Area. The proposed alignment surrounds and overlies the Nant Helen opencast workings (previously operated for extraction of coal by Celtic Energy and now in process of being restored) and covers an area spanning approximately 2.7 km by 1.9 km.

The site is within the influence of historic underground and more recent surface mining activities. Arup has previously completed a Geotechnical and Geoenvironmental Desk Study Report [1], Detailed Mine Workings Study [2] and Ground Investigation Report [3] to inform mining risks at the site.

This work identified a significant instability risk to the proposed project from legacy coal mining activities within the Middle and Lower Coal Measures in the following:

- Brass,
- Peacock (Brass),
- Nine Feet
- Big Seams and
- Unrecorded workings

5.2. Identification of Mining Risks

The risks posed to the scheme emanate from the following:

- Shallow workings present within under the proposed alignment where rockhead cover is insufficient to prevent migration of voids to surface;
- Shafts with collapse zones that encroach on the proposed alignment;
- Adits and/or roadways present under the proposed alignment where rock head cover is insufficient to prevent migration of voids to surface; and;
- Presence of historical bell pitting.

To mitigate the risks, it is considered that actions will be necessary to either 'dig out' or undertake drill and grout treatment of shallow mine workings where these are present below the 'earthwork formation' and where these have less than 20m of rock cover. Arup's assessment separated designated the risks into four discrete Mining Risk Zones (A – D). These risk zones have been further refined by Atkins

Atkins synthesised key information provided by Arup and reviewed this information against available mine abandonment plans from the Coal Authority, open cast completion plans from Celtic Energy and open-access information from both the BGS and the Coal Authority.

The results of this review generally agree with the four mining risk zones previously identified by Arup, with the zones sub-divided to ten areas. Nine MRZs are within the proposed track alignment and one MRZ in the Washery Area. The MRZ's are shown on Drawings GCRE001-AWJV-00-XX-DR-GE-00014 to GCRE001-AWJV-00-XX-DR-GE-00018.

- **MRZ 1:** located in the northwest of the outer loop and extends for approximately 1 km along the track. This zone includes seventeen adits and one shaft not entirely removed by open casting as well as shallow mine workings where bedrock cover is unlikely to be sufficient to prevent void migration. There is currently a limited coverage of deep GI within MRZ 1 and none of the mine entries identified in this MRZ were previously investigated.
- **MRZ 2:** located in the north of the outer loop and extends for approximately 75 m along the track. This zone includes shallow mine workings in the Nine Feet Seam of the Abercraf Colliery with a recorded extraction thickness of 2.7 m – 3 m and bedrock cover unlikely to be sufficient to prevent void migration.

- **MRZ 3a:** located in the north of the outer loop and extends for approximately 45 m along the track. This risk zone includes one shallow SE-dipping mine entry is likely to be present on site according to satellite imagery. Both the adit mouth and the associated underground roadway pose a risk to the embankment in this area.
- **MRZ 3b:** located in the north of the inner loop and extends for approximately 110 m along the outside cutting of the bend. This risk zone includes the edge of the shallow workings of the Duffryn Colliery with a bedrock cover unlikely to be sufficient to prevent void migration.
- **MRZ 4:** is located in the northeast of the outer loop and extends for approximately 150 m along the track. This risk zone is defined by the extent of the shallow workings of the Cwmtawe Colliery with bedrock cover unlikely to be sufficient to prevent void migration. Two adits are recorded approximately 70 m and 50 m north of the embankment in this area, and likely dip beneath the embankment at shallow depth.
- **MRZ 5:** is located in the west of the inner loop and extends for approximately 300 m along the track. It is defined by the extent of the workings of the Abercraf Nine Feet Seam beneath the opencast workings of the Harnlo Seam. Post open cast extraction, the bedrock cover above the Nine Feet Seam is unlikely to be sufficient to prevent void migration. This assumes that a void would propagate through 100 m of opencast backfill material and reach the surface.
- **MRZ 6a:** is located in the north of the inner loop and extends for approximately 250 m along the track.
- **MRZ 6b:** is located in the southeast of both the inner loop and outer loop and extends for approximately 350 m along the track.
- **MRZ 6c:** is located in the south of both the inner loop and outer loop and extends for approximately 360 m along the main track and an additional 1 km along the track leading to the washery area.
 - All three risk zones are underlain by the shallow workings of the Dulais Colliery (Peacock Seam) where bedrock cover is unlikely to be sufficient to prevent void migration. Historical satellite imagery from 1945 also suggests that bell pitting may have occurred within all three MRZs. The cuttings within these areas may also interact with the mine workings and/or coal seams during construction, exposing these at ground level. Additionally, two adits are located approximately 140 m and 220 m southeast of MRZ 6b and there is a risk that these roadways dip beneath the site with bedrock cover unlikely to be sufficient to prevent void migration. A total of nine adits and two shafts also represent a risk to the proposed scheme in MRZ 6c.
- **MRZ 7:** comprises all of the land within the Washery Area Phase 1A Boundary and includes two recorded adits and one recorded mine shaft. There are no recorded mine workings underlying this part of the site. However, the recent GI encountered a 2 m wide void at 3.20 m below rockhead and a 1 m wide void at 13.60 m below rockhead in one borehole (BH30R). Coal was also encountered in three boreholes (BH30R, BH32R and BH33R). These boreholes suggest that there are unrecorded mine workings with bedrock cover unlikely to be sufficient to prevent void migration beneath MRZ 7.

In addition to the risks highlighted in the MRZs, Atkins considers there to be a high probability of unrecorded mine entries occurring across the entire site, but particularly within and surrounding the extents of recorded mine workings. Atkins also considers there to be high probability of unrecorded mine workings occurring across the site, similar to the apparently unrecorded workings identified in the Washery Area (MRZ 7).

5.3. Recommendations and Further Works

Ground Investigation

Ground Investigations have confirmed the presence of legacy mining activities across the site. Further investigation will be required to confirm the extents of treatment required. The scope of investigation will vary but is expected to comprise:

- Rotary core boreholes to categorise geological conditions
- Rotary probe drilling to delineate underground mine workings
- Geophysical surveys to locate entries
- Rotary probe drilling to delineate mine entries
- Trenching to delineate mine entries
- Inspection and mapping of adits

Approval from the Coal Authority is required prior to any further intrusive investigation works.

A site walkover is recommended to locate and map mine entries and identify areas of existing subsidence due to collapse of underground workings or bell pits. This should be undertaken before the design phase is completed.

Hydrogeological Conditions

To allow for opencast mining, the groundwater has been artificially depressed by pumping to prevent flooding of the opencast workings. On completion of the workings, it is understood that the pumps were switched off allowing the groundwater to naturally stabilise.

It is understood from communication with Celtic Energy that rebound has stabilised at between 100-120m AOD. Deep underground workings and adits draining to the River Tawe are believed to be responsible for maintaining the groundwater level at this elevation.

No boreholes were advanced deep enough to measure groundwater during the GI, therefore it has been assumed in agreement with the client, that groundwater will remain at this level (100-120m AOD).

A detailed assessment of the risk due to minewater is required to inform remediation design strategy and the impacts from any such works. Further investigation and monitoring is likely to be required.

Mine Gas

Ground gas monitoring has to date been targeted at the Made Ground and peat. As such the presence, or absence, and composition of mine gases is currently undefined. Further investigation and monitoring is required.

Remediation Strategy

Remediation works will be required to mitigate the mining risk posed to the site. The treatment type will vary depending on the final arrangement and will be subject to the findings of the additional investigation. This will likely comprise either cut and fill for workings near surface or bulk infill stabilisation for deeper workings. The type of remediation will vary subject to the performance tolerances, e.g., at structure locations the use of high strength grout may be necessary.

The risk summary has been developed on the basis of a general work seam thickness of 2m, increased to 3m for the Nine Feet Seam. Application of the '10t rule' after CIRIA C758D [17] is proposed to mitigate risk posed by upward migration from collapsing voids.

Remediation of mine entries is expected to comprise either bulk infill or concrete cap at surface. This will be reviewed once the entry arrangements and conditions have been confirmed. It is noted that a selection of entries are reported as being remediated. Information on the remediation strategy completed should be sought. Additional validation of the remediation may be required.

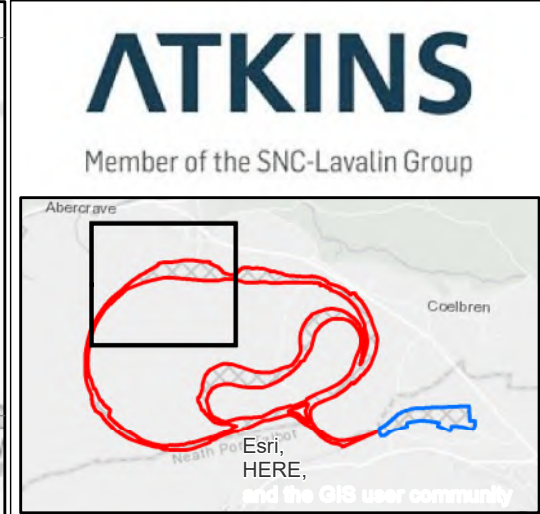
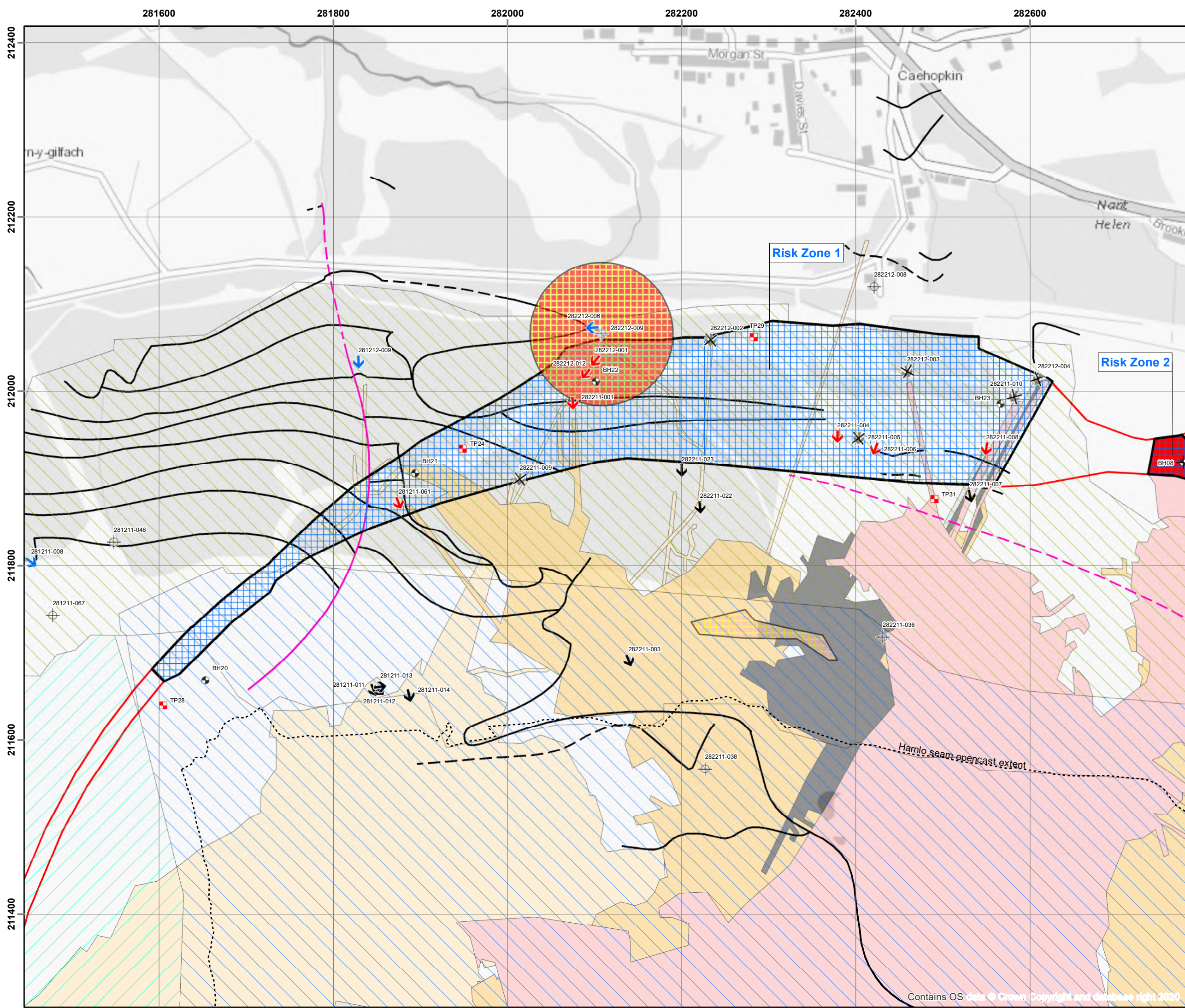
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Annexes



Annex A. Drawings



Legend

Mining Risk Zones (MRZs)	Recorded shallow mine workings beneath the proposed alignment and Washery Area
Recorded adit	Abercraze Big underground working
Recorded adit entry point within the site	Onlywn Bluers underground working
Recorded adit dipping beneath the site	Onlywn Brass underground working
Recorded adit mouth likely extracted but roadway in-situ	Abercraze Black underground working
Recorded shaft	Abercraze Four Feet underground working
Recorded shaft within the site	Abercraze 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	Onilwyn - Peacock opencast (1946-1949)
Potential collapse risk zones for mine shafts	Onilwyn - Nine Feet opencast (1946-1949)
Coal seam, inferred (BGS)	Abercraze/Gwaunton opencast (1963-1973)
Coal seam, observed (BGS)	Onilwyn 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

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VER	DESCRIPTION	BY	DATE	CHK'D	REVW	AUTH

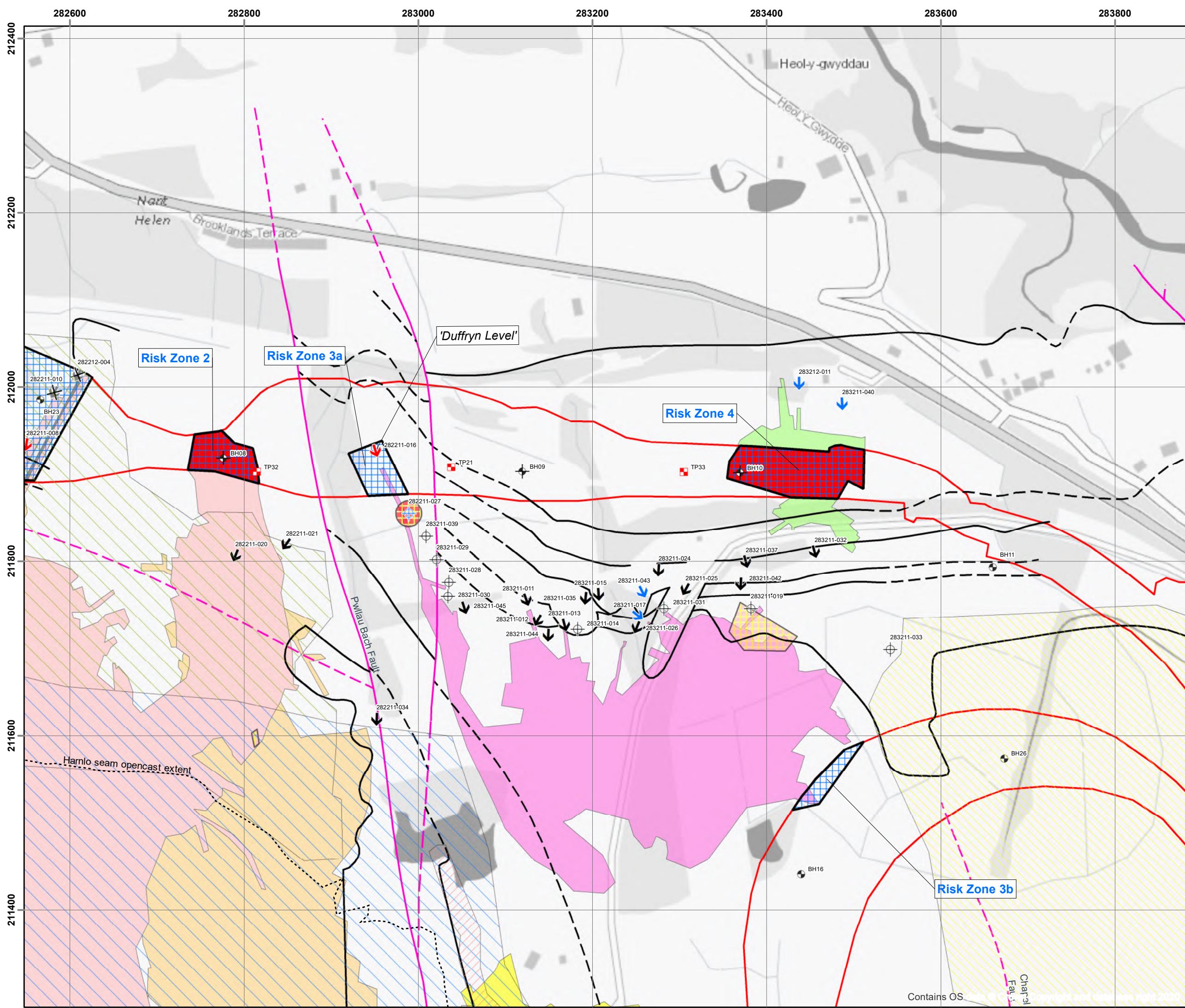
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GCRC Co Ltd

PROJECT:
Global Centre for Rail Excellence

TITLE:
Overview of Mining Hazards (MRZ 1)

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STATUS: DRAFT	DRAWING NO: GCRC001-AWJV-00-XX-DR-GE-00014	VER: 1
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ATKINS

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Legend

Mining Risk Zones (MRZs)

Recorded adit

Recorded adit entry point within the site

Recorded adit dipping beneath the site

Recorded adit mouth likely extracted but roadway in-situ

Recorded shaft

Recorded shaft within the site

Recorded shaft within 30 m of the site

Rotary core borehole

Rotary open borehole

Cable percussion borehole

Trial pit

Potential collapse risk zones for mine shafts

Coal seam, inferred (BGS)

Coal seam, observed (BGS)

Normal fault, inferred (BGS)

Normal fault, observed (BGS)

Washery Area - Phase 1A Boundary (Arup, 2022)

Proposed GCRE Alignment

Evidence for bell pits

Recorded shallow mine workings beneath the proposed alignment and Washery Area

Abercrave Big underground working

Onilwyn Bluers underground working

Onilwyn Brass underground working

Abercrave Black underground working

Abercrave Four Feet underground working

Abercrave White underground working

Cwmtawe Bryn underground working

Duffryn Bluers underground working

Dulais Peacock underground working

International Four Feet underground working

Onilwyn - Peacock opencast (1946-1949)

Onilwyn - Nine Feet opencast (1946-1949)

Abercrave/Gwaunton opencast (1963-1973)

Onilwyn opencast (1972-1982)

Nant Helen opencast (1986-1999)

Nant Helen Extension opencast (2002-2019)

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).

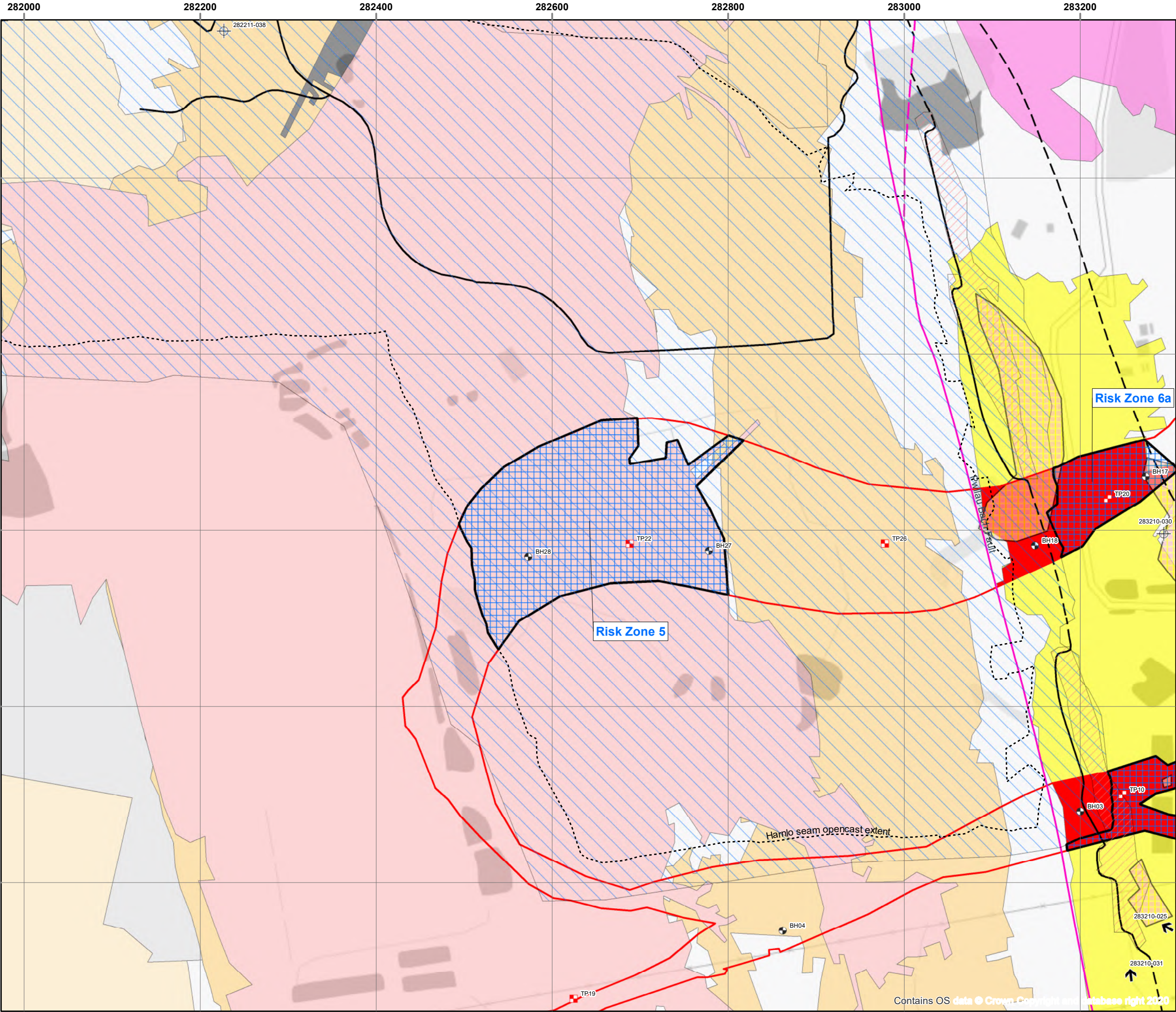
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Metres

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Coordinate System: British National Grid

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PROJECT: Global Centre for Rail Excellence						
TITLE: Overview of Mining Hazards (MRZ 2, 3a, 3b and 4)						
SCALE: 1:4,000	ORIGINATOR: HW	CHECKED: PA	REVIEWED: KP	AUTHORISED: -		
SIZE: A3	DATE: 09/06/2022	DATE: 16/06/2022	DATE: 16/06/2022	DATE: -		
STATUS: DRAFT				DRAWING NO: GCRE001-AWJV-00-XX-DR-GE-00015		VER: 1



Legend

Mining Risk Zones (MRZs)

Recorded adit

Recorded adit entry point within the site

Recorded adit dipping beneath the site

Recorded adit mouth likely extracted but roadway in-situ

Recorded shaft

Recorded shaft within the site

Recorded shaft within 30 m of the site

Rotary core borehole

Rotary open borehole

Cable percussion borehole

Trial pit

Potential collapse risk zones for mine shafts

Coal seam, inferred (BGS)

Coal seam, observed (BGS)

Normal fault, inferred (BGS)

Normal fault, observed (BGS)

Washery Area - Phase 1A Boundary (Arup, 2022)

Proposed GCRE Alignment

Evidence for bell pits

Recorded shallow mine workings beneath the proposed alignment and Washery Area

Abercrag Big underground working

Onlylwn Bluers underground working

Onlylwn Brass underground working

Abercrag Black underground working

Abercrag Four Feet underground working

Abercrag White underground working

Cwmstawe Bryn underground working

Duffryn Bluers underground working

Dulais Peacock underground working

International Four Feet underground working

Onilwyn - Peacock opencast (1946-1949)

Onilwyn - Nine Feet opencast (1946-1949)

Abercrag/Gwaunton opencast (1963-1973)

Onilwyn opencast (1972-1982)

Nant Helen opencast (1986-1999)

Nant Helen Extension opencast (2002-2019)

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).

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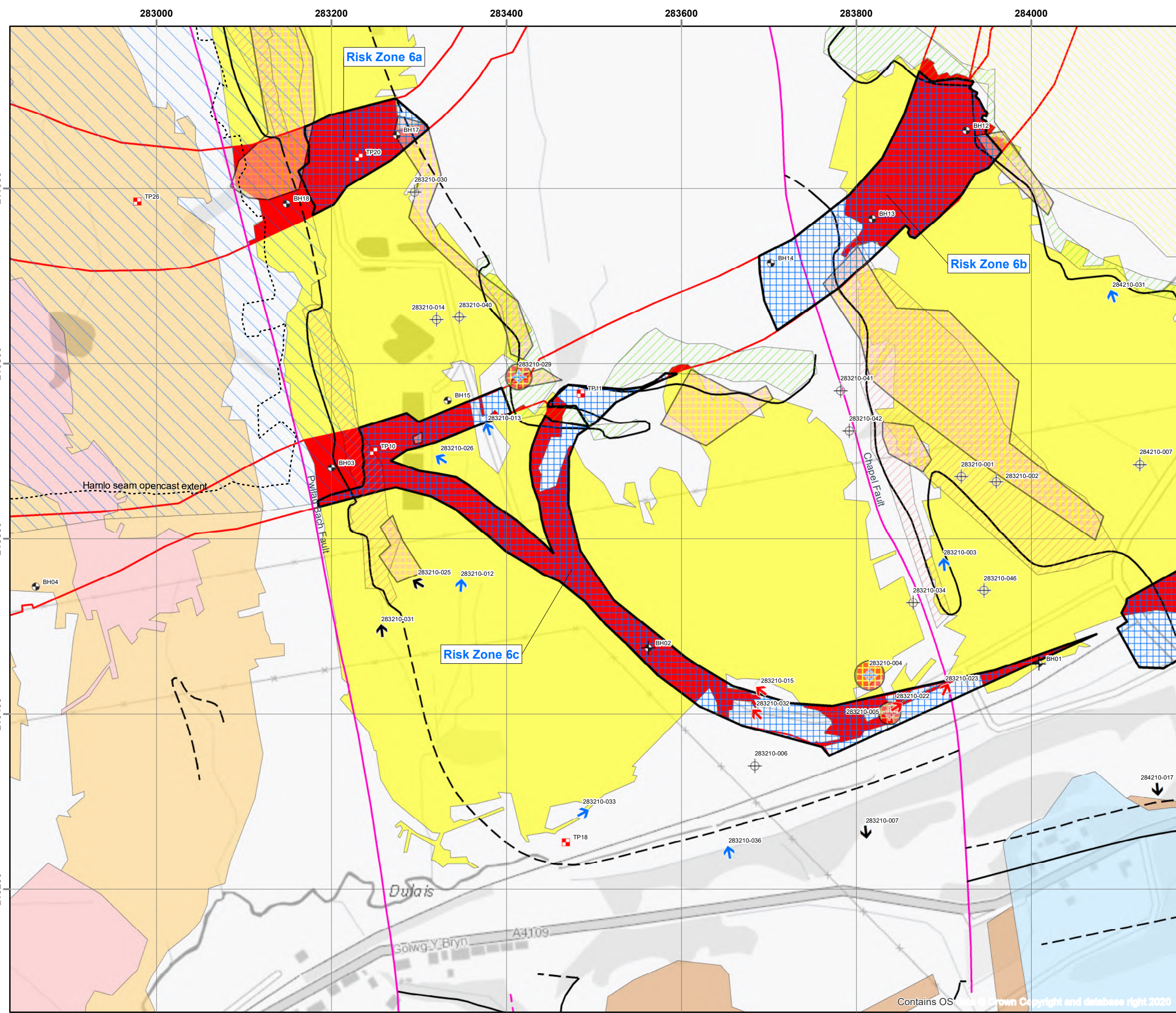
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Metres

Coordinate System: British National Grid

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CLIENT: GCRE Co Ltd						
PROJECT: Global Centre for Rail Excellence						
TITLE: Overview of Mining Hazards (MRZ 5)						
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Legend

Recorded adit

Recorded adit dipping beneath the site

Recorded shaft

Recorded shaft within 30 m of the site

Rotary open borehole

Trial pit

Coal seam, inferred (BGS)

Normal fault, inferred (BGS)

Washery Area - Phase 1A Boundary (Arup, 2022)

Evidence for bell pits

Abercrave Big underground working

Onlylwn Brass underground working

Abercrave Four Feet underground working

Cwmatawe Bryn underground working

Dulais Peacock underground working

Onilwyn - Peacock opencast (1946-1949)

Abercrave/Gwaunton opencast (1963-1973)

Nant Helen opencast (1986-1999)

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).

0

25

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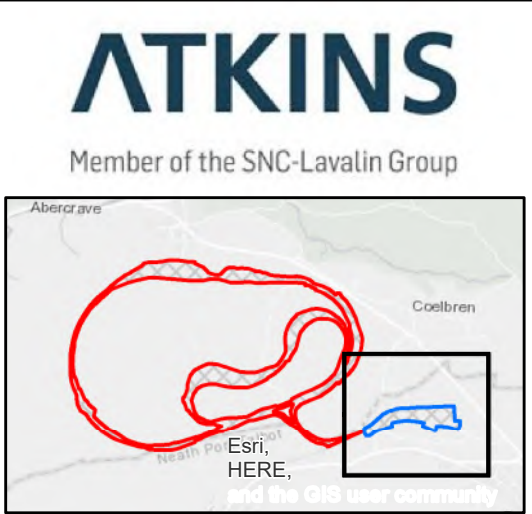
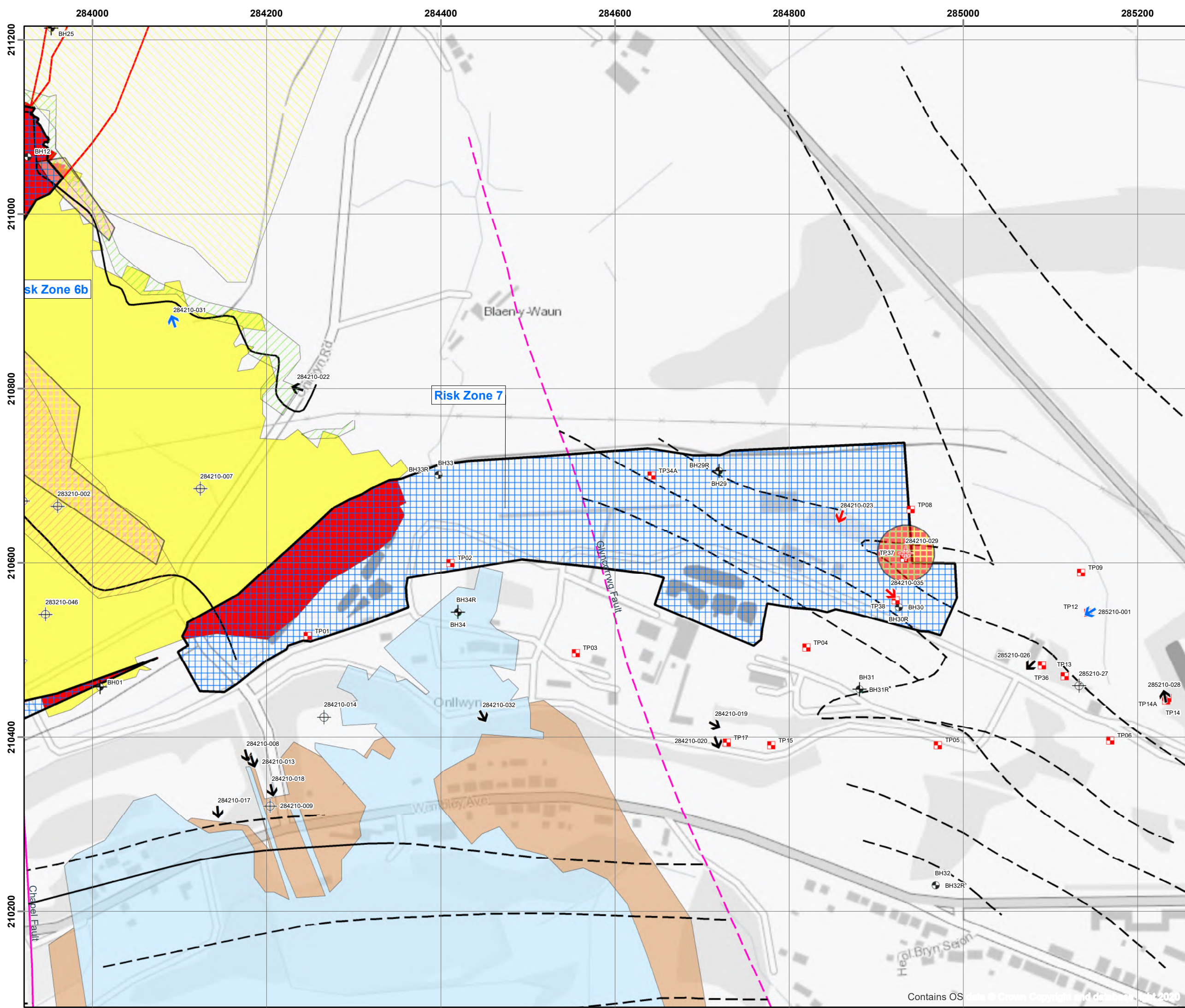
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Metres

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Coordinate System: British National Grid

1	DRAFT FOR ISSUE	HW	09/06/2022	PA	KP
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CLIENT: GCRE Co Ltd					
PROJECT: Global Centre for Rail Excellence					
TITLE: Overview of Mining Hazards (MRZ 6a, 6b and 6c)					
SCALE: 1:4,000	ORIGINATOR: HW	CHECKED: PA	REVIEWED: KP	AUTHORISED: -	
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STATUS: DRAFT	DRAWING NO: GCRE001-AWJV-00-XX-DR-GE-00017				VER: 1



Legend

Mining Risk Zones (MRZs)

Recorded adit

Recorded adit entry point within the site

Recorded adit dipping beneath the site

Recorded adit mouth likely extracted but roadway in-situ

Recorded shaft

Recorded shaft within the site

Recorded shaft within 30 m of the site

Rotary core borehole

Rotary open borehole

Cable percussion borehole

Trial pit

Potential collapse risk zones for mine shafts

Coal seam, inferred (BGS)

Coal seam, observed (BGS)

Normal fault, inferred (BGS)

Normal fault, observed (BGS)

Washery Area - Phase 1A Boundary (Arup, 2022)

Proposed GCRC Alignment

Evidence for bell pits

Recorded shallow mine workings beneath the proposed alignment and Washery Area

Abercrave Big underground working

Onlylwyn Bluers underground working

Onlylwyn Brass underground working

Abercrave Black underground working

Abercrave Four Feet underground working

Abercrave White underground working

Cwmtawe Bryn underground working

Duffryn Bluers underground working

Dulais Peacock underground working

International Four Feet underground working

Onlylwyn - Peacock opencast (1946-1949)

Onlylwyn - Nine Feet opencast (1946-1949)

Abercrave/Gwaunton opencast (1963-1973)

Onlylwyn opencast (1972-1982)

Nant Helen opencast (1986-1999)

Nant Helen Extension opencast (2002-2019)

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).

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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)					
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STATUS: DRAFT	DRAWING NO: GCRC001-AWJV-00-XX-DR-GE-00018				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

Faults and Linear Features

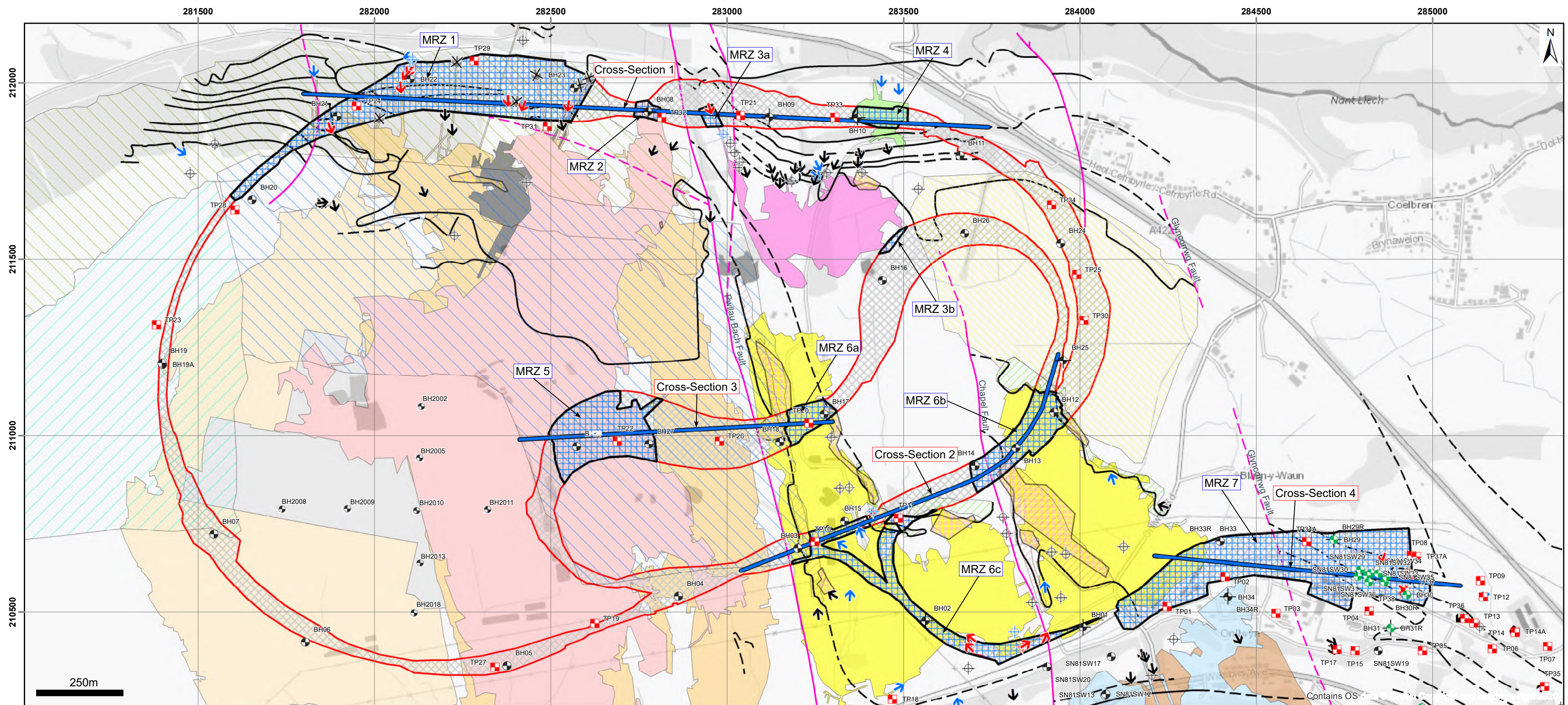
- 10k (BGS)
- Coal seam, inferred
- Coal seam, observed
- Normal fault, inferred
- Normal fault, observed
- Evidence for bell pitting
- Recorded Underground Workings
- Abercrave Big
- Onllwyn Bluers
- Onllwyn Brass
- Abercrave Black
- Abercrave Four Feet
- Abercrave White
- Cwmtawe Bryn
- Duffryn Bluers
- Dulais Peacock
- International Four Feet

Symbols

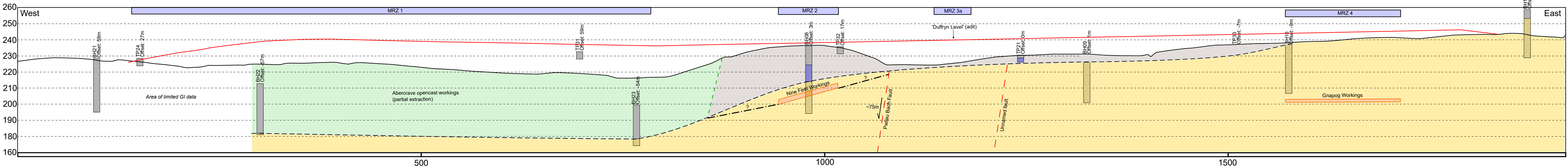
- Existing ground surface
- Proposed ground surface
- Interpreted rockhead
- Interpreted boundary of opencast area
- Interpreted coal seam
- Recorded fault
- Recorded mine working
- Fault displacement

NOTES

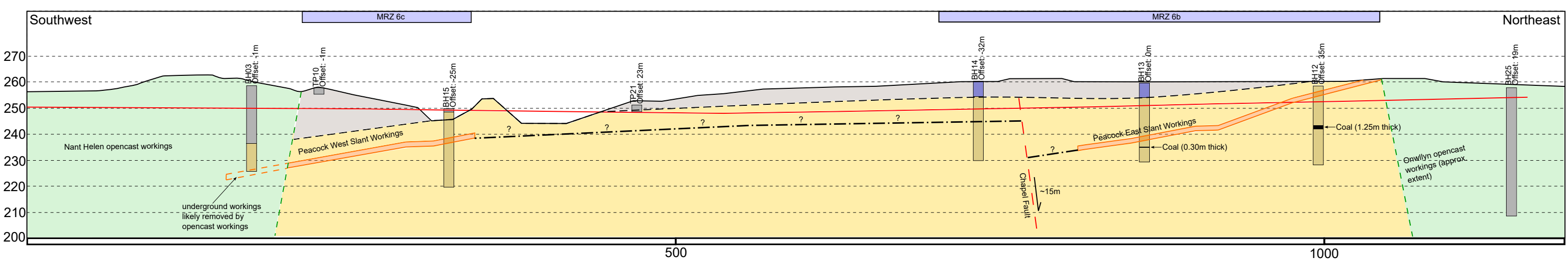
- This drawing and its contents have been prepared and are intended solely as information for GCRE Co. Ltd and use in relation to the Atkins GIR for the earthworks design and associated Mining Risk Review Document. Atkins Limited assumes no responsibility to any other party in respect of or arising out 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.
- Mine entries were omitted from the cross-sections for clarity.



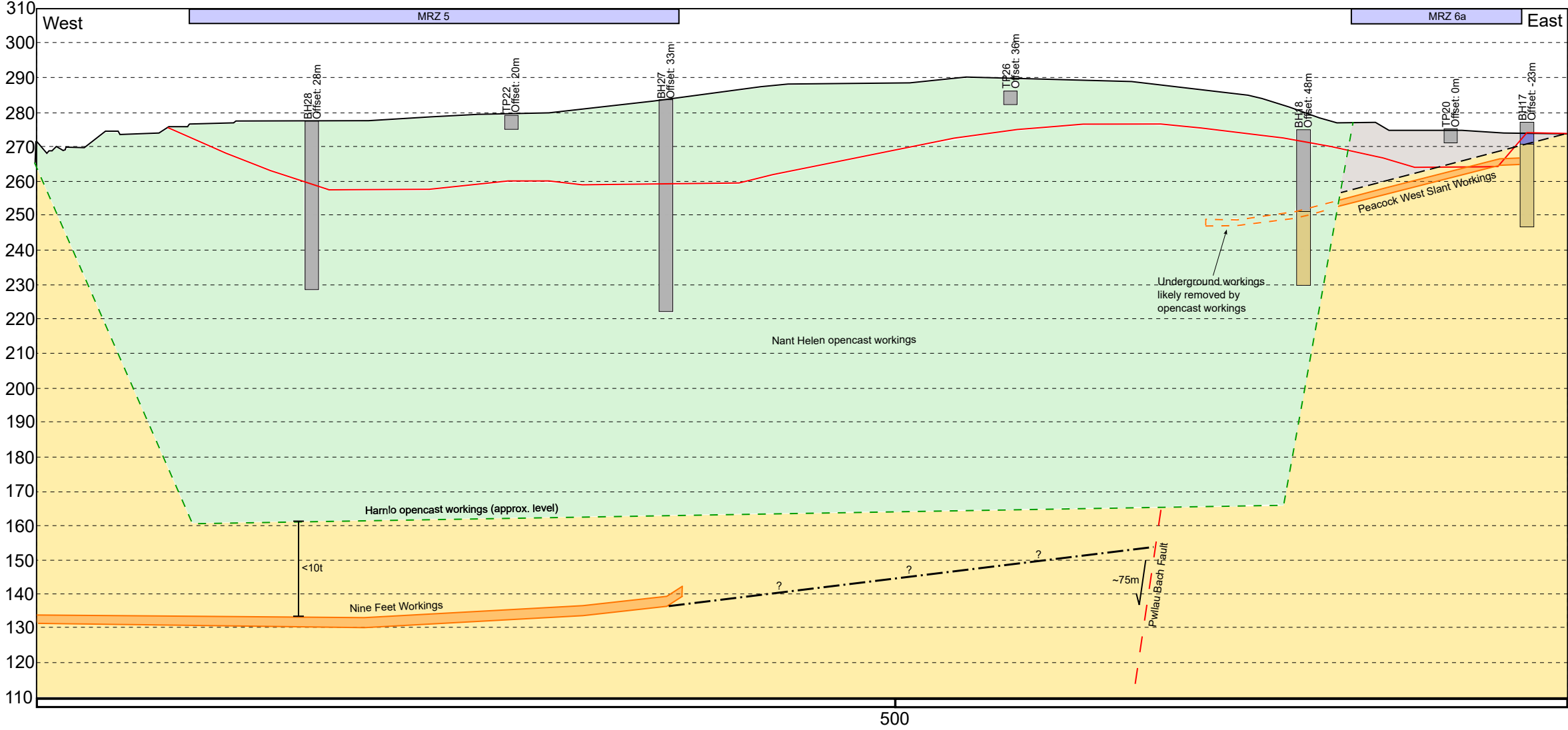
CROSS-SECTION 1



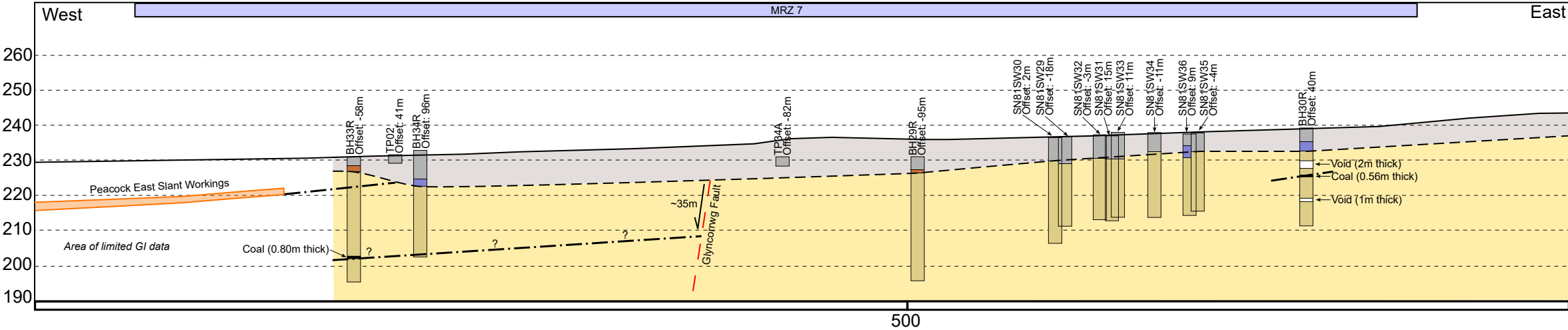
CROSS-SECTION 2



CROSS-SECTION 3



CROSS-SECTION 4



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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			
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STATUS:	DRAWING NO.:					VER:
DRAFT	GCRC001-AWJV-00-XX-DR-GE-00019					2

Annex B. Full Mining Risk Assessment Tables

Table B-1: Full table of assessed mine shafts across the site

Mine Entry ID	Easting (m)	Northing (m)	Distance from alignment/ washery area (m)	Estimated thickness of superficial deposits (m)	Phi (°)	Shaft diameter (m)	Departure (m) [9]	Estimated potential collapse radius (m)	Does the estimated potential collapse zone overlap with the proposed development?	Treatment Records
282211-027	282989	211855	22	2.6	25	1.25	8	15	No	No records of treatment.
282212-009	282108	212066	7	34	25	1.25	8	82	Yes	Treated, no further details.
283210-004	283815	210444	26	5	25	1.25	5	17	No	Treated 01/08/1973, no further details.
283210-005	283838	210401	0 (below)	5	25	2	0	13	Yes	Treated 09/03/1987, no further details.
283210-029	283414	210785	5	2.7	25	1.25	8	15	Yes	Treated, no further details.
284210-029**	284934	210611	0 (below)	10	25	1.25	10	33	Yes	No records of treatment.
281211-048	281548	211827	132	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
281211-067	281478	211743	126	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
282211-036	282431	211718	180	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
282211-038	282227	211567	349	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
282212-008	282421	212120	44	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
283210-001	283920	210671	221	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
283210-002	283960	210665	200	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
283210-006	283684	210341	42	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
283210-014	283320	210850	101	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
283210-030	283295	210996	45	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
283210-034	283865	210527	96	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
283210-040	283346	210853	94	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
283210-041	283782	210769	97	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
283210-042	283792	210723	141	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
283210-046	283946	210541	90	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
283211-014	283183	211722	148	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
283211-019	283382	211746	128	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
283211-028	283035	211776	100	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
283211-029	283021	211802	75	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
283211-030	283034	211760	116	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
283211-031	283282	211746	128	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
283211-033	283542	211699	88	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A

Mine Entry ID	Easting (m)	Northing (m)	Distance from alignment/ washery area (m)	Estimated thickness of superficial deposits (m)	Phi (°)	Shaft diameter (m)	Departure (m) [9]	Estimated potential collapse radius (m)	Does the estimated potential collapse zone overlap with the proposed development?	Treatment Records
283211-039	283009	211829	48	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
284210-007	284124	210685	119	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
284210-009	284204	210321	141	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
284210-014	284266	210423	88	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
285210-003	285363	210228	485	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A
285210-027	285133	210459	169	N/A *	N/A *	N/A *	N/A *	N/A *	No	N/A

*Mine shafts beyond area of concern (30 m), have been reviewed and established that collapse does not pose a risk to the alignment.

** Noted that geophysical anomalies in proximity to this mine entry were investigated by intrusive ground investigation, the location could not be confirmed.

Table B-2 - Full table of adits assessed across the site, ordered by location from northwest to southeast

Mine Entry Ref.	Easting	Northing	Azimuth	Approximately distance from alignment (m)	Direction relative to alignment / Washery Area	Adit Portal Level (mAOD)	Adit Level below alignment/ washery area (mAOD)	Track Level Above Adit (mAOD)	Anticipated Status of Adit Mouth	Risk Comments
281211-008	281453	211804	126	185	Towards alignment	N/A	N/A		Unknown	Directed towards the alignment. May intersect the Nan Helen extension area of opencast. No mine plans are available to inform location/level/extent of this adit. Risk of subsidence / void migration below the alignment.
281211-011	281846	211657	158	160	Away from alignment	N/A	-	N/A	Unknown	Directed away from the alignment. No mine plans are available to inform location/level/extent of this adit. The adit is within the Nan Helen opencast area. Low risk of subsidence / void migration below the alignment.
281211-012	281853	211657	135	160	Away from alignment	N/A	-	N/A	Unknown	Directed away from the alignment. No mine plans are available to inform location/level/extent of this adit. The adit is within the Nan Helen opencast area. Low risk of subsidence / void migration below the alignment.
281211-013	281854	211661	83	160	Away from alignment	N/A	-	N/A	Unknown	Directed away from the alignment. No mine plans are available to inform location/level/extent of this adit. The adit is within the Nan Helen opencast area. Low risk of subsidence / void migration below the alignment.
281211-014	281887	211651	167	190	Away from alignment	N/A	-	N/A	Unknown	Directed away from the alignment. No mine plans are available to inform location/level/extent of this adit. The adit is within the Nan Helen opencast area. Low risk of subsidence / void migration below the alignment.
281212-009	281829	212034	178	118	Towards alignment	N/A	N/A	235*	Unknown	Directed towards the alignment. Mine plans shown that is located within an opencast area, but no levels are indicated for this adit on the mine plan. Risk of subsidence / void migration below the alignment.
281211-061	281875	211872	160	Below	N/A	226.00		240*	In situ	Located below the alignment. Opencast working plans suggest the adit has not been extracted. Risk of subsidence / void migration below the alignment.
282211-009	282014	211899	188	Below	N/A	219.14		236*	Extracted	Located below the alignment. Opencast working plans suggest surface extraction to below the elevation of the mouth of the adit, suggesting the adit mouth has been extracted but the adit roadway may remain in-situ. Risk of subsidence / void migration below the alignment.
282211-001	282075	211987	175	Below	N/A	208.25		208*	In situ	Located below the alignment and beyond known opencast working areas. Risk of subsidence / void migration below the alignment.
282212-012	282090	212020	219	Below	N/A	200.48		205*	In situ	Located below the alignment. Opencast working plans suggest that the mouth of the adit is likely to have been excavated by the roadways likely remain in place. Risk of subsidence / void migration below the alignment.
282212-001	282101	212035	219	Below	N/A	N/A		207*	Unknown	Located below the alignment. No mine plans are available to inform location/level/extent of this adit. The adit is within the Nan Helen opencast area. Risk of subsidence / void migration below the alignment.
282212-006	282097	212073	266	15	Parallel to alignment	N/A	Not dipping below the alignment	N/A	Unknown	Orientated parallel to the alignment approximately 15m from the alignment. Adit located in an opencast working area but no levels are available on plans to inform if the adit has been extracted. Risk of subsidence / void migration below the alignment due to uncertainty of the area of influence of the adit / accuracy of mine plan.
282212-002	282233	212059	186	Below	N/A	199.59		203*	Extracted	Located below the alignment. Opencast working plans suggest surface extraction to below the elevation of the mouth of the adit, suggesting the adit mouth has been extracted but the adit roadway may remain in-situ. Risk of subsidence / void migration below the alignment.
282211-004	282379	211948	180	Below	N/A	N/A	N/A	230*	Unknown	Located below the alignment. No mine plans are available to inform location/level/extent of this adit. Risk of subsidence / void migration below the alignment.

Mine Entry Ref.	Easting	Northing	Azimuth	Approximately distance from alignment (m)	Direction relative to alignment / Washery Area	Adit Portal Level (mAOD)	Adit Level below alignment/ washery area (mAOD)	Track Level Above Adit (mAOD)	Anticipated Status of Adit Mouth	Risk Comments
282211-023	282200	211909	180	11	Away from alignment	221.70	Not dipping below the alignment	N/A	Extracted	Directed away from the alignment, although located approx. 11m from the alignment. Opencast working plans suggest surface extraction to below the elevation of the mouth of the adit, suggesting the adit mouth has been extracted but the adit roadway may remain in-situ. Low risk of subsidence / void migration below the alignment.
282211-022	282221	211867	175	48	Away from alignment	221.82	N/A	N/A	Extracted	Directed away from the alignment. Opencast working plans suggest surface extraction to below the elevation of the mouth of the adit, suggesting the adit mouth has been extracted but the adit roadway may remain in-situ. Low risk of subsidence / void migration below the alignment.
282211-003	282139	211691	158	225	Away from alignment	N/A	N/A	N/A	Unknown	Directed away from the alignment and towards the Nan Helen opencast area and at significant distance from the alignment. No mine plans are available to inform location/level/extent of this adit. Low risk of subsidence / void migration below the alignment.
282211-005	282403	211946	187	Below	N/A	217.10		229*	Extracted	Located below the alignment. Opencast working plans suggest surface extraction to below the elevation of the mouth of the adit, suggesting the adit mouth has been extracted but the adit roadway may remain in-situ. Risk of subsidence / void migration below the alignment.
282211-006	282422	211934	201	Below	N/A	N/A		229*	Unknown	Located below the alignment. No mine plans are available to inform location/level/extent of this adit. Risk of subsidence / void migration below the alignment.
282212-003	282459	212023	165	Below	N/A	185.93		195*	Extracted	Located below the alignment. Opencast working plans suggest surface extraction to below the elevation of the mouth of the adit, suggesting the adit mouth has been extracted but the adit roadway may remain in-situ. Risk of subsidence / void migration below the alignment.
282211-007	282531	211880	167	12	Away from alignment	182.88	N/A	N/A	In situ	Directed away from the alignment, dipping at close distance. Opencast working plans suggest surface extraction to above the elevation of the adit, suggesting the adit remains in-situ. Low risk of subsidence / void migration below the alignment.
282211-008	282550	211934	188	Below	N/A	217.10		227*	In situ	Located below the alignment. Opencast working plans suggest the adit has not been extracted. Risk of subsidence / void migration below the alignment.
282211-010	282582	211994	210	Below	N/A	201.17		208*	Extracted	Located below the alignment. Opencast working plans suggest surface extraction to below the elevation of the mouth of the adit, suggesting the adit mouth has been extracted but the adit roadway may remain in-situ. Risk of subsidence / void migration below the alignment.
282212-004	282609	212014	204	Below	N/A	207.31		208*	Extracted	Located below the alignment. Opencast working plans suggest surface extraction to below the elevation of the mouth of the adit, suggesting the adit mouth has been extracted but the adit roadway may remain in-situ. Risk of subsidence / void migration below the alignment.
282211-020	282790	211807	201	84	Away from alignment	N/A	N/A	N/A	In situ	Directed away from the alignment. The abandonment plan shows that the adit does not intersect with the alignment and ends at a distance from it. Low risk of subsidence / void migration below the alignment.
282211-021	282848	211820	216	61	Away from alignment	N/A	N/A	N/A	In situ	Directed away from the alignment. The abandonment plan shows that the adit does not intersect with the alignment and ends at a distance from it. Low risk of subsidence / void migration below the alignment.
282211-016	282951	211927	162	Below	N/A	222.70		231.71*	Unknown	Located below the alignment. No opencast working plans are available for this area to assess if this adit was extracted or remains in-situ. Risk of subsidence / void migration below the alignment.

Mine Entry Ref.	Easting	Northing	Azimuth	Approximately distance from alignment (m)	Direction relative to alignment / Washery Area	Adit Portal Level (mAOD)	Adit Level below alignment/ washery area (mAOD)	Track Level Above Adit (mAOD)	Anticipated Status of Adit Mouth	Risk Comments
282211-034	282952	211619	183	257	Towards alignment	N/A	N/A	N/A	Unknown	Directed towards the alignment. No mine plans to inform location/level/extent of this adit are available. Consider low risk as occurs at centre of site at a distance from alignment and The Washery areas
283211-045	283053	211747	162	129	Towards alignment	N/A	N/A	N/A	Unknown	Directed towards the alignment. The abandonment plan shows the adit roadway terminating away from the alignment. Low risk of subsidence / void migration below the alignment.
283211-011	283124	211756	160	113	Towards alignment	N/A	N/A	N/A	Unknown	Directed towards the alignment. The abandonment plan shows the adit roadway terminating away from the alignment. Low risk of subsidence / void migration below the alignment.
283211-012	283137	211732	208	136	Towards alignment	N/A	N/A	N/A	Unknown	Directed towards the alignment. The abandonment plan shows the adit roadway terminating away from the alignment. Low risk of subsidence / void migration below the alignment.
283211-044	283149	211715	183	153	Towards alignment	N/A	N/A	N/A	Unknown	Directed towards the alignment. The abandonment plan shows the adit roadway terminating away from the alignment. Low risk of subsidence / void migration below the alignment.
283211-013	283168	211727	165	141	Towards alignment	N/A	N/A	N/A	Unknown	Directed towards the alignment. The abandonment plan shows the adit roadway terminating away from the alignment. Low risk of subsidence / void migration below the alignment.
283211-035	283192	211758	186	111	Towards alignment	N/A	N/A	N/A	Unknown	Directed towards the alignment. No mine plans to inform location/level/extent of this adit are available. However, considered low risk given location relative to alignment and The Washery and expected adit orientation.
283211-015	283207	211762	176	108	Towards alignment	N/A	N/A	N/A	Unknown	Directed towards the alignment. The abandonment plan shows the adit roadway terminating away from the alignment. Low risk of subsidence / void migration below the alignment.
283211-026	283251	211724	203	149	Towards alignment	N/A	N/A	N/A	Unknown	Directed towards the alignment. The abandonment plan shows the adit roadway terminating away from the alignment. Low risk of subsidence / void migration below the alignment.
283211-017	283252	211738	129	137	Towards alignment	254.81	252.07	261	Unknown	Directed towards the alignment. Abandonment plan shows the roadway intersecting with the site. If adit extends into base of cutting then expected <10m of bedrock cover below the alignment which posing a risk of subsidence / void migration.
283211-043	283257	211765	153	109	Towards alignment	N/A	N/A	261	Unknown	Directed towards the alignment. No mine plans to inform location/level/extent of this adit are available. Risk of subsidence / void migration below the alignment if running parallel to adit 283211-043.
283211-024	283276	211790	184	83	Towards alignment	251.84	N/A	N/A	Unknown	Directed towards the alignment. The abandonment plan shows the adit roadway terminating away from the alignment. Low risk of subsidence / void migration below the alignment.
283211-025	283307	211768	209	104	Towards alignment	251.84	N/A	N/A	Unknown	Directed towards the alignment. The abandonment plan shows the adit roadway terminating away from the alignment. Low risk of subsidence / void migration below the alignment.
283211-042	283370	211774	183	100	Towards alignment	N/A	N/A	N/A	Unknown	Directed towards the alignment. No mine plans to inform location/level/extent of this adit are available. However, given alignment and location in relation to alignment and The Washery considered low risk
283211-037	283376	211800	165	75	Towards alignment	N/A	N/A	261	Unknown	Directed towards the alignment. No mine plans to inform location/level/extent of this adit are available. Risk of subsidence / void migration below the alignment.

Mine Entry Ref.	Easting	Northing	Azimuth	Approximately distance from alignment (m)	Direction relative to alignment / Washery Area	Adit Portal Level (mAOD)	Adit Level below alignment/ washery area (mAOD)	Track Level Above Adit (mAOD)	Anticipated Status of Adit Mouth	Risk Comments
283211-032	283455	211811	164	61	Towards alignment	N/A	N/A	N/A	Unknown	Directed towards the alignment. The abandonment plan shows the adit roadway terminating away from the alignment. Low risk of subsidence / void migration below the alignment.
283212-011	283437	212004	180	76	Towards alignment	215.1	N/A	N/A	Unknown	Directed towards the alignment. Abandonment plan shows the adit roadway terminating at approximately <10m from the alignment and becoming mine workings, although adit is not a risk associated mine workings are – risk captured elsewhere in this report.
283211-040	283487	211981	177	45	Towards alignment	216.21	204.78	230*	Unknown	Directed towards the alignment. Abandonment plan shows that intersects at the end with the alignment. Potential for <20m of bedrock cover below the alignment which may pose a risk of subsidence / void migration.
283210-026	283325	210691	302	19.5	Towards alignment	243.84	243.84	249	In situ	Directed towards the alignment. Shown on mine abandonment plan, but no indication of depth beneath alignment is available. Expected <20m of bedrock cover below the alignment which may pose a risk of subsidence / void migration.
283210-013	283379	210725	341	7.9	Towards alignment	241.84	241.84	249	In situ	Directed towards the alignment. Expected <20m of bedrock cover below the alignment which may pose a risk of subsidence / void migration.
283210-025	283299	210549	300	130	Towards alignment	N/A	N/A		In situ	Directed towards the alignment, but mine abandonment plans show the roadway terminating >30 m from the alignment. Opencast working plans suggest surface extraction to below the elevation of the mouth of the adit, suggesting the adit mouth has been extracted but the adit roadway may remain in-situ. Low risk of subsidence / void migration below the alignment.
283210-031	283257	210495	353	154	Towards alignment	N/A	N/A		In situ	Directed towards the alignment but mine abandonment plans show the roadway terminating >30 m from the alignment. Opencast working plans suggest surface extraction to below the elevation of the mouth of the adit, suggesting the adit mouth has been extracted but the adit roadway may remain in-situ. Low risk of subsidence / void migration below the alignment.
283210-012	283348	210547	4	70	Towards alignment	N/A	N/A	247	In situ	Directed towards the alignment. No mine plans to inform location/level/extent of this adit are available. Located out of opencast working areas of Onllwyn opencast. Risk of subsidence / void migration below the alignment.
283210-032	283686	210400	315	Below	N/A	234.31		239	In situ	Located below the alignment. Located outside of working areas of Onllwyn opencast.
283210-015	283691	210426	307	6/ Below	N/A	232.64		239	In situ	Shown below the alignment on the mine abandonment plans. Located outside the working area of Onllwyn opencast. Risk of subsidence / void migration below the alignment.
283210-033	283488	210287	62	178	Towards alignment	N/A	N/A	234	In situ	Mine abandonment plan shows the roadway dipping beneath the alignment. Located beyond the opencast working areas of Onllwyn opencast. Risk of subsidence / void migration below the alignment.
283210-036	283654	210242	349	145	Towards alignment	N/A	N/A	236	In situ	Directed towards the alignment. No available mine plans to inform location/level/extent of this adit are available. Located out of opencast working areas of Onllwyn opencast. Risk of subsidence / void migration below the alignment.
283210-022	283846	210408	56	Below	N/A	228.73		228*	In situ	Located below the alignment. Located out of opencast working areas of Onllwyn opencast. Risk of subsidence / void migration below the alignment.
283210-023	283902	210428	26	Below	N/A	194.26		227*	In situ	Located below the alignment. Located out of opencast working areas of Onllwyn opencast. Potential for <20m of bedrock cover below the alignment which may pose a risk of subsidence / void migration, risk of subsidence / void migration below the alignment.

Mine Entry Ref.	Easting	Northing	Azimuth	Approximately distance from alignment (m)	Direction relative to alignment / Washery Area	Adit Portal Level (mAOD)	Adit Level below alignment/ washery area (mAOD)	Track Level Above Adit (mAOD)	Anticipated Status of Adit Mouth	Risk Comments
283210-007	283811	210265	174	97	Away from alignment	N/A	N/A	N/A	In situ	Directed away from the alignment. Located out of opencast working areas of Onllwyn opencast. Low risk of subsidence / void migration below the alignment.
283210-003	283900	210571	355	128.3	Towards alignment	N/A	N/A	250	Unknown	Directed towards the alignment. Onllwyn completion plans shows that the adit may dip towards opencast working areas, but no mine plans are available to inform location/level/extent of this adit. Risk of subsidence / void migration below the alignment, although possible that adit ends before reaching alignment.
284210-031	284093	210877	341	220	Towards alignment	N/A	N/A	253	Unknown	Directed towards the alignment. Onllwyn completion plans shows that the adit may dip towards opencast working areas, but no mine plans are available to inform location/level/extent of this adit. Risk of subsidence / void migration below the alignment.
284210-022	284235	210800	287	138	Towards alignment	N/A	N/A	N/A	Unknown	Directed towards the alignment, but mine plans show the roadway terminating at great distance from the alignment. Onllwyn completion plans shows that the adit may dip towards opencast working areas, but no levels are available for this adit on the mine plan. Low risk of subsidence / void migration below the alignment.
284210-017	284144	210314	175	135	Away from alignment / washery area	236.51	N/A	N/A	In situ	Directed away from the alignment / washery area. Located beyond opencast working areas of Onllwyn opencast. Low risk of subsidence / void migration below the alignment/washery area.
284210-008	284177	210379	165	75	Away from alignment / washery area	229.38	N/A	N/A	In situ	Directed away from the alignment / washery area. Located beyond opencast working areas of Onllwyn opencast. Low risk of subsidence / void migration below the alignment/washery area.
284210-013	284184	210372	161	85	Away from alignment / washery area	N/A	N/A	N/A	In situ	Directed away from the alignment / washery area. Located beyond opencast working areas of Onllwyn opencast. Low risk of subsidence / void migration below the alignment/washery area.
284210-018	284206	210339	167	120	Away from alignment / washery area	213.36	N/A	N/A	Unknown	Directed away from the alignment / washery area. Located beyond opencast working areas of Onllwyn opencast. Low risk of subsidence / void migration below the alignment/washery area.
284210-032	284448	210424	151	150	Away from alignment / washery area	N/A	N/A	N/A	Unknown	Directed away from the alignment / washery area. No mine plans are available to inform location/level/extent of this adit. Low risk of subsidence / void migration below the alignment/washery area.
284210-020	284717	210394	160	125	Away from washery area	238.42	N/A	N/A	Unknown	Directed away from the washery area. No mine plans are available to inform location/level/extent of this adit. Low risk of subsidence / void migration below the washery area.
284210-019	284715	210414	118	105	Away from washery area	N/A	N/A	N/A	Unknown	Directed away from the washery area. No mine plans are available to inform location/level/extent of this adit. Low risk of subsidence / void migration below the washery area.
284210-023	284859	210653	200	Below	N/A	N/A	N/A	Assume current ground level	Unknown	Located below washery area. No mine plans are available to inform location/level/extent of this adit. Risk of subsidence / void migration below the washery area.
284210-035	284917	210565	131	Below	N/A	N/A	N/A	Assume current ground level	Unknown	Located below the washery area. No mine plans are available to inform location/level/extent of this adit. Risk of subsidence / void migration below the washery area. Noted that geophysical anomalies in proximity to this mine entry were investigated by intrusive ground investigation, the location could not be confirmed
285210-026	285077	210482	225	105	Away from washery area	N/A	N/A	N/A	Unknown	Directed away from the washery area. No mine plans are available to inform location/level/extent of this adit. Low risk of subsidence / void migration below the washery area.

Mine Entry Ref.	Easting	Northing	Azimuth	Approximately distance from alignment (m)	Direction relative to alignment / Washery Area	Adit Portal Level (mAOD)	Adit Level below alignment/ washery area (mAOD)	Track Level Above Adit (mAOD)	Anticipated Status of Adit Mouth	Risk Comments
285210-001	285145	210544	239	155	Towards washery area	N/A	N/A	Assume current ground level	Unknown	Directed away from the washery area but potential for adit roadway to pass beneath washery area. No mine plans are available to inform location/level/extent of this adit. May pass to south of The Washery area.
285210-028	285231	210447	349	160	Away from washery area	N/A	N/A	N/A	Unknown	Directed away from the washery area. No mine plans are available to inform location/level/extent of this adit. Low risk of subsidence / void migration below the washery area.
285210-025	285309	210284	14	410	Away from washery area	N/A	N/A	N/A	Unknown	Directed away from the washery area. No mine plans are available to inform location/level/extent of this adit. Low risk of subsidence / void migration below the washery area.
285210-002	285393	210290	158	470	Away from washery area	N/A	N/A	N/A	Unknown	Directed away from the washery area. No mine plans are available to inform location/level/extent of this adit. Low risk of subsidence / void migration below the washery area.

*Elevation at base of embankment at nearest point

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Appendix F. Factual Report Arup Ground Investigation 2021/2022

GLOBAL CENTRE OF RAIL EXCELLENCE

GROUND INVESTIGATION:

Factual Report

Report No. Q0652/FR_01

April 2022

DOCUMENT CONTROL

Contract Name: Global Centre of Rail Excellence

Contract Reference: Q0652

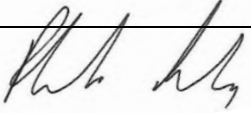
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Report Reference: Q0652/FR_01

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Client: Global Centre of Rail Excellence

Client/ Scheme Engineer: ARUP

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Disclaimer: Quantum Geotechnic Limited has prepared this report in accordance with the instructions of the above named Client for their sole and specific use. Any third parties who may use the information contained herein do so at their own risk.

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0. FOREWORD

The following Conditions and Notes on Site Investigation Procedures should be read in conjunction with this report.

0.1 General

Recommendations made and opinions expressed in the report are based on the strata observed in the excavations, together with the results of site and laboratory tests. No responsibility can be held for conditions which have not been revealed by the Exploratory Holes or which occur between Exploratory Holes. Whilst the report may suggest the likely configuration of strata, both between Exploratory Holes and below the maximum depth of investigation, this is only indicative and liability cannot be accepted for its accuracy.

Unless specifically stated, no account has been taken of possible subsidence due to mineral extraction below or close to the site.

0.2 Investigation Procedures

Cable Percussive Borehole Drilling, Rotary Percussive Borehole Drilling (*dynamic sampled / rotary cored / rotary probed*), Sonic Drilling, Machine Excavated Trial Pits/ Trenches and Geophysical Surveying techniques for ground investigation have been employed on this scheme. All Exploratory Hole operations, sampling and logging of soils, rocks and in-situ testing complies with the recommendations of the British Code of Practice BS 5930:2015+A1:2020, 'Site Investigations', British Code of Practice BS 10175: 2011 + A1:2013, 'Investigation of Potentially Contaminated Sites' and BS 1377: 1990, 'Methods of Test for Soils for Engineering Purposes'. Additional Ground penetrating Radar (GPR) survey of buried utilities was also undertaken.

0.3 Routine Sampling

Representative bulk, undisturbed, disturbed and environmental samples of the different strata are taken during the formation of the exploratory holes and following completion of logging as required and in accordance with Project Specification. These samples are sealed and labelled in clear plastic bags and 2kg plastic tubs. Soil and water samples obtained for environmental testing are sampled and sealed in borosilicate amber jars or in specialist vessels where required. All samples are returned from site to QGL's laboratory for controlled storage within 24 hours of sampling to await test scheduling /requirements.

0.4 In-Situ Testing

- Standard Penetration Testing within Boreholes (SPT)
- Hand Shear Vane Testing in Trenches/ Pits where cohesive soils encountered
- Magnetic Geophysical Survey
- Electromagnetic Geophysical Survey
- Microgravity Geophysical Survey
- Soakaway Testing

0.5 Groundwater

Where possible, or applicable, the depth of entry of any influx of groundwater is recorded during the course of excavation or boring operations. The rate of inflow into the excavation or borehole is monitored during the course of the excavation or during boring procedures. Upon encountering any water strikes, work is temporarily halted and the water levels monitored for a standard twenty minute period recording the change in water level at the end of the twenty minutes.

Groundwater conditions observed in the excavations are those appertaining to the period of investigation. It should be noted, however, that groundwater levels are subject to diurnal, seasonal and climatic variations and can also be affected by drainage conditions or other causes.

0.6 Retention of Samples

After satisfactory completion of all the scheduled laboratory tests on any sample, the remaining material is discarded. Further to notifying the Engineer/ Client with one week's notice all soil and/or rock samples will be discarded 28 days after submission of the approved final report.

1. INTRODUCTION

1.1 General

Upon the instructions of ARUP (Scheme Engineer/ Investigation Supervisor), acting on behalf of the Client, Global Centre of Rail Excellence, Quantum Geotechnic Ltd (QGL) was commissioned to undertake the initial ground investigation for the proposed Global Centre of Rail Excellence, located at the Nant Helen Opencast site, Onllwyn Washery and the adjacent area.

QGL fulfilled the role as Principal Contractors for this scheme.

This report presents a factual account of the fieldwork carried out, including an account of the fieldworks undertaken, descriptions of strata encountered and provision of subsequent laboratory test results. Other available sources of information that have been consulted in the preparation of this Factual Report include the published geological maps for the area and online databases.

General notes on the techniques employed by QGL are described in the Foreword together with the limitations inherent in carrying out site investigation work.

1.2 Purpose of Ground Investigation

The ground investigation is to assist with the design of the proposed development. The proposed main works is the development of a rail testing facility that will include a 7km track, the construction of which will involve the construction of significant cuttings and embankments, a platform environment, train storage facilities, train decommissioning area and an educational facility.

1.3 Scope of Work

The initial scope of works finalised by the Investigation Supervisor / Designer comprised the following:

- 1 no cable percussive with rotary core follow on borehole
- 3 no cable percussive with open hole follow on boreholes
- 3 no cable percussive with rotary coring and open hole follow on boreholes
- 2 no rotary coring boreholes
- 10 no rotary coring with open hole follow on boreholes
- 10 no sonic boreholes
- 33 no trial pits
- Four areas of geophysical testing, including magnetometer, electromagnetic and microgravity surveys

The aim of the exploratory holes is to facilitate:

- Detailed descriptions of the site stratigraphy and the nature and disposition of the superficial soils and rock
- Details of potentially mined coal seams and information to assess subsidence risks associated with these
- Chemical and geotechnical testing of soil and rock samples
- Chemical testing of groundwater samples
- Groundwater and ground gas monitoring from standpipe installations
- In-situ testing, including Standard Penetration Tests, hand vane tests and infiltration tests

2. SITE DETAIL

2.1 Site Description

The site covers an area of approximately 500 hectares and is located between the A4109 to the south and the A4221 to the north-east, at approximate National Grid Reference 282580, 211080.

The majority of the western area of the site is occupied by Celtic Energy as the Nant Helen active open cast coal mine. The western extent is the Nant Helen Extension opencast working. The central and south western portion of the site contains a large overburden storage area whilst the Celtic Energy Nant Helen yard, offices and car parking are located towards the centre of the site. Onllwyn Washery occupies the eastern area of the site and is connected to the Nant Helen site by a series of access roads. The remainder of the site is farmland.

The topography of the site varies significantly and rises inwards to elevations of between 280 and 295m AOD in the central area of the site.

2.2 Statutory Service Information

All service information was provided by the Scheme Engineers and also a separate set of service drawings were obtained by QGL prior to commencement of the intrusive works. A permit to excavate system was implemented by QGL throughout the works for all exploratory holes. Standard QGL procedures for breaking ground were followed and all areas were scanned using a cable avoidance tool. A hand dug trial pit was excavated to 1.2m prior to commencement of borehole drilling. All hand excavation was undertaken using insulated digging tools.

2.3 Published Geology

Details of the geology of the site are provided by British Geological Survey (BGS) Sheet 231 'Merthyr Tydfil', Solid and Drift edition at 1:50,000 scale, and BGS's online tool Geology of Britain Viewer. The maps indicate superficial deposits of Peat to underlie areas of the eastern area of the site, whilst deposits of Glacial Till underlie localised areas below the eastern and central areas of the site.

The solid geology below the site is mapped as the South Wales Coal Measures, typically comprising mudstones, siltstones, sandstones, grits, fireclays, seatearths and coals.

In addition to the geological mapping, the Engineer / Investigation Supervisor provided the following information:

Made Ground material is anticipated beneath the washery site and is likely to comprise a mixture of varied granular backfill material within a cohesive clay matrix. Various gravel inclusions within the Made Ground were noted to be mudstone, sandstone, coal, clinker and wood. The thickness of this material is anticipated to range between 0.25 and 7.0m, although locally thicker deposits could be encountered in the locations of any stockpiles / spoil heaps within the washery site.

Backfilled opencast mining material is anticipated in various areas of the site. The backfill material has derived from the mining of the Middle and Lower Coal Measures. The anticipated depth of backfill between 40 and 150m.

3. FIELDWORK

3.1 General

The fieldwork was carried out between 15th November 2021 and 19th January 2022. Full-time on-site supervision and attendance by an Engineering Geologist from QGL was undertaken on all aspects of the site works.

All works were conducted within safe working practices set out by QGL's Risk Assessed Method Statement including CAT scanning and service inspection hand excavated pits to 1.2mbgl in all borehole locations.

All inductions and regular site briefings were carried out by QGL's Engineering Geologist as well as site specific inductions provided by Celtic Energy. No deviations from the Standards and Procedures adopted for the works were recorded.

Sensitive vegetation clearance was undertaken to access areas of the site where the potential presence of reptiles and amphibians exists, under the supervision of an Ecological Clerk of Works.

Trial Pits and hand excavated service clearance pits outside of the backfilled opencast mines were undertaken under an archaeological watching brief. The scope of the works and supervision was agreed with Glamorgan-Gwent Archaeological Trust and Clwyd-Powys Archaeological Trust prior to commencing work in the areas of interest. The Archaeological report is presented within Appendix VI.

3.2 Exploratory Hole Locations

The exploratory hole locations were set out by QGL in liaison with the Investigation Supervisor. On completion of the ground investigation all exploratory hole positions were surveyed by QGL to National Grid Co-Ordinates and Ordnance Datum (accurate to 0.005m horizontal and 0.01m vertical) using QGL in-house GPS equipment.

An Exploratory Hole Location Plan is presented as Figure 2 in Appendix I, and exploratory hole coordinates and levels are presented on the engineer's log sheets in the corresponding Appendices.

Table 1 presents the National Grid Co-Ordinates and Ordnance Datum for the exploratory holes.

Table 1: Exploratory Hole Co-Ordinates & Levels

Exploratory Hole ID	Easting	Northing	Elevation (mAOD)	Exploratory Hole ID	Easting	Northing	Elevation (mAOD)
BH01	284008.752	210457.288	228.289	TP01	284246.92	210515.985	229.984
BH02	283562.15	210475.288	238.034	TP02	284410.812	210600.045	231.438
BH03	283200	210681	258.30	TP03	284554.783	210496.562	234.921
BH04	282861.715	210545.421	257.69	TP04	284819.634	210502.793	239.164
BH05	282375.778	210348.29	239.39	TP05	284970.622	210390.891	240.574
BH06	281804.05	210415.339	263.08	TP06	285168.401	210396.23	237.139
BH07	281544.876	210721.078	271.278	TP07	285325.242	210402.826	232.565
BH08	282776.077	211918.353	236.309	TP08	284939.196	210661.097	243.459
BH09	283119.525	211903.085	230.86	TP09	285134.983	210589.126	243.465
BH10	283369.5	211901.555	236.953	TP10	283248.015	210699.94	257.767
BH11	283659.495	211793.719	258.786	TP11	283484.765	210766.086	251.088
BH12	283925.43	211066.299	258.21	TP12	285143.133	210543.076	242.244
BH13	283817.797	210965.719	259.335	TP13	285116.027	210469.732	238.825
BH14	283702.056	210915.057	260.008	TP14	285232.47	210442.229	233.459
BH15	283332.648	210758.175	249.628	TP14A	285233.984	210444.909	232.944
BH16	283439.29	211441.069	280.709	TP15	284779.25	210390.75	248.109
BH17	283274.059	211061.09	276.83	TP17	284728	210394	247.22
BH18	283148.397	210982.779	275.032	TP18	283467.81	210253.53	221.201
BH19	281397.517	211205.939	255.047	TP19	282624.076	210468.096	247.39
BH19A	281399.062	211202.028	255.32	TP20	283231.186	211035.804	275.005
BH20	281652.88	211668.6	251.00	TP21	283037.695	211907.981	230.341
BH21	281893.75	211906.21	228.232	TP22	282687.913	210984.945	279.117
BH22	282101.253	212011.3	213.006	TP23	281381.91	211314.37	248.13
BH23	282565.867	211985.864	199.76	TP24	281948.549	211934.417	228.438
BH24	283944.594	211545.584	258.672	TP25	283990.42	211456.97	255.626
BH25	283952.651	211213.21	257.678	TP26	282977.921	210985.136	286.054
BH26	283672.545	211573.995	273.065	TP27	282341.166	210344.218	239.617
BH27	282777.925	210976.889	283.501	TP28	281604.404	211639.767	251.054
BH28	282572.648	210970.189	277.374	TP29	282282.615	212062.103	230.736
BH29	284719.483	210705.393	230.736	TP30	284010.546	211327.163	252.686
BH30	284925.689	210549.408	239.096	TP31	282490.134	211876.52	232.41
BH31	284880.773	210454.806	238.608	TP32	282814.327	211902.586	235.632
BH32	284967.95	210230.008	244.73	TP33	283304.686	211902.413	236.288
BH33	284397.044	210700.878	230.51	TP34	283918.939	211654.186	253.8
BH34	284419.614	210543.602	232.63	TP34A	284641.854	210699.974	230.763
				TP35	285316.156	210289.506	234.766
				TP36	285090.027	210482.138	239.896
				TP37	284931.976	210605.035	239.19
				TP38	284921.927	210557.022	238.95

3.3 Boreholes

A total of thirty-five boreholes were drilled during the site works using a combination of drill rigs and techniques.

The Cable Percussive element of the borehole works were drilled using a Dando 2000 rig utilising 200mm diameter casing and tools.

The dynamic sampling, rotary coring and rotary probing element of the borehole works were undertaken using two Commachio 600 multi-purpose drill rigs, using 101mm diameter dynamic sample barrel for soil sampling and 412F coring barrel for bedrock. A combined air/mist flush was used to clear the hole of returns and debris during the drilling process. 115mm diameter ODEX overburden drill system was used by the Commachio drill rig to maintain the borehole open through the superficial deposits.

Three sonic boreholes were undertaken across the site using a Mito XL140 drill rig operated by Borehole Solutions Limited. Due to ground conditions, which comprised an extensive number of boulders and the continued loss of drill flush, it was not possible to progress the drill casing to the required depths and therefore the scheduled depths were not achieved. The remaining boreholes scheduled as sonic boreholes were undertaken using rotary percussive methods to the maximum depths considered achievable with the available equipment and the ground conditions encountered.

The recovered rock sample liners were split and logged in accordance with BS5930: (2015); BS EN ISO 14688-1:2002; BS EN ISO 14688-2:2005 and BS EN ISO 14689-1:2003, including fracture spacing, by a QGL Engineering Geologist. All retrieved core is stored in wooden lockable boxes and was logged and photographed on site prior to being transported back to QGL premises for storage.

In-situ Standard Penetration Testing (SPT) was carried out in all boreholes (see section 3.5.1.).

Upon completion, selected boreholes were installed with 50mm Internal Diameter combined HDPE landgas and groundwater pipes for subsequent monitoring. Further details are listed in Section 3.7. Boreholes not subject to standpipe installations were backfilled with a Cement and Bentonite grout mix, tremmied to the base of the boreholes, with surfacing reinstated like-for-like.

Details of all Boreholes including final depths are provided below in Table 2.

Table 2: Borehole Detail

Exploratory Hole ID	Borehole Type	Completed Depth (mbgl)	SPT Hammer Ref	Terminating Strata	Backfill Details	Notes/Reason for Termination
BH01	Rotary Probe Borehole	30.0		Sandstone Bedrock	Grout Backfill	Scheduled Depth
BH02	Rotary Probe Borehole	30.0		Hard Drill (Loss of	Grout Backfill	Scheduled Depth

Exploratory Hole ID	Borehole Type	Completed Depth (mbgl)	SPT Hammer Ref	Terminating Strata	Backfill Details	Notes/Reason for Termination
				Flush)		
BH03	Rotary Cored & Probed Boreholes	32.7	Q2 AR830	Mudstone Bedrock	Grout Backfill	Upon Engineer Instruction
BH04	Rotary Cored & Probed Boreholes	30.0	Q2 AR830	Mudstone Bedrock	Grout Backfill	Scheduled Depth
BH05	Dynamic Sampled with Rotary Core follow-on	30.7	Q5	Mudstone Bedrock	Grout Backfill	Scheduled Depth
BH06	Rotary Cored & Probed Boreholes	30.0	Q5	Mudstone and Sandstone Bedrock	Grout Backfill	Scheduled Depth
BH07	Rotary Cored & Probed Boreholes	35.0	Q5	Mudstone and Sandstone Bedrock	Land Gas & Ground Water Installation	Scheduled Depth
BH08	Rotary Probe Borehole	42.0		Mudstone and Sandstone Bedrock	Grout Backfill	Upon Engineer Instruction
BH09	Rotary Probe Borehole	30.0		Siltstone Bedrock	Grout Backfill	Scheduled Depth
BH10	Rotary Probe Borehole	30.0		Sandstone Bedrock	Grout Backfill	Scheduled Depth
BH11	Rotary Cored & Probed Boreholes	30.0	Q2 AR830	Mudstone and Sandstone Bedrock	Grout Backfill	Scheduled Depth
BH12	Rotary Cored & Probed Boreholes	30.0	Q2 AR830	Mudstone Bedrock	Grout Backfill	Scheduled Depth
BH13	Rotary Cored Boreholes	30.0	Q5	Mudstone Bedrock	Grout Backfill	Scheduled Depth
BH14	Rotary Cored & Probed Boreholes	30.0	Q5	Mudstone and Sandstone Bedrock	Grout Backfill	Scheduled Depth
BH15	Rotary Cored & Probed Boreholes	30.0	Q5	Mudstone Bedrock	Land Gas & Ground Water Installation	Scheduled Depth
BH16	Rotary Cored Boreholes	40.2	Q2 AR830	Mudstone Bedrock	Land Gas & Ground Water Installation	Scheduled Depth
BH17	Rotary Cored & Probed Boreholes	30.0	Q2 AR830	Mudstone Bedrock	Grout Backfill	Scheduled Depth
BH18	Rotary Cored & Probed Boreholes	45.2	Q2 AR830	Mudstone Bedrock	Grout Backfill	Upon Engineer Instruction
BH19	Rotary Probe Borehole	19.2	Q2 AR830	Made Ground – Opencast Backfill	Grout Backfill	Unable to progress borehole
BH19A	Rotary Probe Borehole	28.2	Q2 AR830	Made Ground – Opencast Backfill	Land Gas & Ground Water Installation	Unable to progress borehole
BH20	Rotary Probe Borehole	40.2	Q2 AR830	Made Ground – Opencast Backfill	Grout Backfill	Unable to progress borehole
BH21	Sonic Borehole	33.0	XL140	Made Ground – Opencast Backfill	Grout Backfill	Unable to progress borehole
BH22	Sonic Borehole	32.0	XL140	Possible Bedrock	Grout Backfill	Unable to progress borehole
BH22A	Rotary Probe Borehole	34.0		Possible Bedrock	Land Gas & Ground Water Installation	Unable to progress borehole
BH23	Rotary Cored & Probed Boreholes	30.0	Q2 AR830	Mudstone Bedrock	Grout Backfill	Scheduled Depth
BH24	Rotary Probe Borehole	50.7	Q2 AR830	Made Ground – Opencast Backfill	Land Gas & Ground Water Installation	Unable to progress borehole
BH25	Rotary Probe Borehole	50.7	Q2 AR830	Made Ground – Opencast Backfill	Land Gas & Ground Water Installation	Unable to progress borehole

Exploratory Hole ID	Borehole Type	Completed Depth (mbgl)	SPT Hammer Ref	Terminating Strata	Backfill Details	Notes/Reason for Termination
BH26	Rotary Cored & Probed Boreholes	40.2	Q2 AR830	Mudstone Bedrock	Grout Backfill	Upon Engineer Instruction
BH27	Sonic Borehole	61.5	XL140	Made Ground – Opencast Backfill	Grout Backfill	Unable to progress borehole
BH28	Rotary Probe Borehole	49.2	Q2 AR830	Made Ground – Opencast Backfill	Land Gas & Ground Water Installation	Unable to progress borehole
BH29	Cable Percussive Borehole with Rotary Probe 'follow on'	35.0	SAM1	Mudstone / Siltstone Bedrock	Land Gas & Ground Water Installation	Scheduled Depth
BH30	Cable Percussive Borehole with Rotary Cored and Probe 'follow on'	35.0	SAM1	Mudstone Bedrock	Land Gas & Ground Water Installation	Scheduled Depth
BH31	Cable Percussive Borehole with Rotary Probe 'follow on'	35.0	SAM1	Mudstone Bedrock	Land Gas & Ground Water Installation	Scheduled Depth
BH32	Cable Percussive Borehole with Rotary Cored and Probe 'follow on'	35.0	SAM1	Mudstone / Siltstone Bedrock	Land Gas & Ground Water Installation	Scheduled Depth
BH33	Cable Percussive Borehole with Rotary Cored and Probe 'follow on'	35.0	SAM1	Mudstone / Siltstone Bedrock	Land Gas & Ground Water Installation	Scheduled Depth
BH34	Cable Percussive Borehole with Rotary Probe 'follow on'	30.0	SAM1	Mudstone Bedrock	Land Gas & Ground Water Installation	Scheduled Depth

A complete set of borehole logs are presented in Appendix II along with SPT Hammer calibration certificates for both the Cable Percussive and the Commachio drill rigs for reference purposes.

3.4 Machine Excavated Trial Pits and Trenches

A total of forty pits and trenches were excavated using 360 tracked excavators, either 9 Tonne or 13 Tonne, depending on depth requirement and access/ working area constraints.

Trial Pits TP12 – TP17 and TP35 – TP38 were excavated to investigate possible mining related anomalies identified from the Geophysical survey undertaken.

Soil infiltration tests were scheduled within Trial Pits TP01 – TP02, TP04 and TP18 – TP21 (see Section 3.5.2).

The trial pitting method of investigation allows direct sampling of the near surface deposits for identification purposes, locating of buried services, as well as assessment of any salient features and Made Ground or disturbed ground. The trial pits were logged in accordance with BS5930:2015+A1:2020; BS EN ISO 14688-1:2002 and BS EN ISO 14688-2:2004, and supervised at all times by an Engineering Geologist from QGL.

A graticule was used to assist with the field description of grading for material within Trial Pits TP22 – TP33. The graticule records are included as Appendix V.

All machine excavated trial pits and trenches were backfilled with compacted layers of arisings upon completion.

Geotechnical and Environmental samples were taken within the superficial deposits for laboratory testing purposes.

Details of the Machine Excavated Trial Trenches and Pits are provided in Table 3 below;

Table 3: Machine Excavated Trial Trench and Trial Pit Detail

Exploratory Hole ID	Completed Depth (mbgl)	Notes/Reason for Termination	Exploratory Hole ID	Completed Depth (mbgl)	Notes/Reason for Termination
TP01	2.8	Sides unstable and collapsing. Unable to undertake soakaway test due to high ground water encountered	TP21	4	Scheduled Depth
TP02	2.3	Sides unstable and collapsing. Unable to undertake soakaway test due to high ground water encountered	TP22	4.3	Sides collapsing, pit unstable.
TP03	3.3	Sides unstable and collapsing no progress being made	TP23	4	Scheduled Depth
TP04	3.6	Unable to proceed past cobbles/boulders at base of pit	TP24	4.5	Scheduled Depth
TP05	3	Sides unstable and collapsing no progress being made	TP25	4.5	Scheduled Depth
TP06	2.8	Unable to proceed past cobbles/boulders at base of pit	TP26	3.8	Sides collapsing, pit unstable.
TP07	4	Scheduled Depth	TP27	4.5	Scheduled Depth
TP08	3	Sides unstable and collapsing no progress being made	TP28	4	Scheduled Depth
TP09	4	Scheduled Depth	TP29	4.5	Scheduled Depth
TP10	2.6	Sides collapsing, pit unstable.	TP30	4.5	Scheduled Depth
TP11	2.7	Sides collapsing due to fast groundwater ingress.	TP31	4.5	Scheduled Depth
TP12	4.5	Scheduled Depth	TP32	4.5	Scheduled Depth
TP13	4	On natural strata	TP33	4.5	Scheduled Depth
TP14	3.5	Sides unstable and collapsing	TP34	4.5	Scheduled Depth
TP14A	3.5	Sides unstable and collapsing	TP34A	2.5	Sides unstable and collapsing. Unable to undertake soakaway test due to high ground water encountered
TP15	4.5	Scheduled Depth	TP35	4	Scheduled Depth
TP17	4	Scheduled Depth	TP36	4	Scheduled Depth
TP18	3	Significant Instability	TP37	4.5	Scheduled Depth
TP19	4	Scheduled Depth	TP37A	2	Encountered possible service

Exploratory Hole ID	Completed Depth (mbgl)	Notes/Reason for Termination	Exploratory Hole ID	Completed Depth (mbgl)	Notes/Reason for Termination
TP20	4	Scheduled Depth	TP38	4	Scheduled Depth

A full set of machine excavated trial trench and trial pit logs are presented in Appendix III.

The graticule results are provided in Appendix V.

3.5 In-Situ Testing

3.5.1 Standard Penetration Testing

Standard penetration tests (SPTs) were undertaken in all boreholes through the superficial deposits and weak bedrock at intervals shown on the engineer's logs, typically 1m intervals to 5m depth and 1.5m thereafter.

This dynamic in-situ test measures the density of soil or rock and is described in BS1377:1990 (part 9), partially superseded by BS EN ISO 22476-3 (2005). Within fine grained or cohesive soils, the test incorporates a small diameter tube (650mm length, 50mm external diameter and 35mm internal diameter) with a cutting shoe known as the 'split barrel sampler'. The sampler is forced into the soil dynamically using blows from a 63.5kg hammer dropped through 760mm. The sampler is initially advanced 150mm into the soil with seating blows, then the number of blows required to advance the sampler each 75mm increment up to a depth of 300mm is recorded. This cumulative total number of blows over the 300mm test is referred to as the "N" value. For coarse gravels and bedrock, the split barrel is replaced by a 60° cone.

SPT results can be found on the corresponding borehole logs in Appendix II.

3.5.2 Soakaway Testing

Soakaway testing was undertaken in accordance with BRE365 within selected Trial Pits. The test involved pumping clean water into a Trial Pit and measuring the time taken for the water level to fall. Where permeability allows, the test is repeated three times.

The soakaway test results are included within Appendix IV.

3.5.3 Geophysical Survey

A Geophysical Survey was undertaken by Terradat in four zones in and around Onllwyn Washery to identify areas containing possible mining related features. A Magnetic Survey was undertaken to map distortions in the Earth's magnetic field due to the presence of buried ferrous material that may be related to mine workings. An Electromagnetic Survey was undertaken to map variations in the near surface ground conductivity and in-phase response associated with different shallow materials / structures. A Microgravity survey was undertaken

to confirm the presence of any localised areas of mass deficiency within the subsurface that may be associated with voiding or less dense in-fill material associated with the mine entry features.

The Geophysical survey report is presented in Appendix IX.

3.6 Sampling - General

Sampling of soils, rocks and waters were undertaken as instructed by the Client in accordance with the specification. Bulk, disturbed and undisturbed samples were taken where required within the superficial deposits for strata identification and laboratory testing purposes.

Geotechnical samples were returned from site to QGL's offsite controlled storage to await test scheduling/requirements. The environmental samples were transported within 24hrs to QGL's specialist chemical testing laboratory sub-contractor premises, Eurofins Chemtest Ltd to await test scheduling/requirements. Sample type depth are recorded on the corresponding exploratory hole logs found within Appendices II and III. For specific details of laboratory testing see Section 4.

3.7 Groundwater & Landgas Standpipe Installations

Thirteen boreholes were installed with either 50mm Ø HDPE or both 50mm and 19mm Ø HDPE combined land gas and groundwater monitoring standpipe to permit post-fieldwork landgas and groundwater monitoring visits.

Groundwater and landgas monitoring standpipes consist of plastic pipework set in filter aggregate (pea gravel) forming a well. The filter is sealed at one or both ends by use of bentonite grout. Parts of the pipe itself are slotted, allowing the infiltration of groundwater which can then be accessed through the pipe from ground level. Slotted sections are covered by 'geo-sock' to reduce the intrusion of silt into the standpipes and the range of depths at which the groundwater is intercepted is known as the 'response zone'.

Standpipes were installed using 1m lengths of pipework (threaded at either end) fitted together and lowered into the borehole. The boreholes were then filled with either pea gravel or bentonite (depending on which zone or level) and cemented in place at ground level with a steel flush cover. Table 5 details the installation undertaken.

Table 5: Borehole Installation Detail

Exploratory Hole ID	Installation Standpipe Internal Diameter (mm)	Installation Depth (m.bgl)	Installation Response Zone (m.bgl)
BH07	50	10.0	8.0-10.0
BH15	50	5.0	1.0-5.0
BH16	50	10.0	8.0-10.0

BH19A	50	28.2	25.2 – 28.2
BH22	50	34.0	29.0 – 34.0
BH25	50	49.2	39.2 – 49.2
BH28	50	49.2	39.2 – 49.2
BH29	50	15.0	12.0 – 15.0
BH30	50	4.0	3.0 – 4.0
BH31	50	5.0	1.0 – 5.0
	50	21.0	16.0 – 21.0
BH32	50	17.5	12.5 – 17.5
BH33	50	20.0	15.0 – 20.0
BH34	50	3.3	1.0 – 3.3
	50	13.0	11.0 – 13.0

3.8 Post-Fieldwork Monitoring

The standpipe installations were scheduled for two post-fieldwork monitoring visits with two rounds of groundwater sampling from selected boreholes to be undertaken. Each post-fieldwork monitoring visit included the measurement of the following parameters:

- O₂ (% v/v)
- CH₄ (% v/v)
- H₂S (ppm)
- CO₂ (% v/v)
- Flow Rate (l/hr)
- Atmospheric Pressure (mb)
- Groundwater Level (m.bgl/ mAOD)
- CO (% v/v)

The results of the scheduled post-fieldwork monitoring visits are undertaken to date are presented in Appendix X.

4. LABORATORY TESTING

The laboratory testing was scheduled by the Scheme Engineer and comprised a number of geotechnical and geo-environmental tests on soil, water and rock samples recovered from this ground investigation phase.

4.1 Geotechnical Laboratory Testing

Geotechnical tests undertaken on selected soil and rock samples are detailed in Table 6. All the geotechnical soil testing work was carried out in accordance with the procedures stipulated in the various sections of BS 1377:1990 "Methods of test for soils for civil engineering purposes" and to UKAS accreditation where applicable.

Table 6: *Geotechnical Laboratory Tests*

Test	Number of Tests
Moisture Content of Soil	23
4 Point Liquid & Plastic Limit	24
Particle Size Distribution (PSD) Wet Sieve	51
PSD: Sedimentation by Pipette	20
Undrained strength of a single 100mm diameter specimen in triaxial compression without the measurement of pore pressure	4
One-dimensional consolidation properties, test period 5days	4
Dry density/moisture content relationship using 2.5kg rammer	4
Moisture Condition Value/moisture content relationship	11
5 point compaction test using 4.5kg rammer in CBR mould	7
Loss on Ignition	5
Organic Matter	7
BRE SD1 Suite B	31
BRE SD1 Suite D	10
Point load Index (Rock)	47
Unconfined Compressive Strength (UCS – Rock)	1
LA coefficient	6
Freeze Thaw	6
Soundness by magnesium sulphate	6
Slake Durability	6

Available geotechnical laboratory test certificates are provided within Appendix VII.

4.2 Geo-Environmental Laboratory Testing

Geo-environmental testing was carried out on selected soil and water samples gained from the ground investigation as summarised in Table 7.

Table 7: Geo-Environmental Laboratory Tests

Test/ Suite	Number of Tests
Specification Suite E1 – Soils Samples General Suite	28
Specification Suite E2 – Asbestos Suite	26
Specification Suite E3 – TPH CWG Suite	21
Specification Suite E4 – PAH & BTEX Suite	28
Specification Suite E5 – VOC & SVOC	1
Specification Suite E9 – Hex Chromium	7
Specification Suite E16 – Loss on Ignition	7
Specification Suite F1 – Water Samples General Suite	9
Specification Suite F2 – TPH CWG Suite	9
Specification Suite F3 – PAH & BTEX Suite	9
Specification Suite F5 – PCB's	9
Specification Suite H – Waste Acceptance Total Solids	7
Specification Suite I – Waste Acceptance Leachability	7
Specification Suite J1 – Soil Leachability general	9
Specification Suite J2 – Soil leachability PAH	1

A full set of geo-environmental laboratory test certificates are provided within Appendix VIII.

5. REFERENCES

British Geological Survey (BGS)

- BGS online maps and lexicon database – www.bgs.co.uk
- BGS Sheet 261 'Merthyr Tydfil' Solid and Drift edition at 1:50,000 scale.

British Standards

- British Code of Practice BS 5930:2015+A1:2020 '*Code of Practice for Site Investigations*'
- British Code of Practice BS 1377:1990 '*Methods of test for soils for civil engineering purposes*'.
- British Code of Practice BS EN ISO 14688-1:2002+A2:2013 '*Geotechnical investigation and testing – Identification and classification of soil – Part 1: Identification and description*'
- British Code of Practice BS EN ISO 14688-2:2004+A2:2013 '*Geotechnical investigation and testing – Identification and classification of soil – Part 2: Principles for a classification*'
- British Code of Practice BS EN ISO 22475-1:2006 '*Geotechnical investigation and testing – Sampling methods and groundwater measurements*'

Institution of Civil Engineers (ICE)

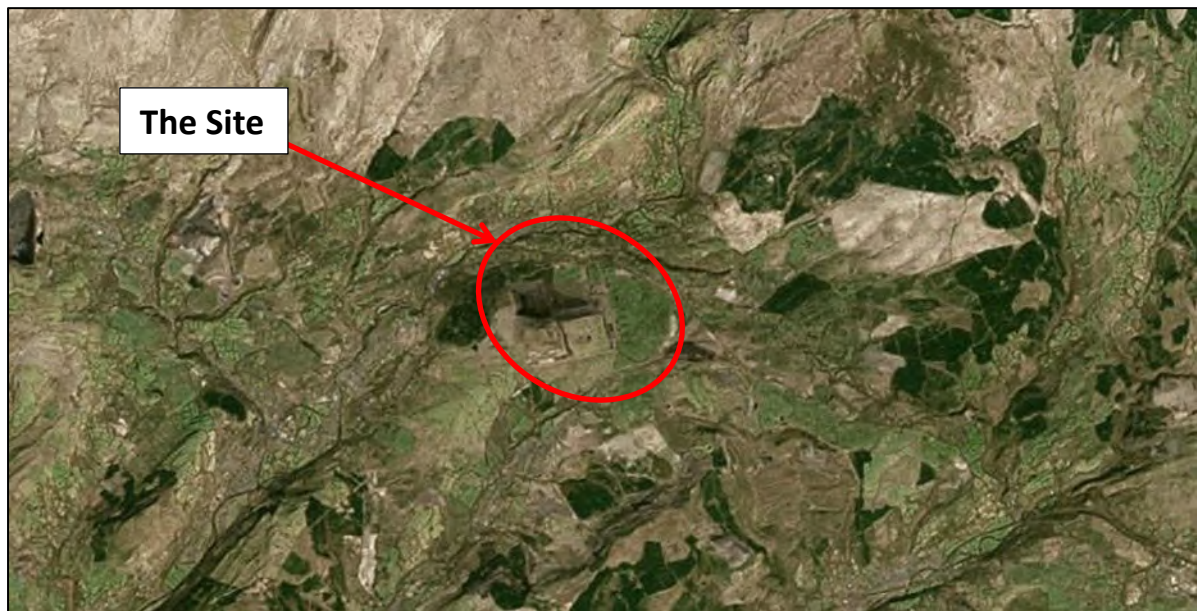
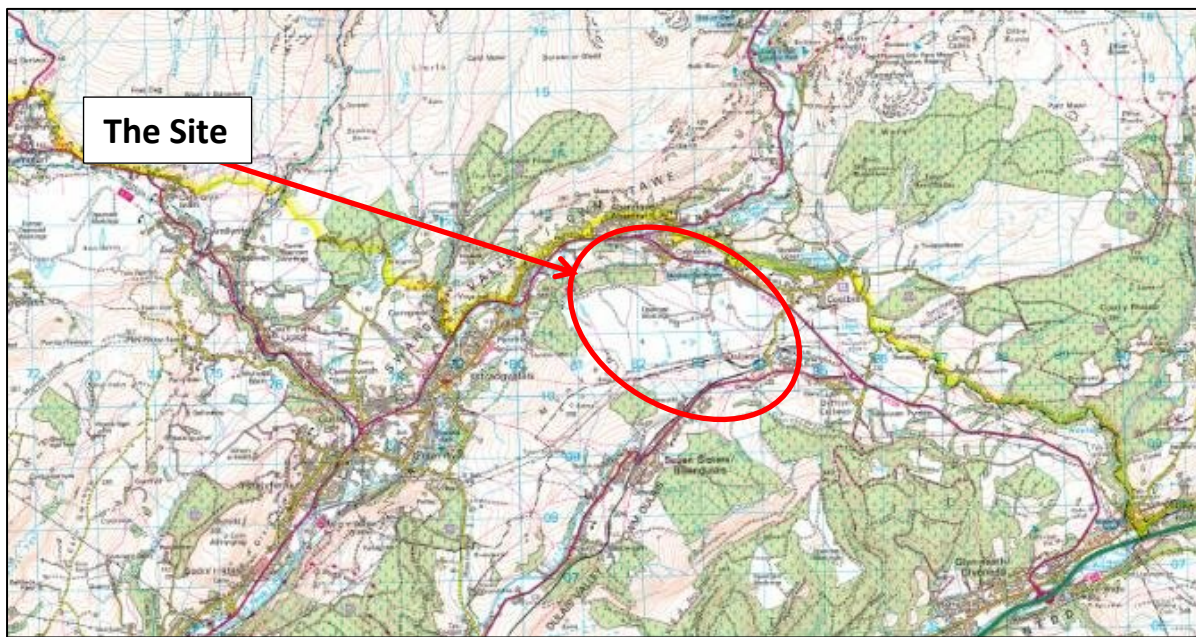
- UK Specification for Ground Investigation, Second Edition (2012)

Specialist Publications

- Health and Safety Executive Guidance Note EH40/90

APPENDIX I – SITE PLANS AND FIGURES

- Figure 1: *Location Plan*
- Figure 2: *Exploratory Hole Location Plan*



Source: www.bing.com/maps



FIGURE 1

Project: Global Centre of Rail Excellence

Job No: Q0652

Drawing Title: Site Location Plan