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AFAN VALLEY

Mining Risk Assessment

(Reserved Matters Application)

Report Reference: 3323106833/3501/R001/r00

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Afan Valley Adventure Resort

Mining Risk Assessment

(Reserved Matters Application)

Prepared for:

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For and on behalf of Stantec UK Limited					

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This report has been prepared by Stantec UK Limited ('Stantec') on behalf of Wildfox Resorts – Afan Valley to whom this report is addressed ('Client') in connection with the project described in this report and takes into account the Client's particular instructions and requirements. This report was prepared in accordance with the professional services appointment under which Stantec was appointed by its Client. This report is not intended for and should not be relied on by any third party (i.e. parties other than the Client). Stantec accepts no duty or responsibility (including in negligence) to any party other than the Client and disclaims all liability of any nature whatsoever to any such party in respect of this report.

1.0 INTRODUCTION

PREAMBLE

- 1.1 Stantec UK Limited (Stantec) has been commissioned by Wildfox Resorts – Afan Valley (the Client) to provide consultancy services, including those relating to ground conditions for the proposed Afan Valley Adventure Resort development.
- 1.2 The site is located on the southern side of the Afan Valley, south of Cymmer, north of Caerau, and west of Croeserw, in South Wales.
- 1.3 This report presents a Mining Risk Assessment for the proposed development, in order to provide the Local Planning Authority and all stakeholders with information relating to the legacy of mining in the area and to provide an assessment of the potential impact to land stability for the proposed development.
- 1.4 The purpose of this Mining Risk Assessment is to:
- Present a desk-based review of information relating to mining relevant to the site, including the Coal Mining Risk Assessment prepared by AECOM in 2017 (see below);
 - Update this information using recent surveys and investigation records from intrusive site investigation work carried out during 2022;
 - Use this information to update and assess the risks to the proposed development from the mining legacy, including the cumulative impact of issues;
 - Set out appropriate mitigation measures to address the mining legacy issues affecting the site, including any necessary works and/or demonstrate how mining issues have influenced the proposed development; and
 - Demonstrate to the Local Planning Authority and the Coal Authority that the Site is, or can be made, safe and stable to meet the requirements of national planning policy with regard to development on unstable land.
- 1.5 This document has been prepared following the guidance presented within CIRIA C579, Abandoned Mine Workings Manual, 2019, and CL:AIRE, Good Practice for Risk Assessment for Coal Mine Gas Emissions, October 2021.

PROPOSED DEVELOPMENT

- 1.6 The proposed development is shown in the Concept Masterplan (Powell Dobson Architects, Proposed Masterchplan, Drawing No. 21055 (05) 104, Revision /, dated 3/08/2022) included in **Appendix A**, and comprises the following main elements:
- Wildfox Hotel and Car Park –comprising a car park, restaurant and hotel;
 - Wildfox Rock & Wild – Low-rise building with swimming pools and associated plant rooms and facilities;
 - Spa – A two-storey building with a variety of pools and courtyards at different levels;
 - Wildfox Mountain – An approximately 15m-high hall for indoor sports facilities;
 - Back of House/Staff Accommodation – staff accommodation and associated car park;
 - Summit Hub –timber structure including restaurant;
 - Lodges – One and two-storey cabins, some at ground level, some recessed into ground, some on ground at one end and above ground at the other;
 - A main access road generally crossing the site from east to west; and

- Mountain bike trails and associated landscaping and minor access roads.

EXISTING INFORMATION

- 1.7 In 2018 an outline planning application (Reference P2018/0493 – Land at Peny-y-Bryn, Croeserw, Cymmer, Port Talbot) was submitted to Neath Port Talbot Council for the development of the site.
- 1.8 An Environmental Statement, was submitted with the planning application along with the following relevant reports:
- BSP Consulting, Caerau Parc, Afan Valley, Wales, Geo-Environmental Phase 1 Desk Study, Reference 16255, dated 10th February 2017;
 - Terra Firma (Wales) Ltd, Afan Valley Development – Landslip Potential, Reference GCL/14536/Let1, letter dated 12th December 2017;
 - AECOM (2017a), Coal Mining Assessment Report, Afan Valley Ltd, dated December 2017;
 - AECOM (2017b), Afan Valley Initial Peat Survey, Afan Valley Ltd, dated December 2017; and
 - AECOM, Summary of Findings in Relation to Peat Survey, Afan Valley Adventure Resort, dated 17th May 2018.
- 1.9 A planning consultation was carried out by Nineteen47 Ltd (Chartered Planners) associated with submission of the application for outline planning permission to in July 2018.
- 1.10 Outline planning approval was granted subject to conditions (Decision Notice reference DN P2018-0493, dated 18th January 2022).
- 1.11 In 2022 further ground investigations and studies have been carried out in relation to the proposed development as follows:
- ESP (2022a) Geomorphology Assessment and Ground Investigation Scoping Report, Reference ESP.8053.3708-03, dated September 2022. Earth Science Partnership, Cardiff;
 - ESP (2022b) Peat Site Investigation, Reference ESP.8053.3713-04, dated September 2022. Earth Science Partnership, Cardiff;
 - ESP (2022c) Geo-environmental Assessment Report, Reference ESP.8053.3747-06, dated September 2022. Earth Science Partnership, Cardiff; and
 - Jackson (2022) Ground Investigation Factual Report, Reference G22033, dated July 2022. Jackson Geo Services.
- 1.12 The Geomorphology Assessment and Ground Investigation Scoping Report (ESP, 2022a) includes a Coal Authority Consultants Mining Report issued by the Coal Authority .

LIMITATIONS

- 1.13 Unless stated otherwise, information from the previous studies, investigations and the recent ground investigations and studies has not been included in this report.
- 1.14 Guidance on the context of this report and any general limitations or constraints on its content and usage given in a separate guidance note included after the text of this report.

2.0 SITE SETTING

INTRODUCTION

- 2.1 A summary of the characteristics of the site and overall site description including location, description, historical setting, geology and hydrogeology are presented in the section below.

SITE LOCATION AND GENERAL DESCRIPTION

- 2.2 The site is located on the southern side of the Afan Valley, south of Cymmer, north of Caerau, and west of Croeserw, in South Wales. It is centred on an approximate National Grid Reference (NGR) of 285523 195668 and covers an area of approximately 130 hectares (ha). The general site location is shown on Figure 1.
- 2.3 Generally, the site slopes from the south towards the River Afan immediately north/northwest of the site, with the highest point on the ridge of Foel Fawr in the south at an elevation of 347 m Above Ordnance Datum (AOD). The lowest point on the northwest boundary is at an elevation of approximately 170m AOD. The topography is generally undulating with some locally steep slopes in particular in the lower parts of the valley of the River Afan along the northern and western parts of the site.
- 2.4 The site is generally undeveloped, comprising the remnants of coniferous forestry, with some stumps, brush and areas of open grassland. An area of forestry remains in the northeast to central extent. A mast and associated infrastructure is located on the ridge of Foel Fawr and a covered reservoir is present in the southeast part of the site. Two small ponds are present in the southeast part of the site, surrounded by boggy marshy ground.
- 2.5 Two historic assets are present on site which are considered to be of high archaeological importance: Glyncymmer Bronze Age cairn and Heol y Moch.
- 2.6 An arcuate ground fissure is present immediately south of the mast. This generally trends east-west, with a second small feature with a similar trend to the southeast, and a north-south trending feature to the north. In addition, a series of ground fissures generally trending east-west are present in the southeast part of the site.
- 2.7 The site is accessed via a gravel track off Maesteg Road on the east boundary. Old forestry tracks facilitate vehicular access across parts of the site.
- 2.8 A disused railway tunnel (Cymmer Tunnel) is located below the site at an approximate elevation of between 190 to 192m AOD, generally trending north-south across the central part of the site. The northern portal is situated at the northern site boundary, and the southern portal is approximately 800m south of the site. According to available information the tunnel is a few metres below ground level (bgl) at the northern boundary reaching approximately 145m bgl at the southern boundary.

HISTORICAL LAND USE

- 2.9 The earliest available historical map from 1877 indicates the site to comprise shrub and rough pasture. Two areas of ground fissures are shown in the south and south-eastern parts of the site. Cymmer Tunnel is shown from the earliest mapping, initially as under construction. A number of historical quarries are recorded in the north and central areas of the site.

- 2.10 Dyffryn Colliery, with a level and trial level, is shown approximately 700m south in the earliest mapping, and subsequently disused from 1897. A trial level is shown on the 1877 map just beyond the east boundary and the 1897 map labels it as old. Glyncymmer Colliery is shown immediately north of the site in 1897, with a coal level off site and an air shaft within the site boundary. By 1919 Glyncymmer Colliery is no longer recorded.
- 2.11 A reservoir and associated access track is mapped from 1962. In 1965, an area of forestry had been planted in the south and between 1972 and 1987 the majority of the site is shown to be covered by coniferous trees.
- 2.12 By 1971 a lookout tower was constructed on Foel Fawr. The 1971 mapping shows the northern portal of the rail tunnel to be dismantled. By 1986 the railway tunnel is recorded as disused. At the same time the lookout tower is no longer recorded and the existing mast was constructed. By 1993 the majority of the forestry is no longer recorded.

PUBLISHED GEOLOGY

- 2.13 The published 1:10,560 scale geological mapping for the area (Sheets XXVI NW, 1947 and XVII SW 1959) show the site to be underlain by the Pennant Measures from the South Wales Upper Coal Measures Formation generally comprising Pennant sandstone with thin mudstone/siltstone and seatearth interbeds and mostly thin coal seams.
- 2.14 The majority of the site is directly underlain by the Rhondda Member, underlain conformably by the Llynfi Member, with the younger Brithdir Member shown to outcrop in the north-western extent of the site.
- 2.15 Numerous named coal seams are indicated to outcrop and underlie the site, this is discussed in more detail in Chapter 3.
- 2.16 The general regional bedding is recorded to dip by about 10 to 12° towards the north/northwest.
- 2.17 The geological maps indicates that superficial deposits are generally absent from the site, with the exception of Glacial Till shown on the northern perimeter and Glaciofluvial Deposits along the northwest site boundary. An area of peat is mapped immediately south of the east section of the southern boundary.

LANDSLIDES

- 2.18 Two landslides are mapped within the site boundary, with a further one mapped immediately north of the east end of the northern site boundary. These are also recorded with further details in the UK National Landslide Database, maintained by the British Geological Survey (BGS). The details are as follows:

Table 2.1 Summary of the Mapped Landslides

NLD Reference	Location	Summary Description
3632	Within central part of site, on northern flank of Foal Fawr.	Shallow translational debris slide in the Rhondda sandstone with flows in toe region.
3633	Northwest part of site, south side of the valley on northwest facing slope, above A4107.	Shallow degraded vegetated slip transitional debris side in superficial deposits, weathered Rhondda mudstone and Rhondda and Brithdir sandstone debris. Indistinct vegetated Brithdir sandstone backscar with Brithdir coal approximately 30m upslope. Lower parts of slip are cut by A4107. Forested.
3624	Immediately north of northeast site boundary. On south slope of Afan Valley.	Slip completely covered by buildings, probably a shallow translation debris slide.

FAULTS

- 2.19 The Pen-y-Castell Fault crosses the western part of the site with a downthrow to the west by approximately 160 to 180m.
- 2.20 A further north-south trending normal fault cross the site in the eastern, downthrown to the east by approximately 2.5 to 8.5m. A shorter parallel fault crosses into the south site boundary.
- 2.21 A summary of the geological setting, extracted from ESP's Geoenvironmental Assessment (2022c) is reproduced in **Appendix B**.

3.0 DATA REVIEW

INTRODUCTION

- 3.1 This Section presents a review by Stantec of existing reports issued by third parties in relation to ground conditions and the potential risk associated with coal mining at the Site.

AECOM COAL MINING ASSESSMENT REPORT (2017A)

- 3.2 The AECOM (2017a) report was a desk-based assessment only, undertaken for a previous iteration of the proposed development and submitted with the Environmental Statement in 2018 for outline planning approval.

COAL AUTHORITY MINING REPORT

- 3.3 A site-specific CA CON29M Non-Residential Mining Report (Reference 51001347705001) was obtained for the BSP Consulting Desk Study (BSP, 2017) and consulted for the AECOM report. This indicates that thirteen workable coal seams underlie the site, as presented below in Table 3.1.

Table 3.1 AECOM Summary of Coal Seams

Seam Name	BGS Borehole Reference	Colliery Seam worked at	Seam Thickness (m)	Minimum depth to top of Seam at the site (m bgl)
Unnamed (A)	N/A	N/A	Unknown	Outcrops
Unnamed (B)	SS89NW10	N/A	1.3 (including partings)	40
Field Vein	SS89BW35	Duffryn Rhondda	0.6	Outcrops
Wernddu	SS89NE4, SS89NW8	Duffryn Rhondda and Glyncymmer	0.6-1.1	Outcrops
Wernpistyll Rider	SS89NE4, SS89NW8	Glyncymmer	0.5	Outcrops
Wernpistyll	SS89NW35	N/A	0.4	Outcrops
Unnamed (C)	SS89NE4	N/A	0.4	25
Tormynydd	SS89NW35	N/A	0.4	45
Victoria	SS89SE13, SS89NW35	N/A	0.7	170
Albert	SS89SE13, SS89NW35	N/A	0.4	180
Yard	SS89SE13, SS89NW35	N/A	0.6	195
Two and a Half Foot	SS89SE13, SS89NW35	N/A	0.7	210
Caedafaid	SS89NW35	N/A	0.3	260

- 3.4 The Consultants Report indicates that coal mining at collieries beneath and adjacent to the site was last performed in 1959. The site is not within an area currently affected by underground mining, nor in an area that the CA intends to grant a licence to remove coal using underground methods. The site is not within an area likely to be affected by planned future underground coal mining despite coal reserves existing within and surrounding the site.
- 3.5 The site is not within an area of past or present opencast mining, nor are any licenses granted to remove coal through opencast methods both within the site and within 800m of the site boundary.
- 3.6 Permissions for withdrawal of mine support were given in 1946 and 1956. There are no notices given, under Section 46 of the Coal Mining Subsidence Act 1991, stating that the land at the site is at risk of subsidence. The CA has not received a damage notice or claim since 31st October 1994 (when records begin).
- 3.7 The Consultants Report recorded four mine entries are recorded to be present within the site boundary, summarised in Table 3.2 below.

Table 3.2 Summary of On-site Mine Entries and Treatment Details

Mine Entry Reference	Details of Mine Entry Treatment
285195-004	*Shaft – Filled with stone and surface reinstated in 1977. No detailed treatment records have been sought from the CA regarding the volume of stone.
285195-007	*Adit – No treatment details
185195-009	Shaft – No treatment details
285195-010	Shaft – No treatment details
*It should be noted that the AECOM report incorrectly lists mine entry reference 285195-004 as an adit, and 285195-007 as a shaft. This has been corrected to match the detail in the CA Report.	

MINE ABANDONMENT PLANS

- 3.8 Mine Abandonment Plans were obtained for the site for the Duffryn Rhondda and Glyncymmer Collieries.
- 3.9 The following abandonment plans were obtained for the Duffryn Rhondda Colliery:
- SWR3776, Duffryn Rhondda/Unnamed Adits & Fan House;
 - SWA778, Duffryn Rhondda/Drift/Drainage Adit; and
 - 8205, Duffryn Rhondda No.2 (noted to be a re-scan of SWA778).
- 3.10 This colliery extracted the Field Vein and Wernddu (the upper and lower leaves of the No.2 Rhondda Seam) west of the Pen-y-castell Fault and had both a drift-mined region accessed via an adit (daylighting off-site), and a deeper underground mined region accessed via two shafts located approximately 350m west of the site boundary. The mined regions extended approximately south to north (longwalls orientated east-west), with chambers gradually deepening towards the north.
- 3.11 AECOM estimated the approximate minimum depth to the longwall mining from existing ground level to be approximately 150m bgl, based on seam depths recorded on the Abandonment Plans and elevation from OS mapping.

- 3.12 SWA778 records that 495,000 gallons of water was pumped per day through the shafts, with a further 289,000 gallons per day draining from the adit.
- 3.13 Plan Reference 9475 was obtained for Glyncymmer Colliery which exploited two areas: east of the River Corrwg (off-site) and to the south of the River Afan (on-site), east of the Pen-y-Castell Fault. The Abandonment Plans indicate this colliery to have worked both leaves of the No.2 Rhondda Seam below the site at depths ranging between 35-122m bgl, and the underlying Wernpistyll Rider seam at depths ranging between 32-84m bgl.

AECOM SUMMARY OF RISKS TO DEVELOPMENT

- 3.14 The AECOM report concluded that there was a risk to proposed development at the site from underground coal mining: both recorded and unrecorded at shallow depths; and mine entries including shafts and adits.
- 3.15 For the purposes of their assessment, they split the site into three zones: A (west of Pen-y-Castell Fault), B (central area) and C (east of unnamed fault). A summary of the risk AECOM considered to be posed from underground workings in the different zones is presented in Table 3.3 below.

Table 3.3 AECOM Summary of Anticipated Workings per Zoned Areas

Zone	Seams Present	Within influencing distance of ground (Y/N)	Worked in the zone (Y/unknown)
A (west of Pen-y-Castell Fault)	Unnamed (A)	Y	Unknown
	Unnamed (B)	Y (in southwest)	Unknown
	Field Vein	N	Y
	Wernddu	N	Y
	Wernpistyll Rider	N	Unknown
	Wernpistyll	N	Unknown
	Tormynydd	N	Unknown
B (central zone)	Field Vein	Y	Unknown, assumed likely
	Wernddu	Y	Y
	Wernpistyll Rider	Y	*Y
	Wernpistyll	Y	N
	Unnamed Seam (C)	N	Unknown
	Tormynydd	N	N
	Victoria	N	N
	Albert	N	N
	Yard	N	N
	Two-and-a-Half-Foot	N	N
	Caedafaid	N	N
C (east of unnamed fault)	Wernddu	Y	N
	Wernpistyll Rider	Y	N
	Wernpistyll	Y	N
*It should be noted that the AECOM report noted the recorded workings in the Wernpistyll Rider seam but left this out of their summary table. This has been corrected above.			

3.16 A summary of the risks AECOM considered to be presented by the on-site mine entries is presented in Table 3.4 below.

Table 3.4 AECOM Summary of Risks Associated with Mine Entries

Coal Authority Mine Entry Reference	Information from CA Mine Abandonment Plan	Associated Risk
285195-004	Shaft for Glyncymmer Colliery	Mine entry reportedly infilled with stone and reinstated in 1977. Risk of settlement due to collapse of the adit.
285195-007	Not present on the Glyncymmer Colliery Mine Abandonment Plan 9475.	Mine entries likely associated with shallow extraction of the Field Vein coal seam, likely to pre-date large-scale industrial extraction at Glyncymmer Colliery. Entries are likely to be reasonably shallow and infilled with non-engineered fill. Principal risk considered to be failure of any existing treatment and resulting collapse.
285195-009		
295105-010		

- 3.17 AECOM flagged the potential for unrecorded ventilation shafts associated with Cymmer Tunnel, although this was considered unlikely due to the tunnel's depth and competent Pennant sandstone cover.
- 3.18 Following review of aerial photography, AECOM concluded that the two landslides present on site were likely examples of coal mining-induced slope instability associated with mining at Glyncymmer Colliery. However, Stantec review of the AECOM report provides no evidence of these being of a mine induced nature. These landslides are also just as likely to represent periglacial landslides as their geomorphological expression is significantly altered by erosion softening these features. Stantec also note that if these features were of mining induced origin and therefor "recent" more evidence of progressive movements (creep tension features) would be expected along with possible evidence of ground motion in these areas recorded by remote sensing such as interferometric synthetic aperture radar (InSAR). If the landslides were triggered by mining it appears unlikely that the village of Cymmer would be built by the miners over this area at a later date, it is much more likely that these represent relic periglacial landslide the reactivation of which is difficult to assess alone from aerial photos.
- 3.19 The AECOM largely desk-based mining risk assessment did not consider analysis of remote sensing data. As such the assessments also did not identify a large area of negative ground motion (possible subsidence) centred over the former deep longwall workings identified by AECOM to underly the western portion of the site at depth greater than 150m bgl.

AECOM'S PROPOSED MITIGATION STRATEGY

- 3.20 Due to the widespread distribution of known workings below the site, it was considered that a significant area may require remedial works, and would require further investigation to further categorise the extent and method of remedial works required. The following outline mitigation measures were proposed:
- Geogrid in areas of low risk and relatively light transient loading, including car parks and light-use access roads;

- Reinforced raft foundations to spread the applied loads over larger areas;
- Infilling of voids including drilling and grouting below high-load and high-risk areas, including large permanent structures or high use roadways to a depth assumed to be approximately 30m below competent rockhead. It was considered likely that this would be required within Zone B (central) to the base of the Wernpistyll and/or Tormynydd seams, subject to confirmation through investigation. AECOM flagged the potential for grout to be lost to the Cymmer Tunnel, or surcharging to cause tunnel damage and potentially failure.;
- Shaft remediation, either by maintaining a 30m-diameter exclusion zone, or through treatment through bulk infilling and/or grouting;
- Soil strip/discovery strategy in case of unrecorded workings;
- Suitable risk assessment for mine gas, followed by the possible requirement for gas membranes; and
- Construction not to be undertaken across the major faults, due to the potential for reactivation due to injection grouting or changes in groundwater regime due to the infilling.

- 3.21 A programme of investigative works was recommended, including rotary boreholes to depths of at least 30m in the areas of recorded shallow workings and the areas where coal is mapped to outcrop, an investigation of the existence, depth and condition of the known mine entries, and a detailed site inspection and geomorphological walkover to assess the impact of any surface features.
- 3.22 Stantec are in general agreement with the majority of these intended mitigation strategies outlined by AECOM, however it should be highlighted a 30m cover criteria ("*30m below competent rockhead*") proposed by AECOM is particularly conservative the majority of void migrations rarely exceed 5-8 times the seam thickness and the largest of seams below these site even at 10 or 15 times seam thickness void migrations would not impact structures at ground level. It should also be noted that the Coal Authority viewers polygons showing the site do not show "development high risk" areas in large proportions of the site as inferred by AECOM.
- 3.23 AECOM also identify a mine entry exclusion zone diameter of 30m, Stantec are not clear how this has been calculated and would also appear excessively conservative given the depth of overburden at the site is minimal a small exclusion zone would normally be expected. It is likely there is little need to treat these mine entries for the intended development of the site and therefore relocation and avoidance is the best form of mitigation and of lower environmental impact. This may include fencing, stone walling, concrete/grill type capping that are more typically present in rural areas.

COAL AUTHORITY RESPONSE

- 3.24 In the Planning Application response (Reference P20180493), the CA confirmed that part of the application site falls within the defined Development High Risk Area, that there are four recorded mine entries on site, and that it falls within an area of recorded and likely unrecorded coal mine working at shallow depth.
- 3.25 They generally concurred with the recommendations of AECOM's CMRA (2017), in that the coal mining legacy potentially poses a risk to the proposed development and that appropriate mitigation measures can sufficiently address the risk.
- 3.26 These include:
- Agreement of the nature and extent of intrusive site investigation works and to undertake these prior to development in order to establish the exact situation regarding coal mining legacy issues on the site;

- The findings of the intrusive site investigations should inform any remedial measures which may be required;
- Any remedial works to treat the mine entries and areas of shallow mine workings must be undertaken prior to the commencement of the development.
- The development layout should be informed by the location of the mine entries in order to ensure that adequate separation is provided between these features and any buildings proposed;
- Due consideration should be given to the potential risk posed by mine gas to the proposed development; and
- Due consideration should be given to the prior extraction of any remnant shallow coal as part of any mitigation strategy, in line with National Planning Policy.

3.27 It was considered that these matters could be satisfactorily addressed by suitably worded conditions.

ESP (2022A), GEOMORPHOLOGY ASSESSMENT AND GROUND INVESTIGATION SCOPING REPORT

- 3.28 ESP undertook a review of the existing information was carried out, and commissioned additional site assessment using remote sensing, comprising of Light Detection and Ranging (LiDAR) and Interferometric Synthetic Aperture Radar (InSAR) data, Aerial Photograph Interpretation (API) and a geomorphological site walkover.
- 3.29 This information was used to provide an updated proposed site-specific scope of investigation for the site, along with a geomorphological and landslide hazard risk assessment, and updated CMRA.
- 3.30 For the purpose of the CMRA, the site was split into three, along the same lines as AECOM.
- 3.31 West of the Pen-y-Castell Fault, three coal seams are conjectured to outcrop, interpreted to be the Brithdir in the north, and the No.1 Rhondda Rider and an underlying unnamed thin coal in the south. Possible unrecorded adits were noted in the western extent, thought to have potentially accessed the No.1 Rhondda Rider seam.
- 3.32 In the central part of the site, four seams were identified to outcrop on site: the Field Vein, Wernddu (together comprising the upper and lower leaves of the No.2 Rhondda), Wernpistyll Rider and Wernpistyll, with the seams anticipated to underlie the site at shallow depth. The CA interactive mapping indicated shallow workings to underlie this part of the site, and the four previously identified mine entries are all within this area. The LiDAR data and aerial mapping indicates the presence of unrecorded incline entries (incline shafts) along the dip of the seam immediately south of this part of the site, considered likely to have accessed the Field Vein and Wernddu seams or resulted in the daylight of the seam from underground.
- 3.33 The area east of the unnamed normal fault is considered to be stratigraphically similar to the central area due to the small displacement over the fault (approximately 10m downthrow to the east). No records of shallow workings or mine entries are present for this area. This is consistent with mine entries of the area which typically avoided penetrating through the competent Pennant Sandstone overlying the seams at depth.
- 3.34 Across the site, the CA has designated the areas in the immediate vicinity of outcrops and shallow workings as a 'Development High Risk Area' however no specific mine entries are recorded.

UPDATED CA CONSULTANTS COAL MINING REPORT

- 3.35 An updated CA Consultants Coal Mining Report was obtained for the site (Reference 51003007499001, dated 21st April 2022). This include the following information:
- 60 No. records of coal mining workings beneath the site in 11 No. named and 4 No. unnamed seams, at depths between ground level and 786m bgl;
 - The shallowest recorded workings are within two coal seams: an unnamed one and the No.2 Rhondda (Field Vein and Wernddu), with reported extraction thicknesses of 0.57m and 0.91m respectively;
 - Further records within these seams at up to 250m bgl indicate a maximum extracted thickness of 1.0m recorded in the No.2 Rhondda seam at 38m bgl;
 - 7 No. records for spine roadways below the site at shallow depth;
 - 6 No. recorded mine entries within and within 100m of the site boundary. This corresponds with the four entries already recorded by AECOM on site, plus a further two adits located 30m north and 65m southeast of the site boundary. ESP consider all these to have accessed workings within the No.2 Rhondda seam, with the exception of the on-site adit which they consider likely to have accessed the No.1 Rhondda seam; and
 - A recorded mine gas emission 210.9m west of the site. Further information relating to this was requested from the CA but none was available.

UPDATED MINE ABANDONMENT PLANS

- 3.36 Mine Abandonment Plan reference SWA778 was consulted again for Duffryn Rhondda Colliery, with ESP concurring with AECOM's conclusions. Additionally, Mine Abandonment Plan reference SWA3139 – Duffryn Rhondda/Cynon was obtained, showing records of workings within the Two-and-a-Half-Foot seam, accessed through the same off-site shafts as for the No.2 Rhondda (approximately 350m west of the site boundary). The shafts are shown to extend to approximately 730m bgl, with the workings within the Two-and-a-Half-Foot seam at approximately 460m bgl.
- 3.37 Mine Abandonment Plan reference (9475) was consulted again for Glyncymmer Colliery. ESP agreed with AECOM's conclusions, adding that the plan indicates the No.2 Rhondda seam to be 2ft6in (0.75m) thick and the Wernpistyll Rider to be 1ft5in (0.45m) thick. The plans also indicate a number of small north-south trending normal faults not recorded on the geological mapping. Downthrows are recorded as up to approximately 5.5m, to the east and west.
- 3.38 A Mine Abandonment Plan was obtained relating to workings within the Two-and-a-Half-Foot seam from the Caerau No.3 Colliery at approximately 250m bgl. The plan records workings outside the site boundary to the southwest, although it is noted that unrecorded workings may extent below the site boundary footprint.

LANDSLIDES

- 3.39 The site walkover undertaken by ESP identified a landslide complex within the central part of the site, broadly correlating with the extent of NLD reference 3632. The complex has been split into two parts:
- Landslide 1 – a rotational landslide with a northwest-southeast trending main scarp and associated debris. Two fissures are present to the rear of the main scarp, with the height measured at between about 1.0 to 4.0m.
 - The landslide was observed to be degraded with no evidence of recent movement. Bedding

within material considered to have slipped were recorded dipping between 20 to 22° to the northwest and southeast.

- Landslide 2 – a larger deeper translational landslide observed as rock deformation with an arcuate scarp feature immediately south of Foel Fawr. The surface expression varies from fissures in rock to linear topographical depressions, interpreted as defining the uppermost extent of the landslide complex. Bedding dip measured as dipping between 3 to 22° with the dip direction ranging between 224 and 354°.

- 3.40 Measurements of the fissures indicate them to be up to 6m deep and generally striking in an east-west direction.
- 3.41 The mapped landslide in the northwest part of the site (NLD reference 3633) was inspected by ESP. Whilst a broad lobate feature was noted, no conclusive geomorphological evidence that this was a landslide was observed. This area of the site was inaccessible to plant at the time of the intrusive investigation. Stantec, believe the feature describe by ESP represents a periglacial landslide that has been significantly weathered softening its general geomorphological expression and is most likely inactive however relic slip surfaces are likely to remain.
- 3.42 The landslide mapped immediately off-site (NLD reference 3624) was also inspected by ESP. The village of Cymmer has been built over this feature and deformation or structural distress are not reported.

ESP (2022A) SUMMARY OF RISKS TO DEVELOPMENT

3.43 ESP's summary of anticipated coal seams underlying the site up to 250m bgl is presented in Table 3.5 below. For the purposes of clarity, AECOM's zoning has been used.:

Table 3.5 ESP Summary of Anticipated Seams and Workings per Zoned Areas

Zone	Seams Present	Reported Thickness (m)	Anticipated Approximate Seam Depth (m bgl)	Worked in the zone (Yes/unknown)
A (west of Pen-y-Castell Fault)	Brithdir	Thin	0-<10	Unknown
	No.1 Rhondda Rider	0.45	0-50	Unknown
	No.1 Rhondda	0-0.60	40-90	Unknown
	Field Vein (No.2 Rhondda Upper Leaf)	0.70	130-180	Yes, Duffryn Rhondda Colliery, Longwall
	Wernddu (No.2 Rhondda Lower Leaf)	0.90	145-195	Yes, Duffryn Rhondda Colliery, Longwall
	Wernpistyll Rider	0.45	155-210	Unknown
	Wernpistyll	0.45	165-220	Unknown
B (central zone)	No.1 Rhondda Rider	0.45	0-10	Unknown
	No.1 Rhondda	0.60	0-50	Unknown
	Field Vein (No.2 Rhondda Upper Leaf)	0.70	0-50	Yes Glyncymmer Colliery, Pillar-and-stall
	Wernddu (No.2 Rhondda Lower Leaf)	0.90	0-60	Yes Glyncymmer Colliery, Pillar-and-stall
	Wernpistyll Rider	0.45	20-50	*Yes Glyncymmer Colliery, Pillar-and-stall
	Wernpistyll	0.45	30-65	Unknown
	Unnamed Thin	Thin	60-100	Unknown
	Unnamed Thin	Thin	80-120	Unknown
	Tormynydd	Thin	150-190	Unknown
C (east of unnamed normal fault)	Field Vein (No.2 Rhondda Upper Leaf)	0.70	0-45	Yes Glyncymmer Colliery, Pillar-and-stall
	Wernddu (No.2 Rhondda Lower Leaf)	0.90	0-60	Yes Glyncymmer Colliery, Pillar-and-stall
	Wernpistyll Rider	0.45	0-65	Unknown
	Wernpistyll	0.45	40-105	Unknown
	Unnamed Thin	Thin	40-105	Unknown

Zone	Seams Present	Reported Thickness (m)	Anticipated Approximate Seam Depth (m bgl)	Worked in the zone (Yes/unknown)
	Unnamed Thin	Thin	80-145	Unknown
*It should be noted that the ESP (2022a) report noted the recorded workings in the Wernpistyll Rider seam but left this out of their summary table. This has been corrected above.				

3.44 ESP considered the hazards presented to the proposed development to be as follows:

- Zone A west of Pen-y-Castell Fault, unrecorded shallow workings associated with the No.1 Rhondda Rider and No.1 Rhondda seams
- Zone B central zone, recorded shallow workings within both leaves of the No.2 Rhondda seam up to approximately 40m bgl. Unrecorded workings within the No.1 Rhondda Rider and No.1 Rhondda seams from ground level. Deeper workings associated with the Wernpistyll Rider, Wernpistyll and other thin coal seams at greater depths.
- Zone C east of unnamed normal fault, unrecorded workings within the No.2 Rhondda seam from ground level to 60m bgl in the southeastern extent. Further potential unrecorded workings within the Wernpistyll Rider and Wernpistyll seams from ground level to 70m bgl. The off-site adit to the southeast is considered likely to access the No.2 Rhondda seam.

3.45 Where the workings were undertaken using pillar-and-stall methods, ESP considered collapse of the pillars and roof structure from shallow mineworkings may lead to void migration and subsidence at the ground surface.

3.46 Where the workings were undertaken using longwall techniques, ESP considered that surface subsidence could occur over a long time period after the extraction of coal using longwall mining that occurred at depths of several hundred metres bgl.

3.47 They also considered there to be a risk of fault reactivation from mining subsidence.

3.48 The proposed further investigation includes the following:

- A series of rotary cored and open-holed boreholes across the site to confirm the ground model;
- Gas and groundwater monitoring wells, targeted for gas sources including workings and shafts; and
- Trial pits or trenches, along with geophysical methods (eg conductivity and magnetometry) to identify the locations of the recorded mine entries.

3.49 Non-intrusive surveys were suggested to potentially further constrain the on-site risk relating to mining, including geophysics to identify mining features and repeat topographical and/or InSAR surveys to identify potential areas of continuing subsidence.

ESP (2022C) GEO-ENVIRONMENTAL ASSESSMENT REPORT

Site Investigation

- 3.50 An intrusive site investigation was carried out between April and June 2022, detailed results of which are included in ESP's Geoenvironmental Assessment Report (ESP, 2022c). This included the following works:
- 52 No. shallow hand dug trial pits using hand tool to depths between 0.30 and 1.20m bgl to allow collection of shallow samples for geoenvironmental testing, and for peat assessment;
 - 140 No. Mackintosh probes to assess and delineate the presence of peat at the site;
 - 26 No. machine-excavated trial pits to depths between 0.85 and 3.40m bgl to examine the near surface ground conditions;
 - 7 No. trial trenches to depths between 2.50 and 3.50m bgl to identify and record the near surface ground conditions, targeting faults and the central landslide;
 - 12 No. windowless sample boreholes to depths between 0.25 and 2.80m to assess shallow ground conditions and allow the installation of combined shallow gas and groundwater monitoring wells;
 - 11 No. rotary cored boreholes to depths between 13.40 and 53.70m to provide information on the deep ground conditions, targeting coal seams and potential coal mine workings, and allow installation of 9 No. deep gas and groundwater monitoring wells, 2 No. vibrating wire piezometers and three inclinometers in and the vicinity of the central landslide. These works were done under the terms of a Coal Authority Permit; and
 - 1 No. rotary open-holed borehole to a depth of 50.00m bgl to allow installation of a deep gas and groundwater monitoring well targeting potential mine workings under the terms of a Coal Authority Permit.
- 3.51 To date four post fieldwork monitoring visits have been undertaken by ESP on a fortnightly basis between 16th June and 12th August 2022 to record gas concentrations and flows, groundwater levels and inclinometer data. The monitoring is ongoing and a further seven visits are scheduled.
- 3.52 It should be noted that whilst deep boreholes were undertaken during the site investigation to allow an update of the preliminary ground model and deep ground conditions, the main aim of this report was to undertake a geoenvironmental assessment and assessment of the risk from historical coal mining.

GROUND CONDITIONS

- 3.53 The ground conditions in the area of the site generally confirm the published geology and known history of the site. It should be noted that whilst the published mapping divides the solid geology underlying the site into the Brithdir Member, Rhondda Member and Llynfi Member, the descriptions are very similar and for the purposes of the ground conditions summary, have been designated as one stratum named "Pennant Measures".

3.54 A summary of the strata encountered is provided in Table 3.6 below.

Table 3.6 Summary of Encountered Strata

Stratum Name	Approximate depth to base (m bgl)	Description
Topsoil	0.1 to 0.5	Soft brown gravelly clayey silt with abundant rootlets
Reworked Natural Soils (locally, associated with tracks)	0.1 to 1.2	Gravelly silty sand with cobbles
Peat (southeast corner only)	Typically 0.5 to 1.0, locally >3.5	Brown very compressible amorphous non-fibrous and fibrous peat
Weathered Pennant Measures	1.2 to 3.4	Grey variably sandy gravelly clay/sandy silty gravel and cobbles with boulders
Pennant Measures	>53.7	Interbedded sandstone, siltstone, mudstone and conglomerate with coal seams and evidence of workings

- 3.55 A thin veneer of topsoil was encountered across the site to a maximum depth of 0.5m bgl. Locally, reworked natural soils were encountered, generally associated with the existing tracks, to a maximum depth of 1.2m bgl. Exploratory holes undertaken in the areas of the historical quarries found no evidence of significant infilling.
- 3.56 An area of deep peat (defined as greater than 0.5m thickness) was encountered within an enclosed basin including two ponds in the south-eastern part of the site
- 3.57 Material interpreted to represent the weathered Pennant Measures or possibly Head Deposits was encountered across the site, generally to depths of 1.2-3.4m bgl. This generally comprised sandy gravelly clay or clayey gravelly sand, with increasing gravel, cobbles and boulder content with depth. These comprised mudstone, siltstone and sandstone.
- 3.58 This was underlain by the Pennant Measures bedrock. Generally, this comprised weak becoming strong and very strong medium to widely interbedded siltstone and sandstone, locally with mudstone and conglomerate.
- 3.59 Coal seams and evidence of workings were encountered locally in the deep boreholes, summarised and discussed further in Section 4.1 below. Inferred bedding fractures were measured dipping up to 10° taken from Alpha angles measured with respect to the core axis, generally confirming the dip amount recorded in the published geological mapping.

GROUNDWATER

- 3.60 With the exception of four hand pits undertaken within the area of peat which encountered a minor groundwater ingress at 0.2-0.4m bgl, groundwater was not encountered within the trial pits or shallow windowless sampled boreholes.

- 3.61 A summary of the groundwater strikes or groundwater observations during drilling in the Pennant Measures bedrock in the rotary boreholes is included in Table 3.7 below.

Table 3.7 Summary of Groundwater Strikes

Hole ID	Groundwater comments
BH01	No strike recorded during drilling. Standing levels at 16.0-27.0m bgl during drilling.
BH02	No strike recorded during drilling. Standing levels at 17.9-18.1m bgl during drilling.
BH03	No strike recorded during drilling. Standing level of 26.0m bgl on completion.
BH04	No strike recorded during drilling. Standing level of 25.1m bgl on completion.
BH05	No strike recorded during drilling. Borehole dry on completion.
BH06	No strike recorded during drilling. Standing level of 34.1m bgl on completion.
BH07	No strike recorded during drilling. Standing levels at 7.0-7.7m bgl during drilling.
BH08	No strike recorded during drilling. Standing levels at 28.3-36.7m bgl during drilling.
BH09	Strike at 44.0m bgl, rising to 40.0m bgl after 20 minutes. Standing levels at 39.0-42.0m bgl during drilling.
BH09a	Strike at 44.0m bgl, rising to 40.0m bgl after 20 minutes. Standing levels at 37.0-40.0m bgl during drilling.
BH10	No strike recorded during drilling. Borehole dry on completion.
BH11	No strike recorded during drilling. Borehole dry on completion.

- 3.62 Post-fieldwork groundwater monitoring to date has indicated a groundwater body to be present within the Pennant Measures bedrock, with groundwater depths measured between 10 to 30m bgl. Locally, shallow perched water is also indicated in some of the shallow monitoring wells in the Pennant Measures bedrock. It is anticipated that this represented perched groundwater and is not necessarily representative of a shallow groundwater body.
- 3.63 While not investigated as part of these works by ESP it is anticipated that the deep mine workings of the Duffryn Rhondda Colliery in the western part of the Site are flooded and are currently undergoing mine water rebound given the evidence of the InSAR data presented by ESP in earlier studies.

LANDSLIDE INVESTIGATION

- 3.64 Inclinometers have been installed within three boreholes within the area/vicinity of the central landslide complex (BH09, BH10 and BH11). Monitoring is ongoing, the results to date do not indicate any significant movement beyond the baseline measurements.
- 3.65 Trial trenching carried out on the peripheries of this landslide (TT01-TT03) were used to delineate the extents of the landslide.

STANTEC DATABASE REVIEWS

- 3.66 A search of the Stantec Natural and Mining (non-coal) Cavities Database and BGS non-coal mining plans database has indicated that there are no recorded naturally occurring or non-coal mining related cavities present within the site boundary.
- 3.67 A review of the Cadw online database indicates that the cairn is round, approximately 0.6m high and 18.3m in diameter, at which kerbing was formerly visible, dating from the Bronze Age. It is not

considered to be associated with historical mining.

- 3.68 A review of the Coal Authority online documentation indicates that the coal seams underlying the site are not known to have suffered from occurrences of spontaneous combustion and are therefore not considered to be at high risk of this when being entered, worked or disturbed.

4.0 UPDATED MINING RISK ASSESSMENT

INTRODUCTION

- 4.1 This Section present an updated Mining Risk Assessment undertaken by Stantec based on the information obtained for the Site.

MINE ENTRIES

- 4.2 Four mine entries, one adit and three shafts, are recorded to be present on site. These were not observed during the walkover and siteworks, and are likely to become masked by vegetation. One entry is recorded to have been filled with stone, however there is no further information available regarding the manner of placement, and nothing further available with regards to the nature of any backfill or caps, if present, for the other entries. To date, no further work has been undertaken to locate these entries on site.
- 4.3 Some possible unrecorded adits, day holes or possible incline entries with the dip of the seam were observed by ESP in the west part of the site, potentially associated with the outcrops of the No.1 Rhondda and No.1 Rhondda Rider in this area. Other unrecorded mine entries may be present at the site. Any unrecorded adits, day holes or incline entries from the outcrop are likely to pre-date the large-scale industrial mining in the area, and to have been relatively simple entries for local extraction of the near-surface seams.
- 4.4 The presence of potentially untreated mine entries at unconfirmed locations on site is considered to pose a potential risk to site users, with a danger of walkers or mountain bikers encountering unseen voids or hollows. However, given the pattern of mine entire in the region and the knowledge that few are recorded to penetrate the competent sandstone cover early mine shaft type entries are considered unlikely as they would have opted for inclined entries with the dip of strata over costly vertical mine shafts in most cases with the exception of airshafts which could still be present.
- 4.5 Additionally, collapse of the entries could be triggered by degradation of an internal support or cap, a change in the ground/mine water level or flow variation, transmitted or direct disturbance, eg construction activity, or an increase in imposed load, for example by construction of nearby structures. Collapse of the entries creates the potential for related surface subsidence.
- 4.6 The recorded off-site mine entries are not considered to pose a risk to the on-site development, although there may be associated workings underlying the site, discussed below.

HISTORICAL SHALLOW COAL MINE WORKINGS

- 4.7 A summary of the coal seams encountered during the intrusive investigation, along with possible seam names, is presented in Table 4.1 below. For clarity, the boreholes locations have been split into the zones designated by AECOM.

Table 4.1 Summary of Encountered Coal Seams

Zone	Location	Intact /workings?	Approximate depth/ level to base m bgl (mAOD)	Approximate thickness m	Possible Seam Name
A (west of Pen-y-Castell Fault)	BH01	Intact coal	21.30 (237.06)	0.05	No.1 Rhondda Rider
B (central zone)	BH02	Two 0.30m thick leaves of intact coal with separation.	11.40 (282.20)	0.70 including separation	No.1 Rhondda
	BH03 (southern boundary)	Four thin (0.05-0.15m) seams of coal gravel with separations	13.10 (300.87)	1.45 including separations	Unnamed
	BH04	0.4m thick seam, separated from underlying thin (0.05m) seam. All intact.	24.15 (264.00)	0.75 including separation	Field Vein
		Coal gravel and cobbles	26.00 (262.15)	0.25	Wernddu?
	BH05 (south)	Two seams of coal gravel (0.30 and 0.25m thick) with separation	38.35 (290.93)	0.75 including separation	Field Vein
	BH06 (just west of unnamed fault)	Soft clay (likely backfilled workings)	32.00 (264.52)	1.90 (likely includes void migration)	Field Vein
		Soft clay (likely backfilled workings)	38.80 (257.72)	0.60	Wernddu
	BH09 (near central landslide scarp)	Black gravel	9.60 (289.11)	0.25	Unnamed
		Coal gravel and pockets of soft clay (possible backfilled workings)	35.20 (263.51)	0.80	No.2 Rhondda (Field Vein and Wernddu)
		Recovered as siltstone and sandstone gravel (possible void migration from workings) over coal	49.85 (248.86)	8.15 (likely includes significant void migration)	Wernpistyll Rider

Zone	Location	Intact /workings?	Approximate depth/ level to base m bgl (mAOD)	Approximate thickness m	Possible Seam Name
	BH09a (near central landslide scarp)	Probable backfilled workings over coal	36.20 (263.02)	0.80 (likely includes void migration)	No.2 Rhondda (Field Vein and Wernddu)
		Soft drill (probable backfilled workings)	50.00 (249.22)	1.30 (likely includes bulking from void migration)	Wernpistyll Rider
	BH10 (within central landslide)	Sandy coal gravel	20.90 (253.58)	0.40	Unnamed?
		Soft gravelly clay with coal (probable backfilled workings)	33.80 (240.28)	2.30 (likely includes bulking from void migration)	No.2 Rhondda (Field Vein and Wernddu)
C (east of unnamed normal fault)	BH07 (just east of unnamed normal fault)	Soft clay (likely backfilled workings) over coal	17.40 (282.95)	2.20 (likely includes bulking from void migration)	Wernpistyll Rider
	BH08	No recovery, soft drill (possible workings)	31.00 (273.07)	1.20 (likely includes bulking from void migration)	Wernpistyll Rider
		Two leaves of intact coal (0.20 and 0.6m thick) with separation	36.20 (267.87)	1.80 (including separation)	Wernpistyll

- 4.8 Evidence of the recorded shallow workings within the Field Vein, Wernddu and Wernpistyll Rider seams was found below the site, encountered both in the area of recorded workings indicated by the abandonment plans, but also in boreholes BH07 and BH08, east of the unnamed normal fault, where shallow mineworkings were not recorded.
- 4.9 Abandonment plans indicate these to be pillar and stall workings, where pillars of coal were left to support the roof rock. Progressive deterioration of the workings through weathering can reach critical levels, propagating failure of the roof rocks (most commonly), pillars and/or pavement of the workings, with the void migrating upwards through the overlying strata and overburden. Subsidence will occur when this reaches the surface.
- 4.10 It is noted that, where material interpreted to represent workings was encountered, this is thicker than the associated recorded seam or the maximum extracted thicknesses, especially at borehole BH09 where 8.15m of soft material was encountered. It is considered that this represents void migration, and not the height of the original workings.

- 4.11 The acceptable cover, representing the limit height on the void migration, can be estimated by multiplying the worked thickness of the seam (t) by the thickness of rock above the workings (h) expressed as a multiple of t. Stantec acknowledge that this is only a rule of thumb and further works are needed to verify its use at the site with appropriate geomechanical assessments once more data is available.
- 4.12 CIRIA (2019), states that “the height of migration in bedrocks might, exceptionally, extend to 10 times the height of the original extraction. Consequently, the 10t criterion has, for over 30 years, been adopted by the industry as providing reasonable assurance against surface subsidence resultant from roof collapse in old room and pillar mines”.
- 4.13 As the structural geology of the site is complex, with many recorded faults and high potential for other unrecorded anomalies, a conservative value for acceptable cover of 15t has been adopted by Stantec for the purpose of this assessment, where t represents the thickness of the seam recorded on the abandonment plans or 1:10,000-scale geological mapping as applicable.

HISTORICAL LONGWALL MINING

- 4.14 Abandonment plans indicate longwall mining to have been undertaken within the No.2 Rhondda Seam (Field Vein and Wernddu) below the site in the area west of the Pen-y-Castell Fault. The estimated minimum depth to the workings is 150m bgl.
- 4.15 Further workings were undertaken below this within the Two-and-a-Half-Foot seam, with recorded workings at approximately 460m bgl. These workings are not considered to pose a risk to the proposed development, due to the depth, and are not considered further for the purposes of this assessment.
- 4.16 Abandonment plan SWA778 for Duffryn Rhondda Colliery, constructed in 1966, indicates that significant dewatering was required with 495,000 gallons of water per day pumped out through the pair of off-site shafts, and a further 289,000 gallons per day draining from the adit into the river. Upon abandonment, the active pumping will have ceased allowing the groundwater to start to return to original levels. Given the large volumes of water that were removed, it is considered likely that groundwater levels in the area of longwall mining are still rebounding.
- 4.17 Rising groundwater levels can drive further consolidation of collapses longwall workings and induce further subsidence and displace any mine gases up through available pathways to be emitted at the surface.
- 4.18 InSAR data for the site, presented within the ESP Geomorphological Report (2022a), shows up to 30mm of vertical ground motion (possible subsidence) in the west part of the site, approximately correlating with the recorded extent of the longwall mining. This is considered to potentially represent subsidence associated with the groundwater rebound and was previously not identified on the AECOM Coal Mining Risk Assessment.

MINE GAS

- 4.19 25 No. monitoring wells were installed and monitored for hazardous ground gases on four occasions at the time of writing. Monitoring is ongoing, with an updated mine and ground gas risk assessment to be undertaken by ESP in accordance with CL:AIRE (2021), BS8485:2018 and BS8576:2013 following completion.

4.20 The installations included general coverage of the site, with some monitoring wells also targeted at encountered coal seams and suspected workings. Full results are included within ESP's Geoenvironmental Assessment (2022c). A summary of the gas monitoring undertaken to date is included in Table 4.2 below.

Table 4.2 Summary of Gas Monitoring Undertaken To Date

*Well	Response Zone Depth (m bgl)	Response Zone Stratum	Maximum Methane (%)	Maximum Carbon Dioxide (%)	Maximum Flow (l/hr)
BH01(s)	1.0-4.0	Weathered Pennant Measures	<0.2	5.9	<0.1
BH01(d)	9.0-21.0	Pennant Measures	<0.2	3.3	<0.1
BH02	9.0-24.0	Pennant Measures and No.1 Rhondda Seam	<0.2	0.7	<0.1
BH03	1.0-10.0	Pennant Measures	<0.2	1.6	<0.1
BH04(s)	1.0-3.0	Weathered Pennant Measures	<0.2	4.6	<0.1
BH04(d)	24.0-27.0	No.2 Rhondda (Field Vein and Wernddu)	<0.2	0.1	<0.1
BH05(s)	1.0-4.0	Weathered Pennant Measures	<0.2	2.5	<0.1
BH05(d)	31.2-40.2	Field Vein	<0.2	0.1	<0.1
BH06(s)	1.0-4.0	Weathered Pennant Measures	<0.2	1.5	<0.1
BH06(d)	24.0-33.0	Pennant Measures and Wernpistyll Rider	<0.2	1.0	<0.1
BH07	3.0-16.5	Pennant Measures and Wernpistyll Rider	<0.2	0.7	<0.1
BH08(s)	2.0-5.0	Weathered Pennant Measures	<0.2	0.9	<0.1
BH08(d)	2.0-31.0	Pennant Measures and Field Vein	<0.2	0.2	<0.1
BH09A	28.0-49.0	Pennant Measures, Field Vein and Wernddu	<0.2	0.9	<0.1
WS01	0.3-0.8	Weathered Pennant Measures	<0.2	2.3	<0.1
WS02	0.5-2.8	Weathered Pennant Measures	<0.2	7.2	<0.1
WS03	0.3-0.65	Weathered Pennant Measures	<0.2	0.9	<0.1
WS04	0.3-0.8	Weathered Pennant Measures	<0.2	2.1	<0.1
WS05	0.5-2.8	Weathered Pennant Measures	<0.2	3.1	<0.1
WS06	0.2-0.7	Weathered Pennant Measures	<0.2	2.3	<0.1
WS07	0.3-0.7	Weathered Pennant Measures	<0.2	1.4	<0.1
WS09	0.1-0.6	Weathered Pennant Measures	<0.2	0.4	<0.1
WS10	0.5-2.0	Weathered Pennant Measures	<0.2	4.5	<0.1
WS11	0.5-1.0	Weathered Pennant Measures	<0.2	2.6	<0.1
WS12	0.3-0.4	Weathered Pennant Measures	<0.2	4.7	<0.1
* (s) denotes shallow well, (d) denotes deep well					

- 4.21 The monitoring undertaken to date indicates no detectable levels of methane or flow, and carbon dioxide generally at concentrations up to 5%, with the exception of WS02 where a peak of 7.2% was recorded. Following the guidance in BS8485:2019, this preliminarily indicates that the majority of the site meets the criteria for Characteristic Situation 1, where no special measures are required.
- 4.22 It should be noted that all the visits to date were undertaken at times of steady or rising pressure; further assessment should be carried out which includes visits and low and falling pressure.
- 4.23 The CL:AIRE document (2021) advises caution in using the BS8485:2019 alone for assessment of mine gas, recommending it should form one strand in a multiple lines of evidence approach. A structure-specific assessment is required, especially when considering on-site shafts, adits and flow in fractured rock. Gas monitoring including shallow and deep monitoring wells targeting coal seams and possible mine workings is undertaken as detailed above.

LANDSLIDES AND GROUND FISSURES

- 4.24 Two areas of landslide have been mapped within the site boundary: a potential shallow translational landslide in the northwest of the site, and a larger landslide complex in the central part of the site, as shown on the plan showing the Geological Settings in **Appendix B**.
- 4.25 A further landslide is mapped immediately northeast of the north site boundary, covered by the village of Cymmer.
- 4.26 Mining-related subsidence below natural slopes can cause or contribute to local instability, generating or reactivating existing landslides. After consulting aerial photography, AECOM suggested that the two landslides present on site were likely examples of coal mining-induced slope instability associated with mining at Glyncymmer Colliery, However they fail to identify that these landslide could also represent periglacial landslide activity and that it is difficult to distinguish this without detailed investigation and analysis.
- 4.27 Boreholes undertaken within the central landslide (BH09 and BH10) have shown a thin bed (0.25-0.40m) of coal and/or seatearth, encountered at 9.35m bgl in BH09 (near the scarp), and 20.50m bgl in BH10. This is considered to be a weak layer within the rock mass, potentially representing the slip surface.
- 4.28 Stantec consider the likely age of the primary movement of the central landslide to be periglacial. The Afan Valley is a former glaciated valley, with evidence of glacial superficial deposits on the northern peripheries of the site. It is considered likely that glacial erosion of the valley over-steepened the slope and the subsequent melting of the glacier removed the support at the toe, triggering movement of the rock mass along the plane of weakness identified above, with material moving down the dip of the strata into the valley. Stantec consider that the geomorphological expression of these landslides points more to a relic landslide, however the possibility of reactivation can't at this stage be conclusively ruled out and ongoing monitoring is undertaken including inclinometer monitoring to confirm if ground movement is ongoing or whether these are stable.
- 4.29 A series of approximately east-west trending fissures are present immediately south of the central landslide, with further fissures indicated in the southeast corner of the site. In the southeast, some of the fissures are partially filled with peat and vegetation, with no evidence of recent movement. These fissures are considered to be tension cracks associated with the periglacial landslides, and not necessarily evidence of mining-induced instability alone.

- 4.30 Monitoring of inclinometers installed within BH09, BH10 and BH11 (near the landslide) is ongoing. The readings to date indicate that the landslide appears inactive however a longer period of monitoring is required over a calendar year to assess trends within the data.

FAULT REACTIVATION & MINE INDUCED FISSURES

- 4.31 Published geological mapping shows two major north-south trending normal faults to cross the site:
- Up the Pen-y-Castell Fault crosses the western part of the site with a downthrow to the west by approximately 160 to 180m;
 - A further unnamed north-south trending normal fault cross the site in the east, downthrown to the east by approximately 2.5 to 8.5m. A shorter parallel fault crosses into the south site boundary.
- 4.32 The abandonment plans show numerous other small normal faults, all generally trending approximately north-south, with downthrows of up to 5.5m noted to the east and west. Further small faults are likely to be present, although unmapped.
- 4.33 Field geomorphological mapping and trenching undertaken across the fault zones failed to identify any surface expression or rupture of any of the major fault zones crossing the site. There is considered to be a low risk of fault reactivation relating to treatment of mineworkings, during any future grouting, if r, and potentially as a result of changes to the groundwater regime due to rebound and the infilling of underground voids.
- 4.34 Given that many mine induced fissures are generally of low persistence and narrow and are typically less the 0.5m in width it is not possible to investigate and locate these by any current practical means and therefore these features were not considered as part of the focus of these investigations, however in consideration of the high vertical ground motions recorded within the western potion of the site above deep mine workings it is considered likely mine induced fissures could be prevalent from the edge of the former longwall working to the projected angle of draw.
- 4.35 The site is located in an area of moderate risk of seismic activity. The potential for seismic activity in relation to fault reactivation will be assessed as part of detailed.

HISTORICAL QUARRIES

- 4.36 No evidence of significant backfill to surface queries was encountered during the intrusive investigations, with a maximum of 1.2m thickness of reworked natural soils encountered across the site.
- 4.37 The quarries are not considered to pose a significant risk to the proposed development.

CYMMER TUNNEL

- 4.38 Cymmer Tunnel is located below the site at an approximate elevation of between 190 to 192m AOD, generally trending north-south across the central part of the site. While it is indicated to be a few metres bgl at the northern portal on the northern boundary, due to steep topography it is at significant depth across the majority of the site, reaching approximately 145m bgl at the southern boundary.
- 4.39 There is considered to be a potential risk of subsidence associated with the northern portal of the

tunnel.

GEOLOGICAL HAZARDS

- 4.40 A number of hazards were identified by Stantec associated with the ground conditions at the Site based on review of the information presented in this report. The hazards that may represent a potential constraint to future development of the site comprise the following:
- Landslides;
 - Faults;
 - Historical coal mining;
 - Peat;
 - Ground Fissures; and
 - Cymmer Tunnel.
- 4.41 A drawing showing the ground related hazards and constraints to development is presented on a drawing named Site Constraints Plan 2022, Drawing Reference 0332310590/3501/001 (Rev:2) presented in **Appendix C**. The drawing was used to inform the masterplan for the proposed development of the Wildfox Resort, Afan Valley as presented by Powell Dobson Architects in **Appendix A**.

5.0 PROPOSED MITIGATION

INTRODUCTION

- 5.1 Parts of the proposed development have been identified to be in areas affected by a number of ground hazards including historical coal mining. The development, including any future ground investigations, assessments, mitigation and/or remediation, should be carried out following CIRIA, 2019.
- 5.2 A mitigation plan was issued by Stantec to inform the proposed development of the site as part of the proposed Afan (drawing ref: 0332310590/3501/002, (Rev: 3) dated 2022.08.03) and is presented in **Appendix D**.
- 5.3 A summary of the mitigation strategy associated with the historical coal mining and other identified ground risks is presented in the sections below.

OUTLINE MITIGATION STRATEGY

Mine Entries

- 5.4 An exclusion zone of 30 m was adopted for development for the on-site mine entries recorded by the Coal Authority as taken from the AECOM report, however it is Stantec's opinion that this remains excessively conservative. For the purpose of the mitigation plan Stantec have kept the 30 m exclusion zone, however it is intended to be reduced it once the mine entries are physically located through investigation.
- 5.5 Once located, all mine entries will be surveyed and recorded and updated recorded supplied to the Coal Authority. For the proposed the development mine entries will be secured with either cap, grills and or walling to mitigate the risk to site users. If necessary the benefits of treatment though grouting will be evaluated after probing of the mine entries are undertaken. No construction will be permitted over or within the influence zone of any identified on-site mine entries and it is the developments intention to avoid these hazards as much as is reasonable practicable to do so.

HISTORICAL SHALLOW MINeworkINGS

- 5.6 Mine workings within 15 x seam thickness (t) from the surface present a high risk of ground collapse and crown holes as a result of void migration.
- 5.7 In these areas that may impact any proposed structures Stantec propose a combination of excavation of the hazard and or consolidation through grouting of any voids or disturbed ground in 15t depth to mitigate the risk.
- 5.8 During construction, all excavations within the High Risk Zone for potential void migration associated with historical mine workings will be inspected and any disturbed soils removed and replaced with granular fill as necessary.
- 5.9 Any structures constructed in the High Risk Subsidence Zone will be supported using raft foundations, with flexible service connections design to accommodate potential ground movements associated with potential void migration.
- 5.10 The proposed attenuation ponds will also use a suitable lining system to minimise the risk of leakage

and flooding of underlying mine workings.

HISTORICAL LONGWALL MINING

- 5.11 If required, structures should be as lightweight as possible, have flexible service connections, use raft foundations and have jacking points at the base of the columns to accommodate any differential movement.
- 5.12 Inspection of any excavated surfaces would be performed in these locations also in advance of construction to identify if any potential mine induced fissures are present within the formation and if over excavation is required to mitigate the risk of these features. Any disturbed soils should be removed and replaced with granular fill as necessary. Foundations in this area should be reinforced strip or rafts, with flexible service connections.

LANDSLIDES

- 5.13 Heavily loaded structures will not be permitted to be constructed within the identified areas of the likely relic periglacial landslides as shown in Drawing 0332310590/3501/001. Development within these areas is recommended to be avoided where possible to minimise the potential for reactivation.
- 5.14 Where structures are proposed, for example the summit hub, these will be as lightweight as possible, have flexible service connections, use raft foundations and have jacking points at the base of the columns to accommodate any differential movement.
- 5.15 Where access roads are proposed to cross the landslides, reinforced road construction, including geotextile, will be used to accommodate subsidence and potential movement.
- 5.16 Current layout plans indicate some cut will be required to accommodate the access road crossing the northwest landslide. It is considered likely that stabilisation of this area, through rock-bolting or netting, will be required.

FAULTS

- 5.17 Structures will not be permitted to be constructed within the identified fault zone areas and associated buffers to minimise the potential for fault reactivation.
- 5.18 Where access roads are proposed to cross the fault zone areas, reinforced road construction, including geotextile, will be used to accommodate subsidence and potential movement.

PEAT

- 5.19 No structures or roads are permitted to be developed on the area of identified deep peat in the south-eastern part of the site.
- 5.20 All proposed drainage arrangements within the peat basin are required to mimic current surface water and hydrogeology conditions.

GROUND FISSURES

- 5.21 Structures are not permitted to be constructed on the identified ground fissures.
- 5.22 Excavations for foundations used to support lodges immediately adjacent should be inspected for

“hidden” fissures and relic tension cracks, any disturbed soils should be removed and replaced with granular fill as necessary. Foundations in this area should be reinforced strip or rafts, with flexible service connections.

- 5.23 Any roads or car parks in these areas should use geogrid reinforcement.

CYMMER TUNNEL

- 5.24 The current proposed development does not show any structures near to the northern tunnel portal. Additional assessments will be required for any structures located within the zone of influence.

ARCHAEOLOGICAL FEATURES

- 5.25 Development is not permitted on the areas identified as being of high archaeological importance.

PROPOSED SUPPLEMENTARY GROUND INVESTIGATIONS

- 5.26 In 2022 a site-wide ground investigation was carried out by ESP to identify the ground conditions at the site including geotechnical, geoenvironmental and land stability, inform the site model, and identify and confirm site constraints in relation to the ground conditions at the site.

- 5.27 It is expected that further plot and structures specific geotechnical ground investigation will be required to be carried as part of detailed design and inform mining related assessments with associated mitigation and remediation where required.

- 5.28 The outline proposed scope of further ground investigation works is summarised below:

- Rotary cored boreholes across the site to between 20 to 50m depth. These will be targeted for the following purposes;
 - To aid foundation design for the larger structures including Wildfox Hotel and Car Park, Wildfox Rock & Wild etc;
 - In areas of suspected shallow mineworkings;
 - To provide information on the ground conditions where the access road is required to cross landslides, including the proposed underpasses;
- Installation of gas and groundwater monitoring wells, to allow both short and long-term monitoring;
- Use of televiwer within selected boreholes to allow assessment of the structural kinematic stability;
- Trial pits across the site to assess the shallow ground conditions;
- Trial trenches targeted for the following purposes:
 - To assess excavatability where areas of rock cut are proposed to enable development;
 - In the areas of the mapped faults to further delineate these areas;
 - To locate the slip surface in the area of the mapped northwest landslide;
 - In the areas where coal seams are projected to outcrop, in order to assess for surface mineworkings;
 - In the areas where development is proposed to be immediately adjacent to open fissures to assess for “hidden” fissures and gulls;
 - Across the fissures to allow assessment of the nature of the structures and potentially allow access for samples to be taken for dating; and
 - Further confirm the alignment of the faults.
- Geophysical surveys to provide further information on the rock mass, faults and landslides;

- Targeted investigation to confirm the location of the four recorded mine entries on site; and
- Structural survey of the integrity of Cymmer Tunnel.

5.29 Further ground investigation reports and assessment will accompany future investigations to inform the design of the proposed structures, infrastructure and any mitigation / remediation required in relation to any coal workings at the site.

5.30 The Coal Authority would be consulted throughout the process with permission and approvals will be sought to be obtained as part of the proposed development.

6.0 CONSULTATION

- 6.1 A meeting was undertaken on 11/08/2022 between representatives of the Coal Authority and Stantec.
- 6.2 The meeting included project background and overview, the presentation of the ground conditions including ground hazards with particular reference to coal mining hazards, including the presentation of the site-specific constraints and proposed mitigation associated with the proposed development of the Site.
- 6.3 A copy of the meeting minutes including the Coal Authority response are presented in **Appendix E**.

7.0 CONCLUSIONS

- 7.1 Stantec has been commissioned to prepare an updated Mining Risk Assessment for the proposed development, in order to provide the Local Planning Authority and all stakeholders with information relating to the legacy of mining in the area and to provide an assessment of the potential impact to land stability for the proposed development.
- 7.2 The site is located on the southern side of the Afan Valley, south of Cymmer, north of Caerau, and west of Croeserw, in South Wales. It is centred on an approximate NGR of 285523 195668 and covers an area of approximately 130 hectares (ha).
- 7.3 The proposed Afan Valley Adventure Resort will comprise a hotel and car park, swimming pool, spa, indoor sports facility, back of house/staff accommodation area including an underground cold store, restaurant at the summit, activity hub, a spread of lodge accommodation, a main access road crossing approximately east to west, mountain bike trails, associated landscaping and minor access roads.
- 7.4 Generally, the site slopes from a maximum of 347m AOD in the south towards the River Afan immediately north/northwest of the site at approximately 170m AOD. The topography is generally undulating with some locally steep slopes in the lower parts in particular.
- 7.5 The site is generally undeveloped, comprising the remnants of coniferous forestry, with some stumps, brush and areas of open grassland. An area of forestry remains in the northeast to central extent. A mast and associated infrastructure is located on the ridge of Foel Fawr and a covered reservoir is present in the southeast part of the site. Two small ponds are present in the southeast part of the site, surrounded by boggy marshy ground.
- 7.6 Cymmer Tunnel generally trends north-south below the central part of the site. While it is indicated to be a few metres bgl on the northern boundary, it is at significant depth across the majority of the site, reaching approximately 145m bgl at the southern boundary.
- 7.7 The published 1:10,560 scale geological mapping for the area show the site to be underlain by the Pennant Measures from the South Wales Upper Coal Measures Formation generally comprising Pennant sandstone with thin mudstone/siltstone and seatearth interbeds and mostly thin coal seams. A number of seams outcrop on and underlie the site at shallow depth;
- 7.8 The general regional bedding is recorded to dip by about 10 to 12° towards the north/northwest.
- 7.9 Two landslides are mapped within the site boundary, with a further one mapped immediately north of the east end of the northern site boundary.
- 7.10 The Pen-y-Castell Fault crosses the western part of the site with a downthrow to the west by approximately 160 to 180m. A further north-south trending normal fault cross the site in the east, downthrown to the east by approximately 2.5 to 8.5m. A shorter parallel fault crosses into the south site boundary.
- 7.11 Records obtained from the Coal Authority show coal mining workings to underlie the site, comprising shallow pillar and stall workings associated with the Glyncymmer Colliery (east of Pen-y-Castell Fault) and longwall mining associated with the Duffryn Rhondda Colliery (west of Pen-y-Castell Fault). Four recorded mine entries (one adit and three shafts) are recorded within the site boundary. There was also considered to be a risk of unrecorded workings and mine entries.

- 7.12 Intrusive works have generally confirmed the ground model, with coal seams generally encountered within the depths indicated by the published records. Additionally, evidence of workings was encountered, both within the area of recorded workings, but also in areas with no workings recorded.
- 7.13 InSAR data shows up to 30mm of vertical ground motion (subsidence) in the west part of the site, approximately correlating with the recorded extent of the longwall mining. This is considered to potentially represent subsidence associated with the groundwater rebound within the workings in the Duffryn Rhondda Colliery.
- 7.14 Additionally, there is the potential for the risks associated with the historical mining legacy to interact with the other ground hazards identified at the site, such as the landslides and mapped faults.
- 7.15 An outline mitigation strategy has been proposed, including the following elements:
- 7.16 The layout and buildings strategy of the proposed development has been set out to accommodate our current understanding of the ground hazards present at the site. This includes the following:
- Up 30m-diameter exclusion zones at the mapped locations of the recorded mine entries which will be revisited after further investigation. Once located, mine entries will be secured, capped and possibly treated subject to their condition and intended land use in that locality. No construction will be permitted within the influence zone;
 - Grouting and/or excavation of all encountered mineworkings below intended structures within 15m of the surface where structures are proposed;
 - Avoidance of development within the area of the longwall mining and landslides where possible;
 - Development within the area of peat, fissures and the identified fault zone areas and associated buffers is not permitted;
 - If necessary, use of raft foundations, jacking points, flexible service connections within the High Risk Subsidence Zones and area of historical longwall mining;
 - Use of suitable lining in the proposed attenuation ponds; and
 - Use of reinforced road construction, including geotextile, when crossing fissures, landslides and fault zones.
- 7.17 A drawing showing the above referenced ground related hazards and constraints to development is presented on a drawing named Site Constraints Plan 2022, Drawing Reference 0332310590/3501/001 (Rev:2) presented in **Appendix C**. The drawing was used to inform the masterplan for the proposed development of the Wildfox Resort, Afan Valley as presented by Powell Dobson Architects in **Appendix A**.
- 7.18 A mitigation plan was issued by Stantec to inform the proposed development of the site as part of the proposed Afan (drawing ref: 0332310590/3501/002, (Rev: 3) dated 2022.08.03) and is presented in **Appendix D**. The plan is presenting the mitigation measures required for the development of the site in relation to the above reference ground related hazards.
- 7.19 Further site investigation is proposed, to inform detailed design and mining related assessments, along with associated mitigation and remediation. The proposed works include rotary cored boreholes across the site, including in areas of suspected shallow mineworkings, installation of gas and groundwater monitoring wells, use of televiwer, trial pits, trial trenches, geophysical surveys, an investigation targeted at finding the recorded mine entries and a structural inspection of Cymmer Tunnel.

7.20 This strategy will be refined following completion of the supplementary ground investigations.

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This report has been prepared within an agreed timeframe and to an agreed budget that will necessarily apply some constraints on its content and usage. The remarks below are presented to assist the reader in understanding the context of this report and any general limitations or constraints. If there are any specific limitations and constraints, they are described in the report text.

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Some of the conclusions in this report may be based on third party data. No guarantee can be given for the accuracy or completeness of any of the third-party data used. Historical maps and aerial photographs provide a “snap-shot” in time about conditions or activities at the site and cannot be relied upon as indicators of any events or activities that may have taken place at other times.

The conclusions and recommendations made in this report and the opinions expressed are based on the information reviewed and/or the ground conditions encountered in exploratory holes and the results of any field or laboratory testing undertaken. There may be ground conditions at the site that have not been disclosed by the information reviewed or by the investigative work undertaken. Such undisclosed conditions cannot be considered in any analysis and reporting.

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The interpretation carried out in this report is based on scientific and engineering appraisal carried out by suitably experienced and qualified technical consultants based on the scope of our engagement. We have not considered the perceptions of, for example, banks, insurers, other funders, lay people, etc., unless the report has been prepared specifically for that purpose. Advice from other specialists may be required such as the legal, planning and architecture professions, whether specifically recommended in our report or not.

Public or legal consultations or enquiries, or consultation with any Regulatory Bodies (such as the Environment Agency, Natural England or Local Authority) have taken place only as part of this work where specifically stated

FIGURE 1 SITE LOCATION PLAN

APPENDIX A

CONCEPT MASTERPLAN, DRAWING NO. 21055 (05) 104 (POWELL DOBSON ARCHITECTS)

APPENDIX B

GEOLOGICAL SETTINGS (ESP, 2022)

APPENDIX C

SITE CONSTRAINTS PLAN 2022, DRAWING 0332310590/3501/001 (REV:2) (STANTEC, 2022)

APPENDIX D

PRELIMINARY SITE CONSTRAINTS MITIGATION PLAN, DRAWING 0332310590/3501/002, (REV: 3) (STANTEC, 2022)

APPENDIX E

CONSULTATION WITH THE COAL AUTHORITY



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