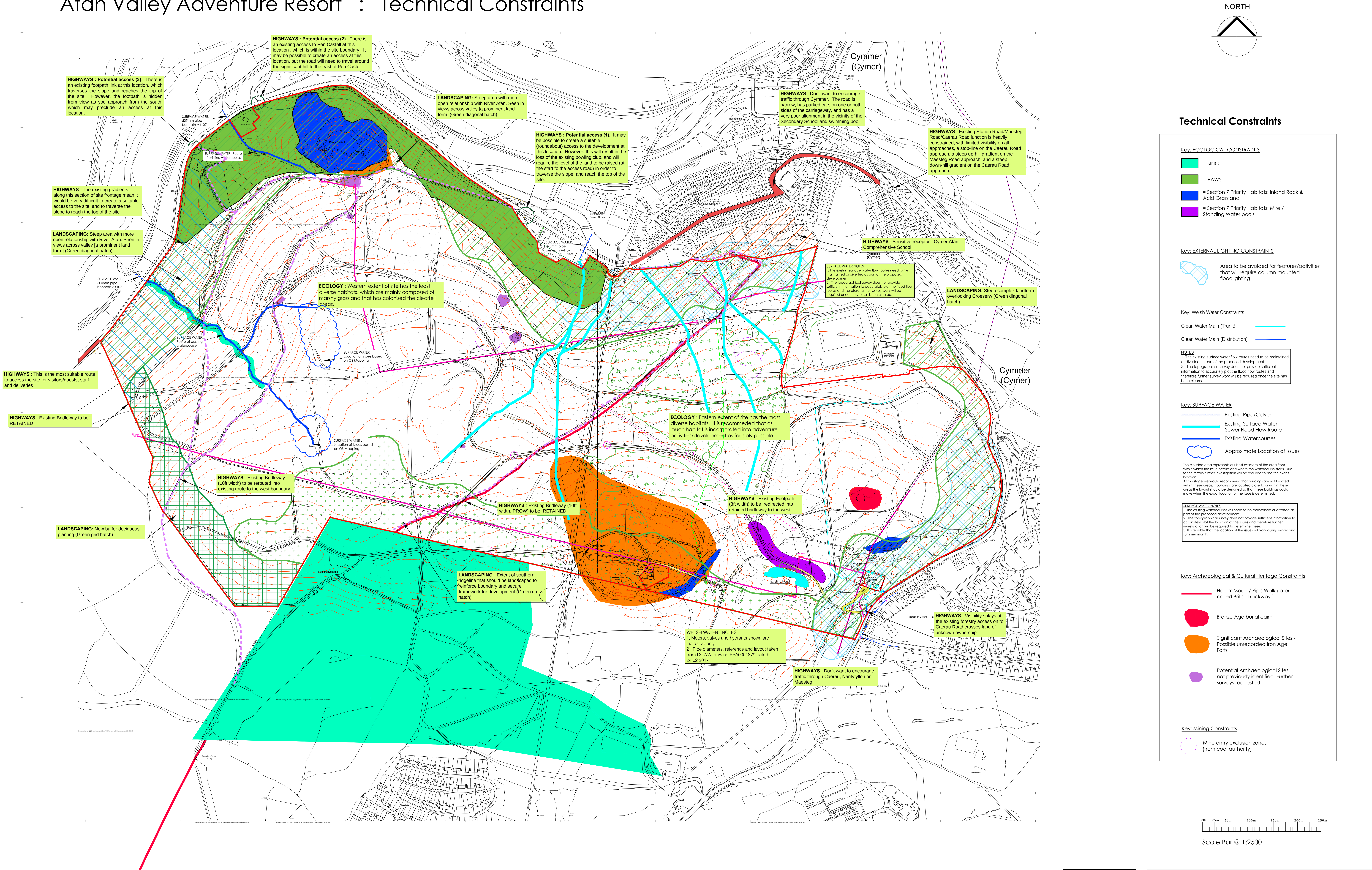


Afan Valley Adventure Resort : Technical Constraints



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Appendix C

[Dropbox Link](#)

The above link contains the following information:

- AECOM Limited (2017) Coal Mining Assessment Report (no reference).
- AECOM Limited (2017) Initial Peat Survey (no reference).
- Breakwell Sumner Partnership Limited (2017) Geo-Environmental Phase I Desk Study (Ref. 16255).
- Landmark Information Group Limited (2017) Envirocheck® Reoirt (Ref, 110795354_1_1).
- Terra Firma (Wales) Limited (2017) Afan Valley Development – Landslip Potential (Ref. GCL/14536/Let1).
- AECOM Limited (2018) Summary of Findings in Relation to Peat Survey (no reference).
Containing:
 - Terra Firma (Wales) Limited (2018) – Preliminary Findings, Peat Survey (Ref. DE/14510/Let2).

Afan Valley

Coal Mining Assessment Report

Afan Valley Ltd

December 2017

Quality information

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Figure 2. Geological Plan (Solid and Drift)

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Figure 5. Geological Cross Section E-W (Line 2)

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Figure 7. Coal Mining Remediation Plan

1. Introduction

1.1 General

AECOM, in partnership with Powell Dobson Architects working on behalf of Afan Valley Ltd, have developed feasibility options for a potential new tourism related development, named 'Cearau Parc'. The current preferred option for the proposed development comprises holiday lodges, public open space and infrastructure associated with outdoor leisure activities.

AECOM has been commissioned to prepare a Coal Mining Risk Assessment Report (CMRA) for the proposed development, in order to provide the Local Planning Authority and all stakeholders with information relating to the legacy of coal mining in the area and to provide an assessment of its potential impact on land stability, for the proposed end use.

This report does not discuss the general geotechnical constraints to the development proposals, as these issues fall outside the current remit. However it should be noted that a number of them are significant and will require due consideration. Of particular note is the potential, given the site topography, is landslip potential arising from coal mine subsidence. It is understood that this issue has been dealt with by others.

1.2 Site Location

The site is located on the southern side of the Afan Valley, south and southeast of Cymmer, Port Talbot, South Wales. The site is located centred on approximate Ordnance Survey National Grid Reference 285060E 195510N and covers an area of approximately 130Ha. A Site Location Plan is shown on Figure 1.

1.3 Site description

The site comprises undulating high ground rising to a maximum height of 1139ft (347m) (at the location of a trig point and antenna) close to the southern site boundary. The northern and western areas of the site slope down steeply towards the River Afan, located approximately 200m lower than the highest point at the site. The eastern part of the site gently inclines towards Maesteg/Cymer Road (A4063) which runs immediately beyond the eastern site boundary.

The northern site boundary is marked by the A4107 (Brytwn Road), while, a built development at Cymmer marks the north-eastern boundary. The southern site boundary is a continuation of woodland and undulating scrubland before encountering the village of Caerau. Similar to the southern site boundary, the western site boundary is a continuation of grassland/scrubland. An abandoned railway tunnel is present beneath the site, orientated north-south, and extends beneath the central region of the site.

No site inspection has been undertaken as part of this commission.

1.4 Proposed Development

It is proposed to develop the site into the 'Afan Valley Adventure Resort/Cearau Parc', as displayed in Appendix E. The proposed development consists of a central leisure complex (Plaza), numerous accommodation areas – understood to be of a typical 'holiday cabin/chalet/lightweight construction, a car park, a forest and alpine area. Numerous roadways throughout the development are proposed including a main site spine road, which would run from the primary site entrance in the west of the site off the A4107 via a winding route to the secondary site entrance off the A4063 at the eastern extremity of the site.

1.5 Scope of the Coal Mining Risk Assessment

The purpose of this Coal Mining Risk Assessment Report is to:

- Present a desk based-review of information on the coal mining issues which are relevant to the Site;
- Use that information to identify and assess the risks to the proposed development from coal mining legacy, including the cumulative impact of issues;

- Set out appropriate mitigation measures to address the coal mining legacy issues affecting the Site, including any necessary remedial works and/or demonstrate how coal mining issues have influenced the proposed development; and
- Demonstrate to the Local Planning 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.

2. Sources of Information Used to Inform the Report

The following sources have been used to obtain information regarding the natural occurrence and historical working of coal- in the area and any treatment of mine workings/entries at the Site:

- AECOM
 - o Bing Maps was used as a source of aerial imagery (<https://www.bing.com/maps>);
 - o AECOM Webs;
- British Geological Survey (BGS)
 - o 1:50,000 Series Sheet 148, Pontypridd (bedrock edition, 1975);
 - o 1:10,560 Series Sheet XVII SW, (1914, with additions in 1948);
 - o British Geological Survey Website – Geology of Britain Viewer, <http://mapapps.bgs.ac.uk/geologyofbritain/home.html>. Accessed on 29th August 2017;
 - o BGS exploratory hole record(s): SS89NE4, SS89NW35, SS89SE13, sourced from BGS website – GeoIndex online on 29th August 2017 (Appendix A).
- Coal Authority (CA)
 - o Non-Residential Mining Report, Site at Brytwn Road, Cymmer. 27th January 2017, CA ref. 51001347705001, (Appendix B);
 - o Mine Abandonment Plans supplied by the Coal Authority (Appendix C);
 - o Coal Authority website, Publications and Information Interactive Map Viewer, <http://coal.decc.gov.uk/en/coal/cms/publications/data/map/map>. Accessed on 31/08/2017.
- Ordnance Survey Historical Mapping
 - o 1:10,560 and 1:10,000 historical maps (dated between 1884 and 2016) and 1:10,000 aerial photographs (dated between 1945 and 1949). Included in this report as Appendix D.

3. Identification and assessment of site specific risks

3.1 General

The information collated from information sources outlined in Section 2 is discussed in detail to assess the potential coal mining risks for the proposed development of the site. Risks identified are summarised at the end of this Section, in Section 3.5.

3.2 British Geological Survey

3.2.1 Geological Information from Published Information and Maps

The published 1:50,000 scale geological maps of the area produced by the BGS, Sheet 148 Pontypridd, Bedrock Edition (1975) and County Series Sheet XVII SW (1914) indicate that the site is underlain by the geological succession presented in Table 3.2-1. An overlay of the anticipated site geology is presented as Figure 2.

Table 3.2-1. Geological Succession from Published Geological Mapping.

Age	Geological Stratum	Typical Description
Recent	Landslip	landslide deposits
Quaternary	Glacial Till	Glacially-derived gravelly clay with frequent cobbles.
	Glaciofluvial deposits	Glacially-derived unconsolidated sands and gravel deposits.
Carboniferous	Rhondda Member of the Upper Coal Measures	Green-grey Lithic Arenite with thin mudstone/siltstone and seatearth interbeds and, thin coal seams.

A summary of geological units present underlying the site, along with associated coal seams and geological structures is provided in Table 3.2-2. This table was formulated through synthesis of geological information provided on BGS County Series, 1:10,560 Geological Mapping, Coal Authority Mine Abandonment Plans (Figure 3) and BGS Borehole Logging. Table 3.2-2 should be viewed in combination with Figures 2 and 4 - 6, Geological Cross Sections and Geological Map.

It should be noted that the combination of topography, geological strata orientation and significant structural faulting results in significant variations of the distribution and depth of coal horizons across the site. This in itself leads to the requirement for more than one 'blanket' approach to discussion and treatment of the legacy coal mining beneath the site.

Table 3.2-2. Summary of Geological Units, Coal Seams and Geological Structures Underlying Site.

Geological Unit	Age (ascending age order)	Coal Seams (Descending depth bgl)	Faulting Present (E-W across site)
Glacial Till	Quaternary	N/A	
Glacio-fluvial Sands	Quaternary	N/A	
Rhondda Member, Upper Coal Measures	Carboniferous	Unnamed Coal Seam (A), Unnamed Coal Seam (B), No.2 Rhondda, Wernpistyll Rider, Wernpistyll, Unnamed Coal Seam (C), Tormynydd, Victoria, Albert, Yard, Two and a Half Foot, Caedafaid	Pancastell Fault, normal fault with 160m to 180m down-throw to the west. Numerous minor normal faults, down-throw to west with displacement magnitudes between 2.5m and 8.5m. A single normal fault is present, down-throwing 4m to the east, to the east of the development site. Information contained within Glyncymmer Colliery Mine Abandonment Plan and BGS County Series (Sheet XVII SW) Geological Mapping.

3.2.2 Geological Information from BGS Borehole Records

The British Geological Survey holds an online archive of readily available historical borehole logs throughout the UK. The database of borehole logs was searched for any records which would provide useful information on the ground profile at the Site. Four borehole logs, relating to historical mine shafts and workings, were utilised during the production of this Coal Mining Risk Assessment. These BGS Borehole Logs are summarised, showing minimum and maximum depth of strata layers, in Tables 3.2-3 to 3.2-6. It should be noted that BGS borehole information was not available for boreholes performed within the site boundary. As such, only BGS borehole information for boreholes located in the vicinity of the site are presented herein.

Table 3.2-3 Borehole Summary of BGS Borehole SS89NW35.

Borehole Location: Located approximately 350m west of the western site boundary. Borehole is Shaft No.1 Pit of Duffryn Rhondda Colliery. Approximate Borehole Elevation: 150m.

Depth, m bgl (min)	Depth, m bgl (max)	Rock Description
0.0	137.0	Rock and Clift
137.0	137.6	Field Vein Coal Seam
137.6	148.1	Coal Measures Formation
148.1	148.7	No.2 Rhondda Coal Seam
148.7	160.0	Coal Measures Formation
160.0	160.4	Unnamed Coal Seam (Wernpistyll Rider)
160.4	174.7	Coal Measures Formation
174.7	175.1	Wernpistyll
175.1	286.2	Coal Measures Formation
286.2	286.6	Tormynydd Coal Seam
286.6	369.4	Coal Measures Formation
369.4	369.8	Black Band Coal Seam

Table 3.2-4 Borehole Summary of BGS Borehole SS89NW10.

Borehole Location: Located approximately 350m west of the western site boundary. Borehole is Borehole No.1 of the Duffryn Rhondda Colliery.
Approximate Borehole Elevation: 230m.

Depth, m bgl (min)	Depth, m bgl (max)	Rock Description
0.0	12.0	Rock, Clift, Fireclay
12.0	12.5	Coal Seam (Unnamed Coal Seam)
12.5	12.8	Fireclay and Clift

Table 3.2-5 Borehole Summary of BGS Borehole SS89NW8.

Borehole Location: Located approximately 350m west of the western site boundary. Borehole is Borehole No.5 of the Duffryn Rhondda Colliery.
Approximate Borehole Elevation: 230m.

Depth, m bgl (min)	Depth, m bgl (max)	Rock Description
0.0	44.0	Clift (mudstone/silt)
44.0	44.7	Coal Seam
44.7	58.3	Clift (mudstone/silt)
58.3	58.4	Thin Coal Seam
58.4	112.8	Clift (mudstone/silt)
112.8	114.1	Coal and Partings (Unnamed Seam)
114.1	152.9	Clift (mudstone/silt)
152.9	153.1	Thin Coal Seam
153.1	166.0	Clift (mudstone/silt)

Table 3.2-6 Borehole Summary of BGS Borehole SS89NE22.

Borehole Location: Located approximately 350m west of the western site boundary. Borehole is described as 'performed in field near Croeserw Farm.
Approximate Borehole Elevation: 200m.

Depth, m bgl (min)	Depth, m bgl (max)	Rock Description
0.0	7.0	Gravel underlain by Hard Sandstone
7.0	7.5	Wernpistyll Rider Coal Seam
7.5	16.0	Grey flaky Sandstone
16.0	16.4	Wernpistyll Coal Seam
16.4	18.1	Grey Hard Sandstone

Table 3.2-7 contains a summary of the coal seams present, in order of increasing age, underlying the proposed development site. The depths provided here and on the accompanying geological cross sections provided in Figure 2 and 3 and BGS Borehole Records (Appendix A) should be considered indicative only until proven by intrusive ground investigation. For the coal seams that do not outcrop at the site, the depth to the top of coal seams is estimated from geological cross sections.

Table 3.2-7 Coal Seams present within Carboniferous Upper Coal Measures.

Seam Name	BGS Borehole Reference	Colliery Seam Worked at	Seam Thickness (m)	Minimum depth to Top of Seam at the site (m, BGL)
miUnnamed Coal Seam (A)	N/A	N/A	Unknown	Outcrops at site
Unnamed Coal Seam (B)	SS89NW10	N/A	1.3m (incl. partings)	40m
Field Vein (Field Seam)	SS89NW35	Duffryn Rhondda Colliery	0.6	Outcrops at site
No.2 Rhondda (Wernddu Seam)	SS89NE4, SS89NW35	Duffryn Rhondda Colliery & Glyncymmer Colliery	0.6 (SS89NE4), 1.1 (SS89NW35)	Outcrops at site
Wernpistyll Rider	SS89NE4, SS89NW8	Glyncymmer Colliery	0.5	Outcrops at site
Wernpistyll	SS89NW35	N/A	0.4	Outcrops at site
Unnamed Coal Seam (C)	SS89NE4	N/A	0.3	25m
Tormynydd	SS89NW35	N/A	0.4	45m
Victoria	SS89SE13, SS89NW35	N/A	0.7	170m
Albert	SS89SE13, SS89NW35	N/A	0.4	180m
Yard	SS89SE13, SS89NW35	N/A	0.6	195m
Two and a Half Foot	SS89SE13, SS89NW35	N/A	0.7	210m
Caedafaid	SS89NW35	N/A	0.3	260m

3.2.3 Assumptions

It should be noted that during the preparation of this report, variation was identified between the names of coal seams provided within BGS Geological records and Coal Authority Mine Abandonment Plans. For example, the names of coal seams, identified as outcropping within 1:10,560 Geological Mapping at the site, are believed to differ from those actually underlying the site, as identified within Coal Authority Mine Abandonment Plans. Table 3.2-8 below highlights the differences between sourced information and the developed ground model. It should be noted that it is not uncommon for coal seams to be given different names by many of the different organisations historically participating in coal mining activities.

Table 3.2-8 Variation in Coal Seam Names Identified within Geological Literature.

BGS County Series (1:10560 Scale)	Coal Seam based on Cross Sections and Coal Authority Mine Abandonment Plans.
Field Vein	No.2 Rhondda (to east of the site)
Unnamed Seam	Wernpistyll Rider (to east of site)
Thin Coal	Wernpistyll (to east of site)
No.1 Rhondda Rider	Field Vein within central region of site (outcrop to east of Pencastell fault);
	Unnamed Coal Seam (B) within western region of the site (west of Pencastell fault).
Unnamed Coal Seam	Unnamed Seam (A) (located to west of Pencastell Fault). Potentially Brithdir Coal Seam, although not confirmed.

3.3 Coal Authority

3.3.1 General

A site specific Coal Authority Mining Report has been obtained as part of the current commission and is included as Appendix B. The information contained within the Non-Residential CON29 Mining Report is summarised below and integrated with information obtained from the Coal Authority's Interactive Map Viewer.

The site-specific Coal Authority Non-Residential CON29 Mining Report (supplied by BSP Consulting) suggests that the site is affected by historic underground mining beneath the site at varying depth. Thirteen (13 No.) workable coal seams underlie the site, at depths ranging from surface outcrop to considerable depth (See Table 3.2-7 for seam depths).

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 and is not in an area the Coal Authority intends to grant a license 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 in within and surrounding the site. It should be noted that the Coal Authority do not provide comment regarding the relative depths spatial distribution of the seams beneath the site.

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.

Permissions for withdrawal of mine support were given in 1945 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. Coal Authority has not received a damage notice or claim since 31st October 1994.

The site specific CON29 report included reference to a number of mine entries present within, or within 20m of the site boundary and these are summarised in Table 3.3-1.

Table 3.3-1 Mine Entries and Treatment Details.

Mine Entry Reference	Details of Mine Entry Treatment
285195-004	Adit - Filled with stone and surface reinstated in 1977. No detailed treatment records have been sought from the Coal Authority regarding the volume of stone.
285195-007	Shaft - No treatment details.

285195-009	Shaft - No treatment details.
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285195-010	Shaft - No treatment details.
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The site lies outside the Cheshire Brine Compensation District.

3.3.2 Mine Abandonment Plans

A search of Coal Authority archives was undertaken by AECOM (September 2017) for mine abandonment records covering the site. Records of workings were identified and copies of these were purchased. These Mine Abandonment Plans are presented in Appendix C. A plan illustrating the composite extent of the former coal workings detailed in the Mine Abandonment Plans discussed below is presented on Figure 3.

The Coal Authority's Interactive Map Viewer records areas of past shallow coal mine workings and probable shallow coal mine workings. The Coal Authority states the past shallow workings dataset has been created by extracting all those underground workings, or parts thereof, whose depth is 30 metres or less from the surface. The probable workings dataset contains locations and estimated extents of probable shallow underground workings for which no recorded plan exists, but where it is likely that workable coal at shallow depths has been mined before records were kept.

Following the implementation of the 1842 Mine and Collieries Bill, the keeping of records of mining activities was required by law while it only became mandatory to deposit or register accurate plans of workings with the regulatory authorities after the 1872 Coal Mines Regulation Act. The accuracy of the surveying of the earlier plans (certainly those pre-dating 1887, when a later version of the Coal Mines Regulation Act was released) was often crude due to the methods employed to undertake the work and so may not reflect the actual position of the workings. These errors can be compounded when attempting to match these plans to the existing/current topography. Any interpretation of a coal mining records search must be carried out with these limitations in mind.

In addition, due to the rudimentary surveying methods most likely used (when compared to modern digital techniques) the accuracy of mapped historical workings may result in a discrepancy with their actual locations.

3.3.2.1 Catalogue No.: SWR3776 Duffryn Rhondda/Unnamed Adits & Fan House

This plan was produced in 1925 and shows the extent and structure of the Duffryn Rhondda Colliery, predominantly located to the west of the development site.

This Colliery extracted the Field Vein and Wernddu (believed to be Rhondda No.2) Seams and had both a drift mined region, accessed via an adit, and a deep underground mined region, accessed via two shafts. These shafts are named West Pit and East Pit on the Mine Abandonment Plan but are called No.1 Shaft and No.2 Shaft (not within influencing distance of the site) on SWA778. These two shafts are not present within the site area and are located approximately 350m west of the site boundary. The mined regions extended approximately south to north (longwalls orientated east-west), with chambers gradually gaining in depth in a northward direction.

Estimates of longwall mined chamber depth below ground level show that their approximate minimum depth, relative to modern ground level, is approximately 150m. The estimation of longwall mined chamber depth below ground level was determined based on seam depths, recorded on Mine Abandonment Plans provided by Coal Authority, and elevation from OS Mapping.

3.3.2.2 Catalogue No.: 9475 Glyncymmer Colliery

This colliery exploited two areas, one to the east of the River Corrwq and one to the south of the River Afan. The latter underlying much of the proposed development site. Glyncymmer Colliery worked two main coal seams, the No.2 Rhondda Seam and the Wernpistyll Rider. According to Mine Abandonment Plans, the former was mined at approximate depths ranging between 35m bgl and 122m bgl. The latter was mined at approximate depths between 32m bgl and 84m bgl. The No.2 Rhondda seam is stratigraphically above the Wernpistyll Rider. Mine entries 285195-004 refers to the Glyncymmer Colliery Adit Mine Entrance.

3.3.2.3 Catalogue No.: SWA778 Duffryn Rhondda/Drift/Drainage Adit

This plan is more recent, reproduction of the original Mine Abandonment Plan published in 1966, and is a detailed section of the Duffryn Rhondda Colliery. The plan shows the same mine structure as Plan SWR3776 but

also includes hydrogeological information such as limit of water and pump flow rates throughout the mine. At the sump of the two shafts (No.1 Shaft and No.2 Shaft described previously) 495,000 gallons per day was pumped out of the mine, while 289,000 gallons per day freely drained from the drift mine entrance.

3.3.2.4 Catalogue No.: 8205 Duffryn Rhondda No.2

This Mine Abandonment Plan is a re-scan of SWR3776 and is therefore a duplicate of the Duffryn Rhondda Colliery plan.

3.4 Ordnance Survey Historic Maps

A review of historical Ordnance Survey mapping, was performed and a site history is summarised in Table 3.4.1. Historical maps are presented in Appendix D. A review of the history of the Site and adjacent area has been undertaken using historical maps dated between 1886 and 1992. The maps were obtained as part of an Envirocheck report from the Landmark Information Group that was supplied to AECOM as part of the Caerau Parc, Afan Valley, South Wales Phase 1 Desk Study Report produced by BSP Consulting.

Table 3.4-1 Summary of Ordnance Survey Historical Mapping Review.

Year (Scale)	Features On-site	Features Off-site
1884 (1:10560)	No coal mining related features present. For details of general historical development see Caerau Parc, Afan Valley, South Wales, Phase 1 Desk Study Report.	
1900 (1:10560)	"Air Shaft" is shown on approximate northern site boundary on 1899 OS mapping. This is believed to be the adit mine entrance to Glyncymmer Colliery.	Glyncymmer Colliery and Duffryn Rhondda Colliery and associated Brick Works are present to the north and west of the site.
1921 (1:10560)		Glyncymmer Colliery and Duffryn Rhondda Colliery are extended.
No coal mining related changes identified in historical mapping between 1938-1951 (1:10,560) and 1975 (1:10,000). Railway tunnel is labelled as disused.		
1982-1988 (1:10000)		Collieries and associated structures and industrial practices to the north and west of the site are no longer identified. This infrastructure has been demolished and removed.
No coal mining related changes identified in historical mapping between 1990 (1:10,560) and 2016 (1:10,000).		

3.5 Potential Risk Summary

Table 3.5.1 below summarises the potential risks associated with coal mining legacy for the proposed development Site, identified from the sources of information listed in Section 2.

Table 3.5-1. Summary of Potential Coal Mining Legacy Risks.

Coal Mining Issue	Yes	No	Comments
Underground coal mining (recorded at shallow depths)	✓		Detailed discussion and assessment provided.
Underground coal mining (probable at shallow depths)	✓		Detailed discussion and assessment provided.
Mine entries (shafts and adits)	✓		Detailed discussion and assessment provided.
Coal mining geology (fissures)			None recorded/observed.
Record of past mine gas emissions or potential			None recorded/observed.
Recorded coal mining surface hazard			None recorded/observed.
Surface mining (opencast workings)			None recorded/observed.

3.5.1 Underground Coal Mining

3.5.1.1 General

Due to the complexity in the ground model at the site arising from the variation in topography and geology; cross sections (Figures 4 - 6) have been prepared in both east/west and north/south orientations to assist with explanation of the salient points. To further assist with assessment the site has been divided into 3 zones (A,B,C) west to east with the divisions being controlled by the presence of the two major faults and the overall regional geological structure..

The extent of shallow underground coal mine workings are shown in Figure 3. Shallow underground mining is shown to have occurred beneath the site at both the Duffryn Rhondda Colliery and Glyncymmer Colliery. The shallowest mining depth within the Glyncymmer Colliery according to cross sections is estimated to be 20m within the central region of the site, where the No.2 Rhondda and Wernpistyll Rider seams were extracted.

Coal Authority supplied Mine Abandonment Plan No.9475, Glyncymmer Colliery (Figure 6) shows that the Wernpistyll Rider Seam and No.2 Rhondda were exploited at relatively shallow depth, of between 32m bgl and 84m bgl (converted from feet and inches) across the site. Similarly, Mine Abandonment Plan No.8205, Duffryn Rhondda Colliery, shows that Field Seam and Wernddu (believed to also be known as No.2 Rhondda) were extracted in the western region of the site.

Workings from the 19th century generally take the form of pillar and stall whereby a seam was partially extracted leaving supporting pillars. Partial or complete collapse resulting from pillar or roof failure may subsequently occur and can lead to upward crown hole and void migration. This can ultimately lead to ground subsidence and is therefore considered to be the principle risk associated with such workings.

The thickness and competence of worked and overlying strata will therefore govern the assessment of void migration and any such assessment is therefore qualitative.

The retention of pillars of unworked coal influences the subsequent collapse of the mine, and later extraction by 'pillar robbing' (removing additional coal from pillars as a mine was abandoned - essentially destabilising the support) which was often practised complicates this. The degradation of old workings, resulting in surface movement, is usually the result of a breakdown of the roof strata between coal pillars, occasionally due to pillar failure, or the 'punching' of the pillars into the roof or floor strata (Ref 4).

Based on industry guidance in relatively level strata if workings exist at more than 30m or ten times the thickness of extraction, if greater, below rockhead it may be assumed that subsidence from old workings is unlikely. This is taken as general guidance relating to the height voids/broken ground may migrate upwards above the worked areas. Given the potential for a number of levels of workings this may complicate the issue at this particular Site.

The potential for void migration and settlement are both also heavily influenced by the tensile strength of the rock between the void and ground surface – for example, a succession of strong sandstone above a mine void will isolate the void much more effectively than weak Mudstone.

3.5.1.2 Discussion

Figure 4 shows a north south section through the site showing the regional dip of the geology to the north. When combined with the evidence gained from the Coal Authority abandonment plans it can be noted that the workings in the No 2 Rhondda and the Wernpistyll Rider are present in the central section of the site (Zone B) at a relatively shallow (approximately within 30m of ground level) depth.

Two further seams are shown to be within influencing distance of the ground level within the site boundary in Zone B – unnamed seam (C) and Tormynydd. No records exist to suggest these were worked, however their proximity to the surface and potential exposure at the surface should be considered as a possible indicator of unrecorded surface winning or more developed workings.

Figure 5 also shows that the known workings in the No. 2 Rhondda and seam are present at shallow levels in Zone B. The Field Vein is present at a shallow level but no abandonment records exist to suggest this is worked; however, given that this seam is known to have been worked locally the possibility of workings cannot be discounted..

The workings in the No 2 Rhondda and Field Vein are considered sufficiently deep to not pose a risk to the development to the west of the western fault – where the downthrow of the fault has taken the worked levels to a depth of approximately >150m below the lowest site level in this area.

The unnamed seam (A) is present at shallow level to the east of western fault at <30m depth. Again the possibility of workings in this seam cannot be discounted at this point. Furthermore a second unnamed seam (B) is present at <100m below ground level in this area. The interbedded nature of the rock in the area is such that a likely competent roof rock exists between seams (A) and (B) thus preventing upward migration of voids if the (B) seam is worked. This would require further refinement of the ground model to prove.

In addition whilst the extent of known workings beneath the site is shown on the abandonment plans it should be noted that the true actual extent of workings may be substantially in excess of those shown. Anecdotal evidence suggests that mining abandonment plans can underestimate the extent of working in a mine by up to 30%. This variation arose from variations in surveyed and true worked volumes.

The existence of shallow recorded past mine workings present a high risk to the proposed development overlying areas of past shallow mining. The potential presence of mining-related voids and galleries at shallow depth could adversely affect the stability of proposed structures, in particular, settlement due to the collapse of voids and galleries, or punch-through of pillars within historic pillar and stall workings into the underlying fireclay/seatearth layers.

In conclusion there are a number of known worked seams beneath the site and in addition there are several shallow and dominant coal seams across the site that, are not reported to have been historically worked at the site. Field Vein, located in the central region of the site, is highly likely to have been historically worked.

After analysis of BGS borehole data it is apparent that there may be other, less economically or spatially significant coal seams that exist at the site but whose existence is not recorded in BGS geological mapping. These unknown seams may historically have been worked and their extents not recorded.

The impact of historic coal mining related hazards on the proposed development was analysed and a mitigation strategy summarised in Figure 7, the Coal Mining Remediation Plan. The Coal Mining Risk Remediation Plan highlights the risk mitigation measures recommended to be implemented across the site. In addition table 3.5.1.1.1 summarises the anticipated worked seams beneath the site.

Table 3.5.1.1.1 summary of working as per zoned areas.

Zone	Seams Present	Within distance ground	Influencing Worked in the zone (Y/N) of (Y/Unknown)
A	Unnamed Seam (A)	Y	Unknown
	Unnamed Seam (A)	Y (in south west of site)	Unknown
	Field Vein,	N	Y
	No.2 Rhondda/ Wernddu	N	Y
	Wernpistyll Rider	N	Unknown
	Wernpistyll	N	Unknown
	Tormynydd	N	Unknown
B	Field Vein,	Y	Unknown – assumed likely given the proximity to ground level at the south of the site.
	No.2 Rhondda/ Wernddu	Y	Y
	Wernpistyll Rider	Y	N
	Wernpistyll	Y	N
	Unnamed Seam (C) It should be noted that there is some confusion regarding the nomenclature of this seam.	N	Unknown
	Tormynydd	N	N
	Victoria	N	N
	Albert	N	N
	Yard	N	N
	Two and a half foot	N	N
	Cadeleid	N	N
	No.2 Rhondda/ Wernddu	Y	N
C	Wernpistyll Rider	Y	N
	Wernpistyll	Y	N

3.5.2 Mine Entries

The Coal Authority records identify that four (4 No.) known mine entries are present within or within 20m of the site boundary and shown on Figures 3 - 7 and summarised in Table 3.5.2.2-1.

The nature of ground instability that may result from a mine shaft feature ranges widely. Sudden catastrophic collapse of the ground can result where the shaft is significantly voided allowing material to fall inward. In contrast where a shaft is filled but this undergoes consolidation a more subdued depression at the surface can become apparent.

3.5.2.1 Adit

Notably the entrance referenced 285195-004 is an adit. This appears to have likely been driven into the hillside at a slight upwards inclination. In doing so works could progress 'up dip' into the coal strata and any groundwater encountered would have naturally drained down through the workings out of the adit into the river. In this manner the workings would have remained 'drained' without any need for active pumping or drainage measures.

In addition the adit would likely have been supported through the installation of timber beams or props. Recent (with the last 10 years) AECOM's experience of similar methods of support elsewhere in the UK coal field has shown that these props can remain sound for many decades if not centuries given the correct conditions, conversely they can fail suddenly leading to suddenly collapse at the surface.

The details of any treatment of these recorded mine entries is only known for 285195-004, located in the central, north area of the site. This is the reported adit and information held by the Coal Authority suggests this was infilled with stone. No indication of the length of the adit treated have been located during the preparation of this report. It should be noted that given the age of the treatment it is unlikely that this work would be considered sufficient or current with modern practices unless additional treatment information could be provided/located. Therefore this adit should be considered untreated at this point. It is concluded full treatment has not been undertaken to a suitable standard to support surface development.

3.5.2.2 Mine Shafts

The three 3 No. shafts which are likely to have been sunk as vertical (or very close to) lined and potentially partially unlined 1.5-2m diameter features taken to a depth in excess of the 'worked' level to allow for the construction of a sump at the base.

No information was provided by Coal Authority regarding the treatment of the other three mine entries. As the condition of mine entries 285195-007, 285195-009 and 285195-010 is unknown, there is the potential for ground instability in the vicinity of these mine entries. It is likely that the shafts would have been poorly backfilled following closure of the mines and experience suggests that whatever mining detritus was present in the vicinity of the shaft may have been used to choke off the throat of the shaft – including the pit head any staging spoil etc.

Consequently until proven otherwise it should be assumed that the shafts are not completely backfilled and any disturbance to the 'plug' of material neat the surface could lead to catastrophic collapse resulting in a significant loss of material at the surface into the shaft.

This risk could manifest during construction, or after completion of the construction phase. A summary of the risks associated with mine entries is provided in Table 4.1-1.

It is understood that in previous discussions with the Coal Authority a 30m exclusion zone has been suggested as a zone of no development in the vicinity of the shafts, and it is understood that this has currently been adopted for the purposes of planning.

Table 3.5.2.2-1. Summary of Risks Associated with Mine Entries.

Coal Authority Mine Entry Reference (see Mine Abandonment Plan 8475, Figure 6)	Information Coal Authority Mine Abandonment Plan	Associated Risk
285195-004	Adit entry for Glyncymmer Colliery. Located at ~190m elevation. Stated as 'mouth of level at Glyncymmer Colliery'.	This is a mine entry was reportedly infilled with stone and reinstated in 1977. A risk of settlement due to collapse of the adit exists. Following review of the Site Layout Plan (Appendix E) this mine entry will have minimal interaction with proposed structures at the development.
285195-007	Not present on the Glyncymmer Colliery Mine Abandonment Plan 9475.	This mine entry is likely associated with shallow extraction of Field Vein coal seam and is likely to pre-date the large-scale, industrial extraction at Glyncymmer Colliery. Due to this, the entry is likely to be reasonably shallow and is likely to be infilled with non-engineered fill. The principal risk associated with this mine entry is failure of existing mine treatment and resulting mine entry collapse. The likelihood of collapse is unknown due to the unidentified condition of the shaft sealing/capping treatment when decommissioned. Shaft sealing/capping is likely to have not been performed in line with engineering design standards. Following review of the Site Layout Plan (Appendix E) this mine entry is located in close proximity the route of the proposed roadway at the development.
285195-009	Not present on the Glyncymmer Colliery Mine Abandonment Plan 9475.	These are likely to be associated with shallow extraction of No.2 Rhondda and are likely to pre-date the large-scale, industrial extraction at Glyncymmer Colliery. Due to this, the entry is likely to be reasonably shallow and is likely to be infilled with non-engineered fill.
285195-010	Not present on the Glyncymmer Colliery Mine Abandonment Plan 9475.	The principal risk associated with these mine entries is failure of mine treatment and resulting collapse. The likelihood of collapse is unknown due to the unidentified condition of the shaft sealing/capping treatment when decommissioned. Shaft sealing/capping is likely to have not been performed in line with engineering design standards. Following review of the Site Layout Plan (Appendix E) these mine entries are located in close proximity to proposed chalet positions at the development.

3.5.3 Abandoned Cymmer Railway Tunnel

The former Cymmer railway tunnel that ran north to south within the central region of the site was abandoned in 1970. The tunnel is of stone construction except for a brick insert at the crown of the arch. Due to the depth of the considerable tunnel beneath the Afan site, the tunnel is not believed to have ventilation shafts. However, as the as built drawings for the tunnel have not been consulted there exists a risk of hidden shafts associated with the tunnel across the site.

Although historical OS mapping states that an 'air shaft' is present to the north of the site, this is believed to be the Glyncymmer Colliery adit entrance.

3.5.4 Coal Mining-induced Instability

According to BGS Geological Mapping, there exist at least two landslides at the site. After review of freely available, proprietary aerial photography, these are believed to be examples coal mining-induced slope instability (i.e. failure arising from collapse or void migration at depth triggering slope stability). A large landslide is present at the crest of the hillslope, where the antenna is located (to south of site). This instability feature shows considerable vertical but only a small amount of lateral displacement. The instability is likely associated with coal seam exploitation at the Glyncymmer Colliery.

4. Mitigation Strategy Proposed

4.1 Influence of Mining Risks to Proposed Development

Currently the depth and lateral extent of historical workings and the proximity of workable coal bearing strata close to the surface of the site have not influenced the layout of the proposed development. The exception to this is the noted exclusion zone around potential suspected mineshaft locations.

Numerous coal mining related hazards were identified during this investigation. Identified coal mining hazards are summarised within this section. Geological cross sections (3 No.) are present in Figures 4 and 6. These cross sections show the orientation and persistence of geological strata across the site.

When identifying and mitigating the risks associated with the proposed development at the site, the most up to date proposed development site layout plan (Appendix E) was consulted throughout. An assessment of risk mitigation measures was made by taking into account the nature of proposed nearby structures.

A significant area beneath the site may require remedial works and will require further investigation to further categorise the extent and method of remedial works required (Figure 7).

Due to the widespread distribution of known workings beneath the site and the localised nature of the proposed development it has not been possible to further refine the site layout at this time, in advance of ground investigation.

It is therefore paramount to appreciate, at this point, that the extent of any mitigation measures can, and must, be refined through discussion with the Coal Authority and following suitable ground investigation. Whilst a number of mitigation measures are proposed below; should the opportunity arise it would be possible through discussion with the Coal Authority to refine the layout of the site to minimise remedial costs.

4.2 Outline mitigation measures.

As noted the site end use will be a mixed development comprising holiday chalets with associated access roads, main access roads a central plaza area and various recreational areas including a ski slope and a cycling area. It is therefore considered that it may be possible (through discussions with the Coal Authority post planning and during any further development period) to apply a number of potential remedial measures to minimise development costs and program.

4.2.1 Geogrids

It is anticipated that geogrids could be used in areas of low risk and relatively light transient loading. This could include car parks and light use access roads across the site in areas identified as being potentially at risk from shallow mining or void migration.

The proposed geo-synthetic would comprise a tensile geo-grid material designed for the expected surface loading and able to span a pre-determined opening in the ground should ground instability occur. This form of mitigation does not prevent instability occurring but does reduce the consequences to an acceptable level. The site operator would be recommended to undertake a regular inspection of the proposed asset. Should instability be identified suitable remedial measures would be required.

Some form of anchoring of the geo-grid shall be incorporated along the edges of the car park and access road. This will ensure that the geo-grid is able to operate fully over the treated area. Anchoring could be achieved by attaching/wrapping the geo-synthetic to gabions or utilising an anchor trench. The geo-synthetic would be laid directly on the subgrade before filling commences. This shall be anchored prior to commencement of construction to provide risk mitigation during the works phase.

It is considered settlement that could result from collapse of deeper seams can be managed by resurfacing and flexible design of the proposed works.

4.2.2 Reinforced Rafts

The exact details of the construction of the proposed holiday chalets is currently unknown however it has been assumed that they will be of a single storey form and lightweight in construction. Rafts spread applied loads over a larger area reducing the bearing pressure to the ground and thus minimising the risk of subsidence. Such a

raft can also be designed to accommodate a loss of support beneath it. It may therefore be possible to utilise a reinforced concrete raft suitable to bridge any void or crown hole appearing at the surface.

The dimensions and level of reinforcement within such rafts cannot be confirmed at the current time.

4.2.3 Infilling of voids – drilling and grouting

For high load and high risk areas - including beneath any large permanent structures or high use roadways it will likely to undertake a blanket drilling and grouting program to a depth (assumed to be approximately 30m below competent rockhead). Drilling and grouting effectively removes the risk of surface settlement through the injection of a cement or resin based liquid grout into the ground to a depth below that identified as being potential worked/voided. This grout infills the void and whilst it provides little strength the action of infilling greatly reduces any risk.

This blanket program would comprise the drilling of rotary boreholes (cased to rockhead) on a staggered grid arrangement. The initial holes would be drilled on a spacing of approximately 4m with secondary and tertiary boreholes drilled as required once target (to be confirmed) volumes of grout injection are achieved.

Based on the existing conceptual site model it is likely that in Zone B this would involve drilling to the base of the Wempistyll seam and then to the south (subject to the confirmation of the absence or low levels of broken/migrated voids), to the base of the Tormyndd.

Due to the dip angles across the site it is anticipated that a close centred number of boreholes (typically 1.5m c-c) will be required to be drilled and infilled using a coarse granular mix to create a curtain cut off to prevent down dip migration of infill material.

The impact of grouting on the local groundwater table must be investigated and discussed further following ground investigation

Of particular note should be the potential for grout to entire the abandoned railway tunnel resulting in a loss of grout and, if uncontrolled, the infilling of the tunnel itself. In addition surcharging arising from the injection process itself could lead to tunnel damage and potentially failure. As previously stated the risk posed by the tunnel is not discussed as part of the current remit and further discussions should be entered into with the current tunnel owner prior to any intrusive works at the site.

4.3 Shaft remediation

It is understood that at the current time a standoff of 30m (diameter) has been applied to the Coal Authority Shaft positions as an exclusion zone. If this approach is maintained it is strongly recommend at the areas be suitably fenced off and highlighted as being a danger to life.

However based on the available BGS information it may be possible to reduce any standoff/exclusion on the following basis:

Assuming the shafts are 2m diameter, and that the margination of error for plotting is a conservative 10m (from centre position) and that the maximum thickness of superficial materials is 3m; and assuming any failure would result in a cone of depression at 45 degrees from rockhead the 30m could be reduced to 13m radius.

However it is strongly recommended that the shafts are searched for on a spiral grid pattern using rotary drilling techniques (with suitable H&S procedures in place) as per the recommendations of CIRIA SP32.

Once disturbed by investigation the liability for the safety of the shafts would sit with the developer. Therefore it is strongly recommended that plans are made in advance to undertake remedial treatment of the shafts immediately following location.

Treatment of the shafts will be dependent upon the conditions of the shafts. However it is likely to comprise either bulk infilling through end tipping and/or grouting to stabilise the shaft column followed by the construction of a reinforced concrete cap at rock head.

It should be noted that following any such treatment outlined above it is considered unlikely that any built structure or form would be allowed over the capped shaft; and it may be prudent to assume that the cap and any defined zone of influence would be exclude from developed to allow access in the event of future issues.

Although as a general rule it should be avoided, it may be possible therefore, to construct forest trails or similar paths in the vicinity of and over the capped shaft but this would require further consultation with the Coal Authority.

4.3.1 Soil strip/ discovery strategy.

As with any site with an extended history of coal mining there remains the possibility of unrecorded workings and mine entries across the site. Throughout any investigation and development phase it is strongly recommended that suitable qualified representation is in attendance full time to undertake a watching brief to identify and respond to any unknown features which may become apparent.

In areas where it may be possible to undertake wide scale soil strips, such as the location of the proposed ski slope this approach would be recommended.

4.3.2 Gas

Whilst not recorded at the site, the possibility of mine gases should not be ignored. During Any investigation works gas monitoring should be undertaken with suitable trigger levels confirmed in advance.

A risk assessment should be undertaken during the design of the ground investigation and this should be used to inform any pre-construction documentation. This should take note of the possibility that preferential pathways may not be intercepted during intrusive works. Following further investigation it may be a requirement to install gas membranes in any structures across the site.

4.3.3 Faults

The sites is bisected by two major geological faults, with the potential to exist for a number of smaller faults as highlighted in the abandonment plans.. There is a low risk of fault reactivation during any remedial works – notably during any form of injection grouting or potentially due to changes in the groundwater regime arising from any infilling works. Whilst the risk of fault reactivation is considered low; the landslips across the site may point to a history of such instability and so this this cannot be fully discounted.

Consequently construction should not be undertaken across the major north –south trending faults

5. Proposed Further Investigation

The proposed Afan Valley Adventure Resort development site is underlain by considerable historical coal mining infrastructure. A ground investigation should be undertaken that examines the following features across the site:

- The location and condition of recorded historical shallow mine workings, with particular focus on those associated with Glyncymmer Colliery and Duffryn Rhondda Colliery. This should be undertaken through a number of suitably positioned rotary/rotary cored boreholes across the site to a depth of no less than 30- 40 m;
- Potentially exploited coal seams associated with extraction at the Glyncymmer Colliery and Duffryn Rhondda Colliery;
- Potential locations and depths of unrecorded historical shallow mine workings, in light of the existence of coal seams outcropping within the site boundary;
- Depth and condition of known mine entries, including investigation of the Glyncymmer Colliery adit (285195-004), and;
- Existence of unrecorded mine entries across the site. However it is noted that this may form part of a later site development strategy.
- Detailed site inspection/geomorphological walkover to assess the impact of any surface features including mine entries and mining induced ground movement.

In addition, due to the unknown but thought to be poor condition of the railway tunnel and likely requirement for considerable coal mining risk mitigation works required in the vicinity of the tunnel, a tunnel stability inspection is recommended in advance of remediation works. Any grouting performed in the vicinity of the abandoned railway tunnel is likely to increase the loads imposed on the tunnel, and increase the tunnels rate of deterioration.

6. Conclusion

AECOM has been commissioned to prepare a Coal Mining Risk Assessment Report for the proposed development, named 'Cearau Park' for clients Afan Valley Ltd, in order to provide the Local Planning Authority with information on the legacy of coal mining and an assessment of its potential impact on land stability, for the proposed end use. It is proposed to develop the site into the Afan Valley Adventure Resort. The development consists of a central leisure complex (Plaza), numerous accommodation areas, a car park, a forest and alpine area as well as numerous roadways.

The site is located on the southern side of the Afan Valley, near Cymmer, Port Talbot, South Wales. The site is centred on approximate Ordnance Survey National Grid Reference 285060E 195510N and covers an area of approximately 130Ha. The site lies at an elevation of approximately 102m above Ordnance Datum (AOD).

The site comprises undulating high ground rising to a maximum height of 1139ft (347m) at the trig point close to the southern site boundary. Northern and western areas of the site slope down steeply towards the River Afan, located approximately 200m lower than the highest point at the site. The eastern part of the site gently inclines towards Maesteg/Cymer Road which runs immediately beyond the eastern site boundary.

After considerable investigation and analysis of both geological and coal mining related records, the following pertinent coal mining related features should be noted about the site:

- Underlying most of the site are numerous shallow coal mine workings, associated with Duffryn Rhondda and Gyncymmer Collieries. These collieries extracted coal from several seams, including, Rhondda No.2/ Wernddu, Wernpistyll Seam and Field Vein Coal Seams.
- Several coal seams outcrop within the site boundary, these are not shown to have been exploited historically, but there is considerable potential for these coal seams to have been mined on a small scale before it was mandatory to record mining activity.

This Report puts forward a strategy for addressing the coal mining legacy at the Site and how development on potentially unstable land could be addressed. The mining legacy of the Site presents risks to the foundations and long term structural stability of the various elements of the proposed development. However, the location of the proposed development elements has not currently been influenced by these – with the exception of the acknowledged standoff surrounding the noted historical mineshaft positions.

Based on a desk based review of information a number of legacy risks have been identified relating to mine workings and shafts. The Site is underlain by a significant mining legacy comprising shallow (<30m deep) and potentially deep coal workings in multiple seams.

Given the likely depth and thickness of workings in these seams, they are considered to pose a risk to the development. In particular the risk is elevated where known worked coal is present, over the majority of the site.

Additionally there are a large number of recorded shafts on Site. These have mainly been untreated although one is noted to have been. There is also a significant risk that unrecorded mine entries are present on the site. AECOM have assumed that given the age of the treatment works to the singular recorded adit it is not in accordance with current standards.

This mining legacy presents a significantly high risk of ground instability to warrant investigation and ultimately mitigation. The remedial measures required for the proposed development Site comprise the potential deployment of a number of remedial measures. This approach (through discussion with stakeholders) is considered to be the most economical and will result in the most proficient manner to develop the site.

Therefore the investigation of historical mine workings, mine entries and potentially worked shallow coal seams is recommended to be performed during the design phase of this project.

The result of the ground investigation should be used in conjunction with discussion with the Coal Authority to agree the election of suitable site wide mitigation measures.

Figures



Image reproduced under licence from Bing Maps.

Purpose For Information	Project Title Afan Valley Adventure Resort, Caerau Parc, Afan Valley, Wales	Figure Title Site Location Plan	Drawn AM	Checked CM	Approved DL	 FigureNo. 1
Client AFAN VALLEY LTD			Project No. 60552818	Date Sept 2017		