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APPENDIX 11.1

Geo-environmental assessment,
Phase 2 Development

Part 1 of 4

Pell Frischmann

excellence through innovation

Phase 2 Development Enivroparks, Hirwaun

Geo-environmental Assessment Report

RQ80023G001B

Submitted by Pell Frischmann

February 2017

REVISION RECORD **Report Ref:** \\EXE-FILE-01\ENGINEERING\DATA\PROJINFO\Q80023 ENVIROPARKS CONSTR\Q80023 HIRWAUN\4 INT DATA\TA\RQ8002G001B.DOCX					
Rev	**Description**	**Date**	**Originator**	**Checked**	**Approved**
A	Draft	Jan. 2017	APC		DS
B	Issue	Feb. 2017	APC	SW	SW

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1. INTRODUCTION

1.1 TERMS OF REFERENCE

A 8 ha parcel of land to the northwest of the town of Hirwaun is being developed as a sustainable waste resource recovery and energy production plant. The proposed development, which is located on the edge of the existing Hirwaun Industrial Estate, is being implemented in three phases. The area incorporating all three phases of the proposed development is hereafter referred to as the 'development area'.

Phase 1 of the development was not taken to completion as was originally intended. The Phase 2 development therefore encompasses the completion of the Phase 1 works as well as the addition of new Phase 2 infrastructure. This report relates to the Phase 2 development, which is hereafter referred to as 'the site'. The areal extent of the site is shown in Drawing ENV_EPT_GEN_DR_A_6011 P7 which is included as Appendix A to this report.

Pell Frischmann has been commissioned by Enviroparks (Wales) Limited to compile and issue an Environmental Statement (ES) Technical Appendix report which, as far is as is reasonably possible using the existing datasets of geochemical data, fulfils the function of a contemporary contaminated land assessment report for the proposed Phase 2 site at Enviroparks Hirwaun.

1.2 DATA SOURCES

Within the production of this report, the following data sources have been utilised:

- Phase 1 Environmental Desk Study, Hirwaun Ecopark, ERM Report, October 2007.
- Hirwaun Industrial Estate Development, Interpretative Report On Site investigation, Soil Mechanics, Report No. H8076, January 2009.
- Enviroparks, Hirwaun – Supplementary Geotechnical & Geo-Environmental Report G345 Enviropark_LR01 October 2013.

1.3 OBJECTIVES

Further to the conclusions of the 2007 desk study, and following the implementation of the two phases of ground investigation (2009 and 2013, as above), the objectives of this Geo-environmental Assessment Report are:

1. To present a geo-environmental review and summary of the ground and groundwater conditions which have been encountered,
2. To interpret the geochemical data arising from the ground investigation, including a quantitative risk assessment of potential contaminants,
3. To update the Conceptual Site Model for the site, and
4. To draw conclusions on 'suitability for use' of the site for the proposed development under the current planning regime.

2. BACKGROUND INFORMATION

2.1 SITE LOCATION AND DESCRIPTION

The site is located to the North-West of Hirwaun on the edge of Hirwaun Industrial Estate. The approximate centre of the site is located at OS GB National Grid Reference 293880E 206790N. The access to the site is gained from the east of the Sste, via. Ninth Avenue.

The Enviroparks Hirwaun development area previously comprised an area of approximately level ground that had been prepared as a development platform by regrading the ground surface. The full development area is approximately rectangular in shape and covers an area of approximately eight hectares. It is approximately 250 m to 300 m across, at its widest.

The development area boundary is defined by:

- a track at the lower edge of the Penderyn Reservoir embankment to the north;
- Ninth Avenue to the east;
- Fifth Avenue to the south; and
- an unnamed stream to the west.

The entrance to the development area was previously established from the southern boundary, from Fifth Avenue. However, during the Phase 1 development work the access was moved to the east of the site and is now made from Ninth Avenue.

The land surrounding the development area is used for the Penderyn Reservoir and farm fields to the north, farm fields and woodland to the west and by industrial units in the south and east.

The Phase 1 building (Fuel Preparation Hall) is now located in the southwestern portion of the overall development area. A concrete apron is located to the north of the building, which joins a concrete access road that runs from east to west across the middle of the site before turning to the south along the western site boundary and joining Fifth Avenue.

2.2 PROPOSED DEVELOPMENT

Pell Frischmann understands that the proposed Phase 2 development will comprise the construction of a Fuel Storage Hall, a Gasification Hall and a Balance of Plant Yard. The layout is showing in drawing ENV_EPT_GEN_DR_A_6011 P7 in Appendix A.

The Fuel Storage Hall will connect to the west of the Phase 1 Fuel Preparation Hall in the south west of the site. The Gasification Hall will be located to the north of the Fuel Storage Hall.

The yard area to the west of the Gasification Hall is the Balance of Plant Yard. A swale will be located along the southern site boundary adjacent to Fifth Avenue.

2.3 DESK STUDY

A Phase 1 Environmental Desk Study report was produced for the Enviroparks Hirwaun site by ERM in October 2007. Key information which was identified and reported by the desk study is summarised in the following sections (updated in places, following the more recent phase of ground investigation reporting).

2.4 SITE HISTORY

The desk study collated historical mapping information and revealed that the history of land use on and around the site was largely industrial.

The mapping indicates that the development area was formally used as an ordnance factory during the Second World War, although all buildings associated with the plant were demolished in the late 1960s early 1970s.

The development area then remained vacant until the late 1990s, when the Welsh Development Agency (WDA) re-profiled the site, creating the current site profile and adding some herring bone drains and open ditches to control surface water.

A small refuse tip which is recorded on the 1964 OS edition is likely to be associated with the ordnance factory. This refuse tip is outside the Phase 2 site area

2.5 GEOLOGY, HYDROGEOLOGY AND HYDROLOGY

The general geology of the site is shown on the British Geological Survey (BGS) 1:50,000 geological map of Merthyr Tydfil (Sheet 231). Further geological information has been obtained from the BGS website.

The site is shown to be underlain by superficial deposits of Alluvium (across the southern part) and Glacial Till (across the northern part). These are underlain by bedrock of the Lower Coal Measures.

Alluvium is described by the BGS as usually being composed of ‘soft to firm consolidated, compressible silty clay, with layers of silt, sand, peat and basal gravel’.

The Glacial Till is described by the BGS as typically being ‘gravel, cobble and boulders within a clay matrix’.

The Lower Coal Measures is a sequence of mainly mudstones and sandstones with rare coal seams. The Lower Coal Measures is described as ‘grey, (productive) coal-bearing mudstones/siltstones, with seatearths and minor sandstones’.

An unnamed coal seam is shown by the geological map to outcrop with an east to west strike through the centre of the site. However, a 1993 coal mining report has been made available to Pell Frischmann, which states that it is extremely unlikely that mining has been undertaken under the site in the past, or will be in the future. We understand that an updated coal mining report has been commissioned by the Phase 1 contractor, but it is not available to us at the time of preparation of this report.

In relation to site hydrogeology, the following aquifer designations are reproduced from the desk study:

- Lower Coal Measures - Secondary A Aquifer

With regard to site hydrology, an unnamed stream flows from north to south along the western site boundary. This stream flows into the River Camnant approximately 50m to the southwest of the site. The River Camnant in turn joins the River Sychryd approximately 500m to the west of the site.

2.6 RECORDS OF POLLUTION, CONTAMINATED LAND AND RADON

The nearest recorded pollution event recorded by the desk study was located 16 m to the west of the site. The event relates to a release of sewage effluent to controlled waters from the Hirwaun Industrial Estate Sewage Works. This event was categorised as 'significant'.

There are no sites determined as Contaminated Land under Part 2A EPA 1990 within 500m of the site.

The desk study reported that the site is not located within a radon-affected area.

2.7 ENVIRONMENTALLY SENSITIVE DESIGNATIONS

The desk study identified three Sites of Special Scientific Interest (SSSI) within 1km. These are the Cores Bryn-Y-Gaer, which is located 114m to the East and the twin sites of Woodland Park and Pontpren, which are located 868m to the East.

3. PRELIMINARY RISK ASSESSMENT

3.1 PHASE 1 CONCEPTUAL SITE MODEL

Based on the desk study findings, a Phase 1 (preliminary) conceptual site model (CSM) was set out in the 2007 ERM report. It is reproduced below, as a precursor to the preliminary risk assessment within this report:

Source

"The following potential contamination risks have been identified as moderate to high following the assessment of the available information:

The Made Ground at the site is thought to be reworked natural material created during the construction of the Ordnance Factory that was locate on the site. There is a possibility that local contamination could have occurred during the site's operational history from structures such as storage tanks.

The refuse tip (locate offsite) *identified in the 1964 map could be a possible source of contamination as the contents of the tip are unknown.*

Pathways

Leaching to groundwater
Vapour migration
Inhalation
Dermal contact

Receptor

*The Stream (*Controlled Waters*)*
*Site visitors (*construction workers, future users*).*

3.2 PRELIMINARY RISK ASSESSMENT METHODOLOGY

As above, the 2007 ERM desk study report included a did not include a preliminary risk assessment. In order to comply with current best practice, we have retrospectively undertaken a primary risk assessment based on the contaminant sources and receptors detailed in the 2007 CSM.

This assessment is qualitative only and based on the potential presence of a pollutant linkage. A pollutant linkage is the relationship between a contaminant source, a pathway and a receptor. Unless all three elements of a pollutant linkage are present, a risk is not considered to exist.

The potential pollutant linkages (PLs) are presented in conjunction with an updated CSM in Table 2 (overleaf, 2 pages), along with a qualitative assessment of the potential risk associated with each of the potential PLs. The assessment of potential risk is based on considering a product of the 'severity of the consequence' and the 'probability of the likelihood' as detailed in the Risk Matrix overleaf (Table 1). The matrix is based on the guidance within the CIRIA Report C552 (Rudland *et al* 2001).

It should be noted that whilst the risk assessment process undertaken in this report may identify potential risks to site demolition and redevelopment workers consideration of occupational health and safety issues is beyond the scope of this report and will need to be considered separately in subsequent construction stage health and safety planning.

Table 1: Risk Matrix and Key for Table 2

		Consequence			
Probability	*product*	**Severe**	**Medium**	**Mild**	**Minor**
	High Likelihood	Very high risk	High risk	Moderate risk	Low risk
	Likely	High risk	Moderate risk	Low risk	Very low risk
	Low Likelihood	Moderate risk	Low risk	Low risk	Very low risk
	Unlikely	Low risk	Very low risk	Very low risk	Very low risk
	No Linkage	No risk			

3.3 PHASE 1 POTENTIALLY COMPLETE POLLUTANT LINKAGES

The Phase 1 CSM has identified a number of potential PLs at the site. In this instance, the key potential PLs and associated risks predominantly relate primarily to on-site contaminant sources.

At Phase 1 stage, these linkages remain as *potential* linkages until such time as data collection or other further work either proves them to exist or to be absent. The risk assessment is updated later in the report, in response to the 'Phase 2' ground investigation findings.

Table 2: Phase 1 Conceptual Site Model (and Preliminary Risk Assessment of Source-Pathway-Receptor Pollutant Linkages)

Source(s)	Possible Pathway(s)	Receptor(s)	Probability	Consequence	Risk Level	Comments
Organic contaminants such as petroleum hydrocarbons and PAHs associated with on-site historical land uses.	Ingestion, inhalation or direct contact. Inhalation of fugitive dust. . Leaching through unsaturated zone. Surface run-off, base flow from contaminated groundwater.	End users of the site. Neighbours. Controlled waters.	High Likelihood	Medium	High	Potential sources of this type of contamination have been identified at the site. Given the industrial history background of the site it is considered highly likely that organic contaminants could exist in the Made Ground, shallow soils and groundwater beneath the site. Construction workers and site neighbours may be at risk from the emission of fugitive dusts particularly during the construction process. These risks can be controlled through appropriate means during the construction.
Metals, Metalloids and other inorganic contaminants	Ingestion, inhalation or direct contact. Inhalation of fugitive dust. Leaching through unsaturated zone. Surface run-off, base flow from contaminated groundwater.	End users of the site. Neighbours. Controlled waters.	Likely	Medium	Moderate	The former land use at the site could have introduced contaminants of this type to the land. Construction workers and site neighbours may be at risk from the emission of fugitive dusts particularly during the construction process. These risks can be controlled through appropriate means during the construction.

Source(s)	Possible Pathway(s)	Receptor(s)	Probability	Consequence	Risk Level	Comments
Elevated concentrations of ground gases (methane & carbon dioxide) from biodegradable matter in the Made Ground.	Migration through soils or groundwater to indoor air.	End users of new buildings Users of off-site properties New buildings Adjacent properties	Likely	Medium	Moderate	The main risk from potential ground gases is likely to be posed by biodegradable matter and potential hydrocarbon vapours within areas of Made Ground and the Alluvium on the site or in the surrounding area.
Asbestos fibres from insulation or asbestos-containing materials in the Made Ground.	Fugitive dust.	End users of the site Neighbours.	Low	Severe	Moderate	Made Ground is present on site and may be asbestos bearing.
Radon	Migration through soils or groundwater to indoor air.	End users of new buildings.	Unlikely	Severe	Low	The site is not located in a Radon Affected Area as less than 1% of properties are above the Action Level for radon. No radon protective measures are necessary at the site, in line with recommendations described in publication BR211 by the Building Research Establishment.
Sulphates present in the Made Ground, and natural geology	Direct contact with dissolved sulphates.	Buried concrete.	Likely	Medium	Moderate	Made Ground and natural strata has the potential to be sulphate bearing.

4. GROUND INVESTIGATION

4.1 GROUND INVESTIGATION PHASING

Two ground investigations (GI) have been undertaken for the Enviroparks Hirwaun development. The first was undertaken by Soil Mechanics in 2008 (reported 2009) and covered the full development area (Phase 1/2 and Phase 3 development areas). The second was undertaken by Quantum Geotechnical in 2013 and primarily targeted what was, at that time, the Phase 1 development area. The GI methodologies are summarised in the following sections.

4.2 SOIL MECHANICS 2009

A scheme-specific ground investigation for the project was scheduled by Pell Frischmann during 2008. The ground investigation (GI) was designed as an integrated investigation, covering both geotechnical and geo-environmental disciplines.

At ground investigation scheduling stage, the scope of the geo-environmental investigation work which was proposed was derived from consideration of the size of the site and the desk study findings and conclusions. The locations of the investigatory holes were determined by reference to the conditions identified in the desk study. No specific sampling statistics or grid were utilised in this instance.

The geo-environmental objectives of the work, which primarily relate to the characteristics and geochemistry of the near surface strata, were addressed by scheduling the collection of samples from the shallow sections of cable percussive boreholes and from the formation of trial pits.

4.2.1 Fieldwork

Soil Mechanics carried out the GI fieldwork between 14 August and 23 September 2008. The fieldwork which was undertaken is summarised in Table 3:

Table 3: Summary of Ground Investigation Fieldwork

Activity	Total No.	No. of Holes in Phase 2 Area	Exploratory Holes in Phase 2 area	Max. Depth	Installations/ Notes
Cable Percussion Boreholes	9	6	BH101, BH102, BH103, BH104, BH105, and BH107	10.9 m bgl	Monitoring wells installed in,BH101, BH102, BH103 and BH105 for ground gas and groundwater monitoring.
Rotary Follow-on	5	4	BH101R, BH103R, BH105R, and BH107R.	18.0 m bgl	
Trial Pits	19	11	TP1, TP1A and TP2 - TP10,	3.8 m bgl	

Full details of the ground investigation work are set out in the contractor's report on the investigation, which is included in full within Appendix C. The approximate position of the ground investigation exploratory hole locations are shown on the Exploratory Hole Location Plan within the report.

4.2.2 Geochemical Laboratory Analysis

Fifty-three of the geo-environmental samples which were obtained from the exploratory holes during the fieldwork were sent for geochemical analysis. Thirty-five of these samples were recovered from the Phase 2 site. Laboratory geochemical analysis was carried out by TES Bretby. The analysis suites (see following Table 4) were compiled based on the findings of the desk study.

Table 4: Geochemical Analysis Suites

Determinants	Soil samples analysed	Soil samples analysed in Phase 2 Area	Water samples analysed	Water samples analysed in Phase 2 area
Petroleum Hydrocarbons – Banded TPH	53	35	5	3
Polycyclic Aromatic Hydrocarbons (PAH) – Total	53	35	5	3
Phenols	53	35	5	3
pH	53	35	5	3
Total Cyanide	53	35	5	3
Free Cyanide	53	35	5	3
Thiocyanate	53	35	5	3
Antimony	53	35	5	3
Arsenic	53	35	5	3
Barium	53	35	5	3
Beryllium	53	35		
Boron	53	35	5	3
Cadmium	53	35	5	3
Chromium	53	35	5	3
Chromium VI	53	28	5	3
Copper	53	35	5	3
Molybdenum	53	35	5	3
Mercury	53	35	5	3
Nickel	53	5	5	3
Lead	53	35	5	3
Selenium	53	35	5	3
Zinc	53	35	5	3
Asbestos screen & ID	31	21		
BTEX	53	35	5	3
PCB	5	3		
COD			5	3
BOD			5	3

The environmental samples were recovered from between 0.3m and 3.3m below ground level and are representative of the Made Ground and Glacial Till Deposits.

The samples were taken, stored and transported in general accordance with BS 10175:2011.

Copies of geochemical analysis results are included in the Soil Mechanics report presented in Appendix C. The results are reviewed, assessed and discussed further in subsequent Chapters 5, 6 and 7.

4.3 QUANTUM GEOTECHNICAL 2013

Further GI which was specifically for the Phase 1 development works was scheduled by Waterman and undertaken by Quantum Geotechnical (hereafter referred to as Quantum) during 2013. The GI was designed to determine the extent the Alluvium, the extent of a hydrocarbon hotspot and also inform the design of the foundations and floor slab for the Phase 1 structure.

4.3.1 Fieldwork

Quantum carried out the ground investigation fieldwork between 11th and 16th September 2013. The fieldwork which was undertaken is summarised in Table 5:

Table 5: Summary of Ground Investigation Fieldwork

Activity	No.	No. of holes in Phase 2 Area	Max. Depth	Exploratory Holes in Phase 2 area	Installations / Notes
Dynamic Probe	12	12	-	None	None
Trial Pits	19	6	3.00 m bgl	TP101-TP106	None

Full details of the GI work are set out in the contractor's report on the investigation, which is included in full within Appendix D. The approximate position of the ground investigation exploratory hole locations are shown in the Exploratory Hole Location Plan within the report.

4.3.2 Geochemical Laboratory Analysis

Ten geo-environmental samples were obtained from the exploratory holes during the fieldwork from between 1.0m and 2.0m below ground level. These samples were sent to I2 Analytical. Five of the were samples tested for speciated PAHs. The other five samples were tested for speciated TPH.

In conjunction with the 2007 data, the 2013 results are reviewed, assessed and discussed further in subsequent Chapters 5, 6 and 7.

5. GROUND AND GROUNDWATER CONDITIONS

5.1 GROUND CONDITIONS

5.1.1 Summary

The geological succession encountered during the two ground investigations was generally as predicted by the BGS geological map.

With the inclusion of the shallow/surfacing materials, the following table summarises the ground conditions findings at the site:

Table 6: Strata Encountered

Stratum Description	Depth to Top* (m bgl)	Depth to Base* (m bgl)	Thickness (m)
Made Ground	-	2.0	2.0
Alluvium	3.0	3.5	0.5
Glacial Till	2.0	8.6	6.6
Lower Coal Measures	9.5	Not proven	Not proven

(*Note: the depths are averages of the available datasets, to provide a simplified summary)

Full strata details are set out in the contractor's reports on the investigations, which are included in full within Appendix C and D respectively. The geological strata in the table above are described in further detail below.

5.1.2 Made Ground

Made Ground was located in all of the exploratory holes undertaken in the site. The thickness of the Made Ground which was encountered, varied from 0.3m to 3.6m. Nine of the trial pits terminated within the Made Ground.

In general, the Made Ground was granular in nature, typically described as *medium dense to dense red, brown and grey very clayey sandy gravel with low cobble content*. The gravel and cobble component is recorded to include sandstone, quartzite and brick fragments. Occasional anthropogenic materials including wire, glass, steel, brick, slag and concrete were observed.

Within the south western area of the site, a thin layer (0.1 m - 0.3 m) of cohesive soil was encountered, described as *soft brown sandy slightly gravelly silty clay*.

In the south-eastern area of the proposed development, four of the exploratory holes (TP1A, TP2, TP4 and TP5) encountered cohesive soils. These were recorded to be present to a maximum thickness of 1.5 m and were described as *soft black grey and brown sandy slightly gravelly silty clay with low cobble content*. The cobbles were comprised of sandstone and quartzite.

5.1.3 Alluvium

Alluvium was only encountered in a single trial pit (TP6). It was present between 3.0 m and 3.5 m bgl, and it's the base was not proven.

The Alluvium was described as *soft to firm grey brown to black clayey SILT with rare small pockets of woody peat and many roots and rootlets*.

The trial pits TP101-TP106 undertaken by Quantum in 2013 were commissioned with the intention of defining the extent of the soft 'peaty' Alluvium. No cohesive or 'peaty' Alluvium was recorded in any of the pits.

5.1.4 Glacial Till

The ground investigation findings indicate the Glacial Till to be present below the site. All five of the cable percussive boreholes encountered Glacial Till. Four of the five boreholes fully penetrated the Glacial Till, proving respective thicknesses of 8.30 m (BH101), 5.5 m (BH102), 8.50 m (BH103) and 7.0 m (BH105). In BH104 the base of the Glacial Till was not proven but was recorded to be a minimum of 8.3 m thick.

The Glacial Till was generally described as *loose to dense dark grey and brown clayey sandy gravel with low cobble content*. The gravel and cobble content is described as sub-angular to sub-rounded sandstone and quartzite.

5.1.5 Lower Coal Measures

Strata of the Lower Coal Measures were encountered in the boreholes that were extended using rotary coring methods.

The first core runs in the Lower Coal Measures (between 10m and 12m in BH103R and between (9m and 10m in BH105R) resulted in poor core recovery. The driller described the material as broken sandstone with joints filled with brown sandy clay. We interpret this to represent an initial weathered zone of the Lower Coal Measures that comprises weaker and more fractured sandstone.

Below the initial weathered layer, the Lower Coal Measures strata typically comprised very strong grey fine grained sandstone with orange brown staining on discontinuity surfaces. The discontinuities were typically sub-horizontal and closely to medium spaced.

5.2 VISUAL AND OLFACTORY EVIDENCE OF CONTAMINATION

No direct visual or olfactory evidence of contamination was noted in any of the exploratory hole locations undertaken across the site during the ground investigation.

5.3 GROUNDWATER

On completion of boring, slotted 50 mm diameter standpipes were installed into four of the boreholes (BH101, BH102, BH103 and BH105) for groundwater and ground gas monitoring.
Groundwater level readings were made in the monitoring standpipes on four subsequent visits.

Boreholes 101, 102, 103 and 105 indicate a shallow groundwater regime, with phreatic surface generally located 2m bgl, towards the top of the Glacial Till and base of the Made Ground.

The groundwater level in BH109 (located outside of Phase 2) is typically 0.13 m bgl. The response zone within the monitoring well ranges from 1.5 m bgl to 3.0 m bgl and extends through the Made Ground and into the natural strata. The groundwater monitoring may be indicative of sub-artesian ground water conditions.

These sub-artesian groundwater conditions appear to be a local issue rather than site wide.

The results of the groundwater monitoring are summarised in the following table:

Table 7: Groundwater Summary – Phase 2 Development Area

Monitoring Well	Average m bgl	Max m bgl	Min m bgl	Average m aOD	Max m aOD	Min m aOD
BH101	2.35	2.42	2.27	196.89	196.82	196.97
BH102	2.20	2.25	2.12	196.96	196.91	197.04
BH103	2.11	2.13	2.10	197.66	197.64	197.67
BH105	2.05	2.06	2.04	197.48	197.47	197.49

The full groundwater level monitoring results are all presented in the Soil Mechanics report in Appendix C.

5.4 GROUND GAS

Ground gas monitoring was undertaken alongside the groundwater monitoring during and after the fieldwork period.

The results of the Ground Gas monitoring are summarised in the following table:

Table 8: Ground Gas Summary

Date	Unit	BH103	BH105
Max. CH_4	%	1.2	0.7
Av. CH_4	%	0.33	0.25
Max. CO_2	%	1.4	0.7
Av. CO_2	%	0.93	0.18
Min. O_2	%	17	19.8
Av. O_2	%	19.1	17.88
Max. Flow	l/h	0.3	0.1
Av. Flow	l/h	0.15	0.08
Atm. Pressure	mb	978-1013	978-1013

Further consideration with regard to ground gas is presented in Section 6.4 of this report.

The full ground gas monitoring results are presented in the Soil Mechanics report in Appendix C.

5.5 GEO-ENVIRONMENTAL LABORATORY ANALYSIS RESULTS

5.5.1 Soil Chemistry

The results of the geo-environmental chemical analysis on soil samples are presented in the Soil Mechanics and Quantum reports in Appendix C and D of this report.

The soil analysis results are reviewed in subsequent Section 6.2 of this report.

5.5.2 Asbestos

Twenty-one samples recovered from the shallow soils across the Phase 2 development area were subjected to asbestos screening. No asbestos fibres were recorded in any of the tested samples.

5.5.3 Groundwater Chemistry

The results of the geo-environmental chemical analysis on soil samples are also presented in the Soil Mechanics report in Appendix C of this report.

The groundwater analysis results are reviewed in subsequent Section 6.3 of this report.

6. RISK ASSESSMENT

6.1 CONTAMINATION RISK ASSESSMENT

Pell Frischmann have used the geochemical results from the ground investigation to implement a ground contamination risk assessment in accordance with current guidance and best practice. The assessment is reported in the following sections.

6.2 GENERIC QUANTITATIVE RISK ASSESSMENT – HUMAN HEALTH

A generic quantitative risk assessment (GQRA) has been undertaken using the geochemical results for the soil samples retained during the ground investigation in order to assess any human health liabilities associated with potential in-ground contaminants at the site.

The approach to human health risk assessment adopted in this report is consistent with the Environment Agency's Model Procedures (CLR11), CL:AIRE statistics guidance and other relevant guidance (including SP1010, SR3, BS10175:2011 and the NPPF). Further information on the methodology can be provided on request.

As set out in Section 2.2, Pell Frischmann understands that it is intended to redevelop the site with a new sustainable waste resource recovery and energy production plant.

In order to formulate a reasonably conservative baseline for the site, the assessment of the available data has been undertaken using the relevant land uses provided in DEFRA's SP1010 Category 4 Screening Level (C4SL) guidance and LQM/CIEH Suitable 4 Use Level (S4UL) guidance documents. Given the proposed use as a waste to energy plant, the C4SL and S4UL 'Commercial' guidelines have been applied to the entire site (using a 1% SOM value where appropriate, to provide an initial conservative assessment).

The C4SL's have been used where available. Where they are not available, the LQM/CIEH published S4UL's are utilised.

6.2.1 Data Assessment

The results of the laboratory geochemical soil analysis have been statistically analysed to ensure a true representative assessment of the site is made and to allow a comparison with the appropriate assessment criteria described above.

The statistical analysis has been undertaken in accordance with the report: Guidance on Comparing Soil Contamination Data with a Critical Concentration, published by the Chartered Institute of Environmental Health through CL:AIRE (Contaminated Land: Applications In Real Environments) in May 2008.

In order to undertake the statistical assessments, the ESI Contaminated Land Statistics Calculator software has been utilised. This software has been developed in accordance with the CL:AIRE guidance.

The site is being assessed under the current planning regime and as such the following hypotheses have been used to statistically assess the data:

H_0: the level of contamination *is the same as, or higher than*, the critical concentration; and
H_1: the level of contamination *is lower than* the critical concentration.

If H_0 cannot confidently be rejected, then further assessment or remediation may be required. However, if H_0 can confidently be rejected in favour of H_1, it can be concluded that there is good evidence that no further action is required.

6.2.2 Non-detects Methodology

Non-detects are results that are reported by the laboratory as 'less than' a specified minimum value, usually the method detection limit (MDL). The ESI Contaminated Land Statistics Calculator allows non-detects to be set either at method detection limit or at half the MDL. As part of this conservative screening exercise all non-detects were detects set at the MDL.

6.2.3 Outlier Methodology and Initial Data Review

According to the CL:AIRE guidance, statistical outliers can only be excluded from the dataset where:

- They are obviously and demonstrably the result of an error that can be identified and explained; or
- They clearly indicate that more than one soil population exists within the dataset and this can be justified by (or informs the further development of) the CSM.

In all other cases, outlying data should be assumed to be genuine and reflective of the full range of soil concentrations to which receptors may be exposed.

For this assessment,the ESI Contaminated Land Statistics Calculator, which uses the Grubb's test, has been utilised to assess the data for statistical outliers. The data sheets for the statistical assessment can be found in Appendix E.

The analysis of the data set indicates that statistical outliers may be present within the Made Ground at the site. However, Made Ground is typically heterogeneous in nature and it is more conservative to include statistical outliers in the assessment. Consequently, a conservative approach has been adopted and no outliers have been removed from the dataset.

6.2.4 Risk Estimation (incl. statistical analysis) – Commercial

A total of thirty-five soil samples recovered during the ground investigation were scheduled for chemical analysis. These samples were analysed for a range of determinants including metals, PAH's and petroleum hydrocarbons.

Metals - Statistical Assessment

With regards to human health, based on an Upper Confidence Limit (UCL - 95th percentile) exceedance of the GAC, no pervasive metal contaminants of potential concern have been identified which require further assessment and/or remediation.

Based on the analysis the Null hypothesis (H_0) can be rejected for metals.

Polycyclic Aromatic Hydrocarbons

The polycyclic aromatic hydrocarbon (PAH) analysis undertaken to date are predominantly reported as total PAH and are not speciated. There are currently no C4SL or S4UL which Total PAH results can be compared against.

The reported total PAH concentrations are generally low and are considered unlikely to represent a significant risk. Additionally, where some Speciated PAH testing analysis has been reported (Phase 1 development) the concentrations were below the relevant thresholds. However, in the absence of site wide speciated PAH results the H_0 for PAHs cannot confidently be rejected.

Petroleum Hydrocarbons

The results of the banded TPH analysis (which is not spilt into Aliphatic and Aromatic fractions) have been compared against the lowest S4UL (Aliphatic and Aromatic) for the respective band. This comparison reported no exceedance of the S4ULs, therefore, no pervasive petroleum hydrocarbon fractions of potential concern have been identified which require further assessment and/or remediation.

Based on the analysis the Null hypothesis (H_0) can be rejected for hydrocarbons.

Polychlorinated Biphenyls

The results of all three of the samples tested for polychlorinated biphenyls (PCBs) were below the laboratory limit of detection.

Based on the analysis the Null hypothesis (H_0) can be rejected for PCBs.

6.2.5 Risk Evaluation – Soils

In summary, following statistical analysis of the samples obtained during the site investigation, potentially pervasive risks to human health have been identified from PAHs within the soils. However, the risk arises more from an absence of suitable data to allow assessment using current criteria than from actual measured concentrations.

In order to further inform this assessment of risk it is recommended that a limited ground investigation is undertaken to obtain soil samples and to enable speciated PAH analysis to be undertaken. The results of the analysis can then be compared against published C4SL or S4UL thresholds.

6.3 GENERIC RISK ASSESSMENT – CONTROLLED WATERS

Groundwater was encountered during the ground investigation. Groundwater samples obtained from BH101, BH103 and BH105 were subjected to chemical analysis that included a suite of metals, PAHs and petroleum hydrocarbons.

The risks to groundwater and surface water from contaminants on site have been assessed according to the remedial targets methodology (RTM) prescribed by the Environment Agency (2006). Pollutant inputs from contaminated land sites are considered as passive inputs under the European Water Framework Directive (2000/60/EC) (WFD) and its daughter Directives, and as such are regulated under the Agency's 'limit' pollution objective.

Acceptable water quality targets (WQT) are defined for protection of human health (based on drinking water standards (DWS)) and for protection of aquatic ecosystems (environmental quality standards (EQS)).

For the purposes of this report, the ground investigation data is compared with the various targets as set out according to the source-pathway-receptor scenario presented in subsequent Table 12, on the basis that the Lower Coal Measures that underlies the site is designated as Secondary A Aquifer.

The area is not within a Source Protection Zone (SPZ). However, the groundwater body may be used for human abstraction and may also contribute to the Cammant and the River Sychryd base flow (and hence poor groundwater quality has the potential to impact upon ecosystems).

Table 9: Summary of Water Quality Risk Assessment Protocol

Water Body Receptors	Secondary Receptors	Example Contaminant linkages	RTM Level and Data Used	Water Quality Targets
Groundwate Surface water	Human health (abstraction) Aquatic ecosystem	Contaminants from site leach or seep into groundwater body and this feeds surface water by base flow. The surface water may be used for human consumption and is an aquatic ecosystem.	RTM Level 2 - Groundwater	DWS EQS (inland)

The results of the remedial targets methodology assessment are summarised in Table 10 overleaf.

There are no water quality standards for petroleum hydrocarbons in water. However, because of the sensitivity of the water environment to petroleum hydrocarbons, an initial screening exercise is also included in Table 10 irrespective of the assessment scenario(s) stated in Table 9.

Table 10: Chemicals of potential concern for which further assessment is required (Controlled Waters)

Chemical of Potential Concern	Water Quality Target (ug/l)	Basis for Water Quality Target	No. of Samples	Range of Concentrations (ug/l)	Max. < Criterion
As	50	EQS Inland	3	2 – 14	PASS
B	2000	EQS Inland	3	30-80	PASS
Cd	0.25	EQS Inland	3	<0.01 – 0.03	PASS
Cr (total)	4.7	EQS Inland	3	0.1 – 0.2	PASS
Cr (VI)	0.6	EQS Inland	3	<10	**FAIL**
Cu	10	EQS Inland	3	3 – 6	PASS
Hg	0.05	EQS Inland	3	<0.1	**FAIL**
Ni	20	EQS Inland	3	2 - 15	PASS
Pb	7.2	EQS Inland	3	<1 –3	PASS
Zn	125	EQS Inland	3	19 - 95	PASS
Cyanide (total)	1	EQS Inland	3	<40	**FAIL**
Phenols	7.7	EQS Inland	3	<50	**FAIL**
Sulphate	400,000	EQS Inland	3	16000 - 32000	PASS
PAH Benzo(a)pyrene	0.05	EQS Inland	3	<0.01	PASS
PAH naphthalene	2.4	EQS Inland	3	0.01-0.065	PASS
PAH sum of benzo(b)fluoranthene benzo(k)fluoranthene	0.03	EQS Inland	3	<0.02	PASS
TPH	10^	None	3	20 - 40	**FAIL**

From Environment Agency (2002c) Appendix A and Agency web site (annual average basis), Water Quality Regulations 2001 and WHO 2004.
*depends on water hardness and fish type. The site is in a hard to very hard water area according to www.britishwater.co.uk; an appropriate EQS has been used.
^ The Water Supply Regulations 1989 and the Private Water Supply Regulations 1991 both contained a prescribed concentration of 10 µg/l for "dissolved or emulsified hydrocarbons (after extraction with petroleum ether); mineral oils". This was removed when these Regulations were updated in 2000 (consolidated 2007) and 2009, respectively. However 10 µg/l is used in this report as an initial screening assessment as it is frequently the preferred approach of the Environment Agency.

6.3.1 Risk Evaluation of Controlled Waters

After review, five chemicals of potential concern are recorded to exceed the assessment criteria, these being chromium VI, mercury, phenols, cyanide and total petroleum hydrocarbons.

The exceedance for chromium VI, mercury, phenols and cyanide are only apparent because the laboratory method detection limit (MDL) is above the relevant EQS value used. The MDL used for the chromium VI, mercury, phenols and cyanide

analysis is not sufficiently low enough to completely discount the risk associated with it.

Based on the current hydrocarbon analysis all three of the samples exceed the threshold. As such, the risk from hydrocarbons cannot be discounted. The total petroleum hydrocarbon (TPH) analysis that has been undertaken is a coarse test that combines all the hydrocarbon fractions into a single result. This test can result in natural organics such as humic acid being reported within the TPH result.

The current benchmark for hydrocarbon analysis follows the Criteria Working Group (CWG) method which splits the results into carbon bands (e.g. C10-C12) and also into aliphatic and aromatic fractions. The more thorough analysis method tends to strip out the natural organics so it is less likely to report background hydrocarbons.

Notwithstanding the limitations of the dataset, given the site setting and the development context (i.e. lack of human abstractors and low contaminant concentrations), it is considered that the overall risk posed to Controlled Waters by the ground conditions at the site is likely to be low.

To conclude on this aspect, we recommend that further groundwater samples are recovered and sent for analysis. The analysis should target chromium VI, mercury, phenols, cyanide and hydrocarbons (TPH CWG method) and should be undertaken to current standards with a MDL below the relevant threshold value. The results of this analysis will then be assessed to improve confidence in the assessment of risk to Controlled Waters.

6.4 GROUND GASES - CARBON DIOXIDE AND METHANE

The risks associated with the ground gases methane (CH_4) and carbon dioxide (CO_2) have been assessed using BS 8485:2015 *Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings,* guidelines from CIRIA 665 (Wilson et al 2007) and the NHBC (Boyle and Witherington 2007).

Qualitatively, it is judged from the available soil descriptions in the ground investigation exploratory hole records that the gas generation potential at the site is likely to be low (i.e. the Made Ground which was recorded across the site had a low organic content).

Current UK best practice guidance suggests that the ground gas assessment and characterisation for a site is dealt with separately for different types of development. In the above guidance:

- **'Situation A'** covers all forms of development (residential and industrial/commercial developments), other than low rise residential development; and
- **'Situation B'** is defined as the specific development of low-rise (one to three storeys in height) housing with beam and block floors, vented sub-floor void and gardens.

Given the industrial nature of the development proposals, the site is characterised as Situation A.

The sensitivity of the development can be considered low (in line with CIRIA 665 which considers industrial developments to be of low sensitivity).

Based on BS 8485:2015 the proposed development would comprise Type D (Industrial) buildings.

One of the assumptions in using the above guidance is that the worst-case ground gas regime has been identified on the site, for either CH_4 or CO_2, at the worst-case temporal conditions that the site may be expected to encounter (such as immediately following rapid changes in atmospheric pressure or prolonged rainfall).

To this end, the idealised frequency of monitoring is suggested in CIRIA 665 Tables 5.5a and 5.5b. These tables are adapted from Wilson and Haines (2005) Table 3 which gives examples of ground conditions with the various gas generation potentials, ranging from inert Made Ground (very low potential) to post 1960s domestic landfill (very high potential).

In this respect, it is judged from the available soil descriptions in the ground investigation exploratory hole records that the gas generation potential at the site is likely to be low (i.e. the Made Ground which was recorded across the site had a low organic content).

It is considered that the post-fieldwork monitoring visits which have been carried out are likely to have detected a worst case scenario with regards to gas generating potential at the site as they have been undertaken at low atmospheric pressure conditions.

For a particular site, BS 8485:2015 and the other references quoted above require identification of the gas flow rate from monitoring wells and the associated concentrations of carbon dioxide and methane, in order to generate a Gas Screening Value (GSV) for the site.

Gas monitoring of the monitoring wells was undertaken on four occasions. During each gas monitoring visit, each well was monitored for methane, carbon dioxide, oxygen, hydrogen sulphide and carbon monoxide, with measurements of barometric pressure and flow rates also noted. The full results of the gas monitoring are included in the Soil Mechanics report presented in Appendix C.

Four monitoring visits have been undertaken, the results of which indicate:

- methane concentrations of up to 1.2% v/v;
- carbon dioxide concentrations of up to 1.4% v/v;
- oxygen concentrations of between 17% v/v and 21% v/v; and
- gas flow measurements were recorded up to 0.3l/hr.

To generate a worst case GSV for the site, it is assumed that the flow rate is 0.3l/hr and the maximum methane and carbon dioxide concentration is used in the calculation. The GSV for methane is calculated to be 0.0036. The GSV for carbon dioxide is calculated to 0.0042.

In general accordance with BS 8485:2015 and based in the calculated GSVs, the site may be classified as Characteristic Situation 1 (CS1). However, BS 8485:2015

suggests that consideration should be given to upgrading to Characteristic Situation 2 (CS2) if the methane concentration exceeds 1%.

Should the Characteristic Situation be raised to CS2 then gas protection measures with at minimum gas protection score of 1.5 points would be required.

A cast in situ monolithic reinforced slab with minimum penetrations, such as is proposed for the Phase 2 structures, would provide the necessary 1.5 gas protection points.

The proposed development is designed to accept and process methane producing waste. In order to be compliant with Dangerous Substances and Explosive Atmospheres Regulations (DESEAR), the proposed scheme will have to be designed with appropriate gas control measures to mitigate the risks from methane, carbon dioxide and depleted oxygen.

Based on the low gas concentrations, the low flow rates, the CS1 GSV, the proposed floor construction and the intrinsic gas control measures that will be included within the development, we consider that the risk to future users of the proposed Phase 2 development from ground gas is very low.

7. PHASE 2 GEO-ENVIRONMENTAL ASSESSMENT CONCLUSIONS

7.1 GEO-ENVIRONMENTAL RISKS TO THE PROPOSED DEVELOPMENT

Table 11 below provides a summary of the findings of the generic risk assessment set out in Chapter 6.

Table 11: Risk Assessment Potential Pollution Linkage Summary

Receptor Group	Pollution Source
Human Health	Polycyclic Aromatic Hydrocarbons (PAH) within the Made Ground on the site may pose a risk to human health. Further sampling and analysis is recommended. Hydrocarbon concentrations within the Made Ground on the site may pose a risk to potable water supplies. No other potentially pervasive risks to human health have been identified.
Controlled Waters	Five chemicals of potential concern are recorded to exceed the preliminary assessment criteria. In combination with the site setting and the development proposals, the result indicate that the risk to Controlled Waters from the site is Low. Further sampling and analysis is recommended.

7.2 HEALTH AND SAFETY OF CONSTRUCTION WORKERS

Construction workers are more likely than end-users to come into direct contact with contaminants in the ground due to the nature of their work. Any associated exposure would be more likely to be acute than chronic.

In consequence, a Contractor engaged in groundworks at the site must be aware of the sample contaminant concentrations which have been recorded within the ground investigation, to inform their method statements and risk assessments. Appropriate PPE, good hygiene practices and dedicated welfare facilities should be adopted. In particular, a no 'hand to mouth contact' regime should be promoted and enforced to reduce the accidental ingestion of soils. Dust masks should also be worn whenever excavation work generates any airborne dust.

7.3 UPDATED CONCEPTUAL SITE MODEL

In the Phase 1 assessment, a preliminary CSM was developed which summarised the potential pollution linkages identified by the desk based review.

The CSM has been updated in Table 12 (overleaf) to reflect the findings of the ground investigation and the associated risk assessment set out within this report.

Table 12: Updated Conceptual Site Model

Source	Pathway	Receptor	Probability	Consequence	Risk Rating	Mitigation	Post Mitigation Risk Rating
PAH contaminants in the shallow soils at the site.	Ingestion of soil and/or dust. Dermal contact with soil and/or dust. Inhalation of dust.	Future site users.	Likely	Medium	Moderate	*Mitigation required:* Further sampling and analysis for PAHs is recommended. Further assessment required.	Not known
Ground gases in the Made Ground at the site.	Inhalation of ground gases.	Future site users.	Low	Medium	Low	*Mitigation required:* Cast in situ monolithic reinforced floor slab. Monitoring ventilation and gas control measures.	Very Low
Metals, PAH and petroleum hydrocarbon contaminants in the shallow soils at the site.	Dermal contact, ingestion and/or inhalation of dust and/or vapours.	Construction workers and neighbours of the site	Likely	Severe	High	*Mitigation required:* PPE, risk assessments and method statements	Low
Organic contaminants in the soil and groundwater on site	Direct contact with potable water supply pipe.s	Future users	Likely	Medium	Moderate	*Mitigation required:* Barrier pipe should be used for the potable water supply.	Very Low
Metals and petroleum hydrocarbon contaminants in the groundwater at the site.	Leaching and /or percolation to underlying strata.	Controlled waters	Likely	Medium	Moderate	*Mitigation required:* Further groundwater sampling and analysis is recommended. Further assessment required.	Not known
Potential radon on-site and migrating from off-site	Radon intrusion into proposed buildings and structures on site	Future users	Unlikely	Severe	Low	The site is not located within a radon affected area as less than 1% of homes are above the action level for radon. No mitigation is required.	NA

8. GEO-ENVIRONMENTAL ASSESSMENT RECOMMENDATIONS

Further to the collective site investigation findings to date, the following recommendations are made in relation to the continued progress of the development scheme:

1) Further soil sampling and analysis of the Made Ground for speciated PAHs is recommended.
2) Further groundwater sampling and analysis is recommended;
3) Further assessment is required to assess the findings of the additional soil and ground water sampling and analysis;
4) Protective water supply pipework (barrier pipe) is likely to be required; and
5) Appropriate implementation of construction phase health and safety measures by all contractors involved in excavations and groundworks.

9. UNCERTAINTIES AND LIMITATIONS

This report details the findings of site investigation work carried out by Soil Mechanics in 2008 and Quantum in 2013. The report has been prepared by Pell Frischmann on the basis of the above and other available third party information on the site conditions. Information provided by third parties has been used in good faith and is taken at face value; however, Pell Frischmann cannot guarantee its accuracy or completeness. Although every reasonable effort has been made to gather all relevant information, all potential environmental constraints or liabilities associated with the site may not have been revealed.

The report has been prepared for the exclusive benefit of Enviroparks (Wales) Ltd and those parties designated by them for the purpose of communicating geo-environmental assessment recommendations for the site. The report content should only be used in that context. Furthermore, new information, changed practices or new legislation may necessitate revised interpretation of the report after the date of its submission.

The work has been carried out in general accordance with recognised best practice as detailed in guidance documents such as the CLR 11 Model Procedures (Environment Agency 2004), BS5930:2015 and BS10175:2011. Important aspects of the risk assessment process are transparency and justification. The rationale behind the assessments can be provided upon request. Unless otherwise stated, no assessment has been made for the presence of radioactive substances or unexploded ordnance.

The risk assessment process outlines potential risks to groundworks and other redevelopment workers. However, detailed consideration of occupational health and safety issues is beyond the scope of this report.

Notwithstanding any site observations concerning the presence or otherwise of archaeological sites, asbestos-containing materials or invasive weeds such as Japanese knotweed, this report does not constitute a formal survey of these potential hazards.

APPENDIX A

PROPOSED DEVELOPMENT PLANS

ALL DIMENSIONS TO BE CHECKED ON SITE.
DO NOT SCALE THIS DRAWING.
ALL DISCREPANCIES TO BE REPORTED IMMEDIATELY.
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KEY:

1. VISITORS CENTRE (791sqm GEA)
2. EXISTING GATEHOUSE (103sqm GEA)
3. EXISTING FUEL PREPERATION AREA (5200sqm GEA)
4. HV SUBSTATION (220sqm GEA)
5. BIOMAX AREA (2742sqm GEA)
6. PROPOSED B2 HIGH ENERGY USE UNIT 10,240sqm (INC OFFICE CONTENT)
7. WATER TREATMENT PLANT
8. FUEL STORAGE HALL (2110sqm GEA)
9. TURBINE HALL (380sqm GEA)
10. GASIFICATION HALL (6270sqm GEA)

KEY

- RED LINE AREA = 12.4 acres / 50,010 sqm
- LAND WITHIN APPLICANTS CONTROL
- TOTAL SITE AREA = 21,1 acres / 85,511 sqm
- GRASS
- SHRUBS & HEDGES
- PROPOSED LANDSCAPE BUFFER TO BBNP
- GRASSCRETE
- EXISTING BUILDINGS
- ENVIROPARKS SIGN SET IN STONE GABION FILLED WITH LOCAL STONE
- GREEN WALL WITH LOCAL STONE GABION BASE
- EXISTING BUILDINGS
- PROPOSED BUILDINGS
- TARMAC ROAD SURFACE
- BRUSHED CONCRETE SURFACE
- LIGHT GREY BLOCK PAVING TO ROADS
- BLOCK PAVING TO PARKING
- BLOCK PAVING TO PEDESTRIAN AREAS
- GANGWAY
- CONCRETE PAVING SLABS
- CYCLE SHELTER (10 CYCLE SPACES)
- POST & RAIL FENCE
- 2.4m HIGH SECURITY FENCE
- INDICATIVE LOCATION OF NEW TREES
- GATE

IMPORTANT NOTES: ALL LANDSCAPING SHOWN INDICATIVE ONLY. REFER TO LATEST LANDSCAPE DRAWINGS.

LAYOUT OF SUDS PONDS SHOWN INDICATIVE ONLY. REFER TO DETAILED SUDS DESIGNER DRAWINGS.

No.	Revision Description	Date	By
P7	Additional notes added	24/02/17	DJS
P6	Various amendments following client meeting dated 09/02/17	22/02/17	DJS
P5	Site Areas updated	17/01/17	DJS
P4	Revision clouds removed for clarity	13/01/17	DJS
P3	Motocycle parking and path amended following client comments	12/01/17	DJS
P2	Various amendments following clients comments dated 04/01/17 & updated FBW site model dated 10/01/17	11/01/17	DJS
P1	Issue for Planning	19/12/16	MT

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PROJECT
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TITLE
Proposed Overall Site Plan

Drawn : MT Date : 08/12/16 Checked : MT

Scale : 1:500 Original sheet size : A0

DRAWING STATUS
- ■ Planning
- ☐ Tender
- ☐ Design Development Pre-Construction
- ☐ Construction
- ☐ Record

Drawing No ENV_EPT_GEN_DR_A_6011 Revision P7