



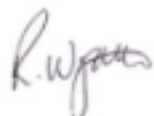
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CLIENT CONTACT	-
For and Behalf of Groundtech Consulting	
SIGNATURE	
AUTHOR	Cameron Wellece BSc (Hons) FGS
SIGNATURE	
CHECKED	Richard Wyatt MEng (Hons) FGS
SIGNATURE	
REVIEWED	James Doyle BSc (Hons) OGeol FGS

SUMMARY

Site Details		
Site Location	The site is located c.6.7 miles east of Swansea Town Centre at approximate National Grid Reference 275907, 189387.	
Site Area	The site covers an area of approximately 1.12Ha and is roughly triangular in shape. The site is currently vacant and predominantly covered in scrub and light vegetation. Some areas of hardsurfacing comprising concrete and tarmac are present at the site entrance and to the east.	
Preliminary Risk Assessment		
History	The site was occupied by a Tin Plate Works from 1881 and was developed for various industries through time including a railway terminus, engineering works, corporation yard, mortuary, residential dwellings and petrol filling station. Through the various land uses, features such as a well, chimneys, tanks and electricity substation have been present on site.	
Geology/Hydrogeology	The site is underlain by Estuarine Alluvium Deposits (Secondary Undifferentiated Aquifer) comprising Clay, Silt and Sand. The solid geology beneath the site is the South Wales Middle Coal Measures Formation (Secondary A Aquifer) comprising Mudstone, Siltstone, Sandstone and coal seams.	
Mining	The Coal Authority consultation indicates that there is no risk from past or future underground mining on the site.	
Environmental Setting	An obsolete petrol filling station was present on site. The site is not within 500m of a Source Protection Zone. There are no groundwater or potable water abstractions within 2000m of the site.	
Pollution Linkage (PL) Assessment	Human Health	The risk to human health is considered to be Low as the site will be covered in hardsurfacing.
	Controlled Waters	The risk to controlled water is considered to be Low to Moderate.
	Permanent Ground Gas	The risk to human health from ground gases is Moderate to High.
Ground Model		
Made Ground Soils	Hard surfacing was present within TP02, TP03 and TP05 to a maximum depth of 0.15m bgl. This was underlain by tarmac within TP02 to a depth of 0.2m bgl. Made Ground was found to a maximum depth of 2.9m bgl and generally comprised sand and gravel with minor constituents of ash, slag, coal, brick and concrete.	
Natural Soils	Natural soils on site generally comprised very low to medium strength silty variably organic Clay to depths of between 3.9m and 5.3m bgl where very dense Gravel was encountered.	

Bedrock	<i>No bedrock was encountered during the investigation.</i>
Groundwater	<i>Perched groundwater was encountered in TP06 and TP07 at depths of 1.0m and 1.3m respectively within the Made Ground. Elsewhere across the site, groundwater strikes were identified in the natural ground at depths of between 2.4m and 3.0m bgl.</i>
Ground Engineering Assessment	
Foundations	<i>Shallow foundations are not considered to be suitable due to the low strength, compressible deposits that are present to a maximum depth of 3.3m bgl. The most suitable foundation solution for the development is piles and bearing into the very dense gravels.</i>
Highways	<i>CBR values of between 1.8% and 3.2% were achieved at formation level. In order to achieve a value of at least 5% some reengineering will be required if the existing materials are to be reused under the road surface.</i>
SuDS	<i>Due to the depth of Made Ground beneath the site and the underlying natural Clay, the use of a Sustainable Urban Drainage System is not considered feasible at this site.</i>
Constraints	<i>The main limitation is the number of obstructions encountered associated with the previous development at the site. As part of the enabling works, all obstructions will need to be grubbed up prior to the construction phase of works taking place.</i> <i>In addition, soft very low to low strength Clays are present to depths of up to 3.3m bgl.</i>
GQRA and Revised (PL) Assessment	
Human Health	<i>The site has relatively low levels of hydrocarbon contamination given the previous usage as a petrol station, and generally low levels of contamination considering the sites historical land usage. There was one exceedance when compared to commercial screening values. The exceedance is relating to benzo(a)anthracene in a sample obtained from TP03 at a depth of 0.3m bgl.</i> <i>No other elevated Contaminants of Concern were recorded based on the proposed commercial end use. Asbestos was detected in four samples of Made Ground at a maximum concentration of 0.04 mass %.</i> <i>The site is to be predominantly covered with hardsurfacing which will break the pathway from site and users to potentially contaminated soils. The risk to human health is Low.</i>
Controlled Waters	<i>Out of four groundwater samples that were tested, there was one slight exceedance relating to dissolved chromium within CP02. There were no other exceedances when compared to the EQS screening values. The risk to controlled water is Low.</i>
Permanent Ground Gas	<i>Preliminary gas monitoring indicates that the site is within CS1 and gas protection measures will not be required in the proposed development. However, based upon observations on site and findings from previous investigations indicating the localised presence of free phase within shallow soils, vapour protective measures are required in proposed buildings in the vicinity of the PFS or remedial action undertaken. The level of gas protection measures will be confirmed on completion of the gas monitoring. The site lies in an area not requiring radon protective measures.</i>

Final Appraisal

The following further work is considered necessary to progress the site to construction phase:

- *Completion of gas monitoring programme and issue gas assessment.*
 - *Production of Remedial Specification.*
 - *Detailed foundation design.*
 - *Confirmation of remedial recommendations with the Regulators.*
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Plans

<i>Plan Reference</i>	<i>Revision</i>	<i>Title</i>
GRO-21252-P01	-	<i>Project Location Plan</i>
GRO-21252-P02	-	<i>Preliminary Development Constraints Plan</i>
GRO-21252-P03	-	<i>Illustrative Preliminary CSM</i>
GRO-21252-P04	-	<i>Combined Exploratory Hole Location Plan</i>
GRO-21252-P05	-	<i>Olfactory Contamination Plan</i>
GRO-21252-P06	-	<i>Laboratory Testing Contamination Plan</i>
GRO-21252-P07	-	<i>Obstructions Plan</i>
GRO-21252-P08	-	<i>Generalised Ground Model</i>
GRO-21252-P09	-	<i>Illustrative Revised CSM</i>

1.0 INTRODUCTION

1.1 Project Objectives

Groundtech Consulting Limited have been instructed by Aldi Stores Ltd and their consultant Craddys to undertake a Geo-Environmental Appraisal for a site off Afan Way in Port Talbot.

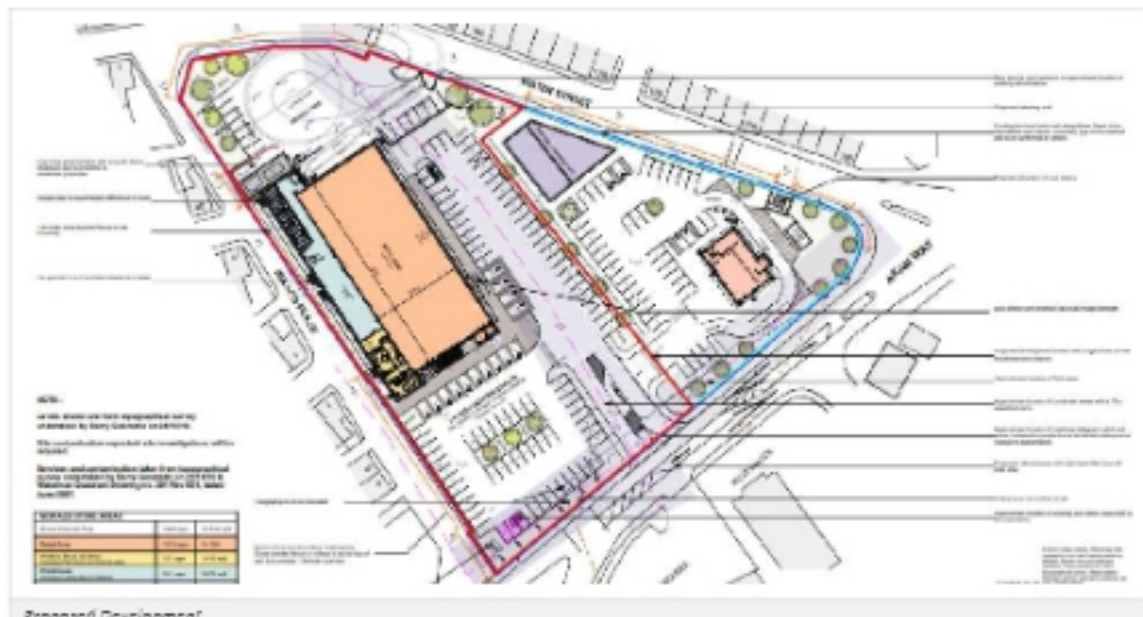
The objectives of the Preliminary Risk Assessment were to establish the sites environmental and geotechnical background in order to generate a Conceptual Site Model to identify any potential constraints and linkages which may affect the redevelopment of the site.

A main investigation was undertaken in accordance with BS 5930:2015, BS 10175:2017, BS 8576:2013 and Eurocode 7 to revise the CSM and quantify the level of risk identified in the PRA. The Appraisal has been prepared in accordance with current UK Legislation and to discharge Land Quality pre-commencement planning conditions. Several phases of investigation have previously been undertaken on the site, these reports are discussed where relevant.

The report has been undertaken to fulfil the requirements of a preliminary risk assessment in accordance with current risk assessment guidance.

1.2 Proposed Development

The proposed development is commercial end-use comprising the construction of an Aldi retail store with service yard and car parking. A separate drive thru unit and commercial unit will be constructed to the east of the Aldi store.



1.3 Limitations

This Preliminary Risk Assessment is based on information obtained from a number of sources, and the information is assumed to be correct.

Other conditions may exist on the site that have not been taken into account in this assessment as they are outside the scope of works. Groundtech Consulting are not responsible for these circumstances that are not outlined in the report.

The assessment has been prepared for the exclusive use of the client. No third parties may rely on or reproduce the contents of the report without the written permission of Groundtech Consulting Limited. If any unauthorised third party comes into possession of the report, they rely on it at their own risk and Groundtech Consulting Limited will not be obliged to provide a duty of care.

2.0 SITE SETTING

2.1 Location

The site is located circa 6.73 miles east of Swansea Town Centre, as shown on the Project Location Plan (GRO-21252-P01) and is approximately centred on National Grid Reference 275907, 189837.



Project Location

Access to the site is gained off Water Street to the north.

2.2 Site Description

The site is roughly triangular in shape covering an area of approximately 1.12 hectares, site elevations fall slightly from west to east.

Site Features

The site surfacing is largely scrub, grass and light vegetation. Hardsurfacing is present at the site entrance comprising tarmac which is in poor condition. Remnant concrete footings from two steel framed buildings are present in the western and south western areas. A small electricity substation sitting on a concrete slab is situated in the southern corner of the site.

Small localised areas of concrete are present in the eastern and central areas associated with the sites previous uses. Small mounds and stockpiles are also present in the central and eastern site areas comprising soils and demolition waste.

Fly tipping is evident across the site and includes discarded tyres and general litter.

Boundaries and Surrounding Area

The site boundary is delineated by a 2m high brick wall to the north east and 2m high metal hoarding around the remaining extents of the site. The site is bound by Water Street to the north, Afan Way to the east and Isaacs Place to the west.

The site is surrounded by following features/land uses:

- North - Water Street and residential development.
- East - Water Street and residential development.
- South - River Afan and weir.
- West - Isaacs Place and residential development.

Site photographs are presented in *Appendix 2*.

3.0 SUMMARY OF PREVIOUS INVESTIGATIONS

A summary of available and existing site information is summarised below. Geo-environmental test data obtained from the Quantum Geotechnical investigation and the Arcadis Ground Investigation has been made available in electronic form and where relevant has been referred to below.

3.1 Quantum Geotechnical Supplementary Phase II GI Interpretative Report (G762/IR)

Scope of Works

The following scope of works was carried out between 2nd December and 14th December 2015:

- 6 No. light cable percussive boreholes.
- 19 No. windowless sample boreholes.
- 22 No. machine excavated trial pits.
- 4 No. machine excavated trial trenches.
- 11 No. in-situ California Bearing Ratio tests.
- Photo-Ionisation Detector (PID) readings of selected soil samples for Total Volatile Organic Compounds (VOCs).

Ground Conditions

Made Ground was encountered to a maximum depth of 3.1m bgl beneath the site comprising black sandy gravel with a medium to high cobble content and low boulder content. The Made Ground minor constituents comprised sandstone, mudstone, limestone, brick, concrete, slag, metal, plastic, glass and concrete.

A Made Ground stratum defined as a 'Mixed Layer' was observed in the east of the site, underlying the main Made Ground populations, and overlying the natural Estuarine Alluvium Deposits. This layer comprised medium dense brown slightly silty gravelly very clayey sand with wood fragments.

Natural strata encountered on the site consisted of Estuarine Alluvium Deposits recorded between 2.1m and 3.7m bgl comprising very soft to soft grey silty Clay occasionally interbedded with orange brown slightly silty very sandy Clay and grey mottled light brown sandy Clay. Fluvial Glacial deposits were found underlying the Alluvium at a typical depth range between 3.5m and 6.6m bgl and consisted of dense to very dense brown sandy Gravel.

Visual and olfactory evidence of contamination was noted within the soils across the site. All cases of contamination related to strong to very strong hydrocarbon odours within both the sandy clay and gravel at depths ranging between 0.9m and 4.3m bgl. Sheens were also noted within the Gravel at depths between 3.5m and 4.3m bgl. Groundwater sheens were also observed in a number of trial pits and window sample boreholes.

Buried brick structures including walls and a culvert were encountered, numerous concrete obstructions were also observed.

The following risks were identified within the assessment for a residential end use:

Human Health

- Elevated Tin leachate in Made Ground at 0.6m bgl.
- Elevated Cadmium leachate at 1.0m and 2.5m bgl.
- Elevated Mercury leachate levels at 1.0m and 2.5m bgl.
- Asbestos encountered at 0.3m to 1.6m bgl.

Controlled Waters

- Extremely high concentrations of speciated TPH were recorded in all groundwater samples that were tested from the site.
- Elevated concentrations of heavy metals including Arsenic, Copper, Nickel, Tin and Zinc were encountered across the site particularly in the vicinity of the former PFS, council yard and former pond areas.

Ground Gas

- Preliminary results classify the site as CS-1.
- PID screening results from soil samples indicate significant risk posed from harmful volatile vapour gases emitting from the shallow soils. There is likely to be a requirement for a Volatile Organic Compound vapour membrane and measures to be implemented.

Remedial Work (Recommended by Lee Remediation Ltd in 2008)

- Removal of free product hydrocarbons from 1.2m diameter ring wells constructed to the Fluvio-Glacial Gravels.
- Excavation and ex-situ bioremediation of hydrocarbon impacted soils.
- Confirmatory monitoring of groundwater over a period of up to 6 months.
- Provision of vapour protection measures in new buildings on the former PFS including a gas membrane and passively ventilated sub-floor layer.
- Protection to water supply pipes.

Remedial Work (Recommended by Quantum)

- Offsite disposal of all Made Ground following hydrocarbon remediation works, and replacement with imported inert fill material.
- Ground improvement if shallow foundations are to be adopted.

Shallow foundations were not considered to be a suitable foundation solution due to the low strength soft Clay present at founding depth, unless ground improvement is undertaken. The deeper Fluvio-Glacial Deposits offered allowable bearing capacities in excess of 150kN/m², however the depth typically exceeds 3.0m across the site and significant groundwater would be encountered forming deep trench foundations difficult.

Deep piled foundations would pose a significant risk in creating a new source-pathway-receptor linkage through the overlying contaminated soils and waters. If the overlying soils were to be remediated to permit installation of pile foundations, this may be an option but may not be economically viable.

3.2 Arcadis Burrows Yard Remedial Options Appraisal and Remedial Strategy

Arcadis were instructed by Neath Port Talbot County Borough Council (NPTCBC) to compile a remedial options appraisal and remedial strategy.

The recommended strategy is as follows:

- Dispose of existing waste mounds that are present on site, and the two locations of buried asbestos containing bulk materials.
- Maintain a watching brief during all further remedial activities.

- Surface pick to remove existing sharps (related to drug use) and fragments of visible asbestos containing materials (ACMs).
- Dismantle existing steel frame structures, grub out foundations where required.
- Pull up tarmac and concrete surfacing (crush if suitable for re-use / e.g. via CL:AIRE CoP).
- Remove (recover) floating NAPL (diesel and petroleum spirit that is less dense than water) from the upper groundwater surface to the extent possible by current industry recognised techniques.
- Remediate PFS and similarly impacted contaminated Made Ground and natural sandy Clay soils.
- In all soft landscaped areas, excavate a sufficient amount of contaminated materials to enable a robust depth of clean cover material.
- Remediate leachable materials in soft landscaped areas
- Elevated Cadmium leachate at 1.0m and 2.5m bgl.

3.3 Arcadis Burrows Yard Ground Investigation Report

The following scope of works was completed between 4th December and 12th December 2017:

- 4 No. cable percussive boreholes.
- 6 No. machine excavated trial pits within existing waste mounds.
- 12 No. machine excavated trial pits across the site.
- 20 No. laser induced fluorescence tests.

The following observations of contamination were made during the fieldwork:

- Strong hydrocarbon odour in ABH04 2.3m bgl.
- Strong hydrocarbon odour in ATP06 2.0m to 2.1m bgl.
- Groundwater sheen in ATP08a 2.2m bgl.
- Organic odour in M04a GL to 1.0m bgl.
- Potential asbestos fragment in M06 0.1m to 1.4m bgl.
- Potential asbestos in LIF01a in pit wall face.
- Pocket of granular material, possibly degraded tarmac at 0.5m bgl.

3.4 Arcadis Burrows Yard Revised Remedial Strategy

Ground Conditions

Made Ground topsoil was found to a depth of 0.2m with general Made Ground present to a maximum proven depth of 2.7m bgl comprising clayey sandy gravel, clayey gravelly sand, and sandy gravelly clay with high cobble content.

Made Ground encountered within the waste mounds comprised dark grey brown slightly clayey sandy gravel with a high cobble content. The gravel comprised brick, plastic, glass, wood and concrete.

Cohesive Estuarine Alluvium deposits comprising sandy gravelly Silt or soft to firm slightly sandy Clay was encountered at depths between 2.0m and 4.7m bgl. Granular Estuarine deposits comprising dense light orange brown sandy Gravel or very gravelly Sand with low to medium cobble content was encountered at depths between 3.6m to a maximum proven depth of 10.0m bgl.

Geo-Environmental Testing - Soils

30 No. samples of Made Ground were screened for the presence of asbestos fibres. Quantification analysis was undertaken on 21 of the samples across the site which had a positive identification for asbestos fibres.

Two samples of suspected ACM fragments were tested for identification, Chrysotile and cement type material was identified in both samples.

7 No. natural samples and 5 No. Made Ground samples were analysed for metals. No exceedances were recorded from the natural samples tested. Exceedances were recorded in two samples of Made Ground from the waste mounds which are to be removed offsite.

9 No. natural samples and 7 No. Made Ground samples were tested for TPH CWG including BTEX. Exceedances of Benzene was recorded in ABH04 at 3.8m bgl. An exceedance in TPH Aromatic C16-C21 was recorded in ATP06 at a depth of 2.0m to 2.1m bgl. Both exceedances were in natural strata.

Geo-Environmental Testing - Vapours

9 No. natural samples were analysed for Contaminants of Concern, exceedances of Naphthalene were recorded in two samples from ABH04, benzene in one sample from ABH04, and TPH Aromatic C16-C21 in one sample from ATP-6. All of these samples are in the vicinity of the former PFS in the eastern site area.

It is considered unlikely that there is a risk of vapour generation to future site users in areas of soft landscaping due to the presence of heavy end hydrocarbon fractions and the depth of which they were identified. Any hardstanding will effectively sever the pathway for exposure from vapours. A watching brief should still remain in place and the removal of residual LNAPL and removal of overtly TPH impacted soils should be carried out in order to address any issues relating to odours and quantitative vapour risks.

Geo-Environmental Testing - Groundwater

21 No. groundwater samples were collected from the mobile groundwater and screened for metals. 13 No. exceedances in Copper, Manganese and Zinc were recorded. Most exceedances were in the same order of magnitude as the EQS, however Copper and Manganese were up to twice the EQS, but not regularly exceeded. Zinc concentrations were recorded at 7 to 8 times the EQS. There is a modest degree of metallic impaction of the mobile groundwater due to infiltration and leaching from site soils. Development of the site will reduce infiltration and this mitigation is integral to the design. Groundwater migrates towards the coast and the inter-tidal River Afan therefore significant dilution of metals will rapidly occur.

All 21 No. groundwater samples screened for speciated PAHs were below the laboratory limit of detection in all three monitoring rounds.

All 21 No. groundwater samples screened for TPH CWG and BTEX were below the laboratory limit of detection. This indicates that previous results from the Quantum investigation in 2015 were a "false positive" and representative of water quality encountered in shallow excavations where control of water ingress and the recovery of residual LNAPL will need to be undertaken.

Data from the LIF probe indicates that LNAPL is present as residual pockets of weathered LNAPL likely associated with former petrol station and tanks, but there is no site wide mobile or recoverable layer of LNAPL. There are likely some areas where quantities of LNAPL will allow for the use of physical recovery methods to remove LNAPL from the water surfaces.

Waste Disposal Testing - Stockpiles

6 No. samples of Made Ground from the waste mounds were identified as *Hazardous* and 4 No. other samples were classified as *Non-Hazardous*.

Waste Disposal Testing – Made Ground

39 No. samples of general Made Ground from across the site were analysed and 5 No. were classified as *Hazardous* with respect to TPH, 5 No. were classified as *Hazardous* due to the concentration of metals and speciated PAH compounds, the remaining soils were classified as *Non-Hazardous*.

Remedial Strategy

The below recommendations have been made:

- *It is recommended that 90% of the site is covered in hardsurfacing with an imported clean cover layer 800mm thickness in soft landscaped areas to mitigate any risk relating to the exposure of future site users to contaminated soils or the inhalation of indoor and outdoor vapours.*
- *Water supply pipes should be protected with barrier piping to prevent the infiltration contamination to drinking water.*
- *A watching brief should be maintained during the works to identify any areas of residual LNAPL. Impacted materials should be removed and the remaining soils should be validated against the LQM/CIEH soil saturation limit values.*
- *A materials management plan should be in place to segregate impacted material from 'clean' material to minimise the volume of material requiring disposal as Hazardous Waste.*
- *All impacted excavated materials including the waste mounds that are in excess to the development plans should be disposed of in accordance with relevant waste legislation.*
- *Asbestos fibres are present in the Made Ground and suitable measures should be in place to mitigate the risk of airborne fibres.*
- *Concrete and tarmac should be recycled and used onsite where possible.*
- *Below ground obstructions and foundations should be removed and recycled where appropriate.*
- *A full services survey should be undertaken to identify unmarked services including the brick culvert which may require further investigation.*
- *Removal of below ground fuel tanks if encountered and validation of remaining soils.*

All relevant site features are recorded on the Preliminary Development Constraints Plan GRO-21252-P02.

4.0 ENVIRONMENTAL SETTING

4.1 Site History

Available historical maps have been obtained, a list of dates and scale are listed in the table below:

Scale	Date
1:1,250	1950/51, 1951/52, 1958, 1957/62, 1967, 1964/68, 1971/75, 1979, 1988/91, 1989/93, 1991/93, 2003.
1:2,500	1881, 1899, 1917, 1939, 1951/53, 195/957, 1967/68.
1:10,000/10,560	1884, 1897/1900, 1914, 1921, 1947, 1957, 1957/62, 1965, 1980/82, 1993/95, 2001, 2010, 2021.

The plans were examined and potential issues have been identified and summarised in the table below:

Date	Site	Surrounding Area
1881	Site is occupied by Burrows Tin Plate Works with numerous buildings. Possible pond in western area.	Port Talbot Chemical Works immediately to the north. Marshland immediately south east. Afon-vale Tin Plate Works c.100m east. Tramway c.100m south. Marshland immediately south and c.100m west. Gas Works c.150m north east.
1897-1900	Possible pond no longer shown, infilled.	Margam & Mansel Tin Plate Works c.150m east. Iron Foundry c.100m southwest. Gasometer c.400m west.
1899	Site no longer labelled as Burrows Tin Plate Works. Railway lines on western area.	Port Talbot Chemical Works immediately to the north now residential housing fronted by Scythian Road. Glanwalia Tin Plate Works immediately west. Saw Mill c.100m north east. Tin Plate Works c.110m east now 'disused'. Port Talbot Railway c.110m south. Port Talbot Iron Foundry c.120m south west. Swansea Bay Railway c.150m south west Gas Works c.150m north east no longer indicated.
1914	No apparent change.	Iron Works c.100m southwest. Port Talbot Steel Works c.450m east.
1917	No significant change.	Afon-vale Tin Plate Works c.100m east no longer present, presumed demolished.
1939	Tin Plate Works occupying western site area. Tank positioned centrally.	No apparent change.
1950/51	Tin Plate Works renamed Boro' Tinplate Works. Talbot Works Bakery Engineering in eastern site area. Additional Tank within Boro' Tinplate Works. Two Chimneys within Boro' Tinplate Works. Well in northern site area. Travelling Crane centre of the site. Residential dwellings in northern site area.	Slaughterhouse immediately east. Garage c.50m south west. Talbot Works Bakery Engineering c.55m south west. Engineering Works c.75m south west. Self-Sentering Works c.90m east. Allotment Gardens c.100m north west. Wagon Works c.110m south east. Numerous Chimneys c.120m south east.
1957/62	Tinplate works renamed Corporation Yard. Mortuary east of residential dwellings.	Three Warehouses c.50m south west.

	<i>Well in central eastern area.</i>	
1958	<i>No apparent change.</i>	<i>Self Sentering Works c.90m east renamed Works.</i>
1964/68	<i>Bakery Engineering Works renamed Sign Posts Works.</i>	<i>Pump House c.50m south Engineering Works c.75m south west renamed Bottle Top Works.</i>
1967/68	<i>No apparent change.</i>	<i>Works c.90m east renamed Repair Works.</i>
1971/75	<i>Residential dwellings no longer indicated, presumed demolished.</i>	<i>Bottle Top Works c.75m southwest renamed Metal Closures Works. Tyre Depot c.70m south east and c.100m east.</i>
1979	<i>No apparent change.</i>	<i>Works c.90m east renamed Depot & Garage.</i>
1988/91	<i>Electricity Substation southern corner of the site.</i>	<i>Metal Closure Works c.75m southwest renamed Works.</i>
1989/93	<i>Mortuary no longer indicated on site, building remains. Works no longer indicated on site, building remains.</i>	<i>No significant change.</i>
2001	<i>No apparent change.</i>	<i>Port Talbot Industrial Estate c.150m southeast.</i>
2003	<i>No apparent change.</i>	<i>Works c.75m southwest renamed Warehouse & Works. Garage c.110m southwest.</i>
2021	<i>Site vacant, all previous buildings presumed demolished.</i>	<i>No apparent change.</i>

The historical plans are presented in *Appendix 3*.

4.2 Geology

The following British Geological Survey (BGS) records and other available information were inspected to accurately determine the geology underlying the site:

- *1:50,000 Scale Geological Sheet 147 Swansea – Solid and Drift Edition.*
- *Memoir.*
- *BGS Records.*

Made Ground

Made Ground is not indicated to be present on site on the BGS maps. However, the previous investigations encountered 2 to 3m of Made Ground relating to historical land usage.

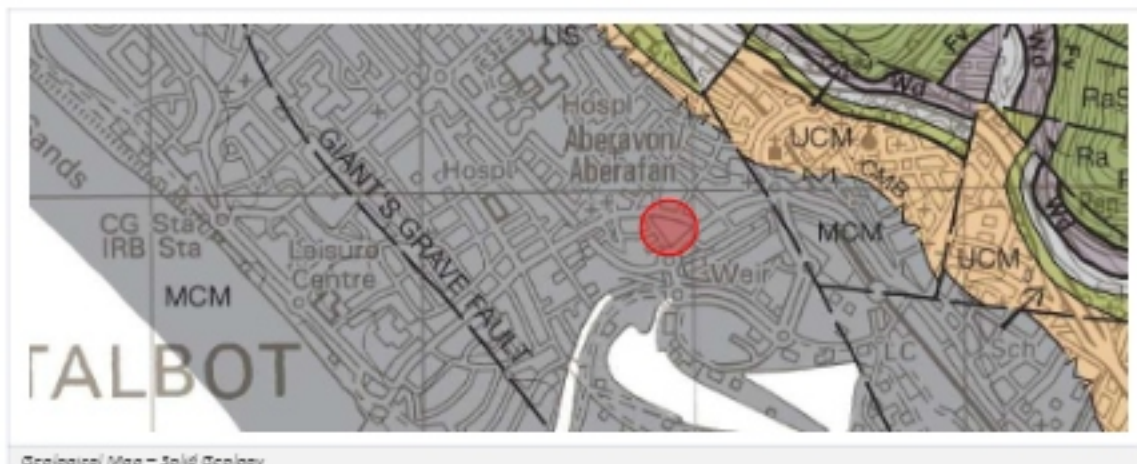
Superficial Deposits

The site is indicated to be underlain by Estuarine Alluvium Deposits which characteristically comprises Clay, Silt and Sand.



Solid Geology

The solid geology beneath the site is indicated to be of the South Wales Middle Coal Measures Formation comprising Mudstone, Siltstone, Sandstone and Coal seams.



Geological Faults

No faults are shown on or within an influencing distance of the site. The nearest fault is 0.3 miles to the east.

4.3 Hydrogeology

The superficial Estuarine Alluvium Deposits in this area are classified by the Environment Agency as a Secondary Undifferentiated Aquifer. This is assigned where it is not possible to attribute either category A or B to a soil type. In general, these layers have been previously designed as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.

The South Wales Middle Coal Measures Formation bedrock is classified as Secondary A Aquifer comprising permeable layers capable of supporting water supplies at a local level rather than a strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.

The soils beneath the site are classified as being of high leaching potential.

The site is not within 500m of a Source Protection Zone and there are no groundwater or potable water abstractions within 2000m of the site.

4.4 Hydrology

The nearest named watercourse is the River Afan which is circa 86m south. The overall rating of the river is Moderate, with a Good chemical rating and a Moderate ecological rating in 2016.

Environment Agency information indicates that the site lies within land that is naturally vulnerable to surface water ponding or flooding. A 1 in 30-year event is likely to result in 0.1m to 0.3m flooding.

The nearest active surface water abstraction is circa 107m south east relating to process water for usage by Tata Steel UK Ltd.

4.5 Environmental Consultations

A request has been submitted to the Contaminated Land Officer at Castell-nedd Port Talbot – Neath Port Talbot County Borough. At the time of writing the report a response was outstanding.

An environmental consultation has been conducted through Groundsure, which accesses British Geological Survey and Environment Agency databases. The complete Groundsure Report can be found in *Appendix 4* and a summary of the more relevant points is presented in the table below.

Record	<250m	250 – 500m	Description
<i>Authorised Processes</i>	-	1	<i>This is a Part B permit 448m east relating to a waste oil burner.</i>
<i>Pollution Incidents</i>	13	12	<i>Nearest was 9m north east relating to lubricating oils. General bio-degradable waste had a minor land impact 57m south east. A minor incident c.146m south west relating to dust.</i>
<i>Landfill and Waste Treatment</i>	3	3	<i>A scrap metal yard was c.118m east. Recycling centre was 212m south east.</i>
<i>Discharge Consents</i>	8	4	<i>Nearest was a discharge into the River Afan c.12m south east.</i>
<i>Petrol Filling Stations</i>	1	1	<i>An obsolete petrol filling station was present on site.</i>
<i>Current Industrial Uses</i>	24	-	<i>The nearest is c.20m north relating to Electronic Equipment. Unspecified tank 82m south west. Electricity substation 168m east.</i>

4.6 Radon

Map 11 Southwest Wales from BRE 211 and HPA were examined which defines areas requiring radon protective measures. The probability is less than 3% and the site is not an area requiring radon precautions in foundations in accordance with BRE Report 211 'Radon – Guidance on protective measures for new dwellings' 2015 Edition.

The radon data in the Groundsure report is supplied by the BGS/Public Health England and is the definitive map of Radon Affected Areas in Great Britain and Northern Ireland, the Groundsure report contradicts the Groundsure report recommendations and indicates that less than 1% of properties are affected and no radon

protection measures are required. The dataset was created using long-term radon measurements in over 479,000 homes across Great Britain and 23,000 homes across Northern Ireland, combined with geological data. The dataset is considered accurate to 50m to allow for the margin of error in geological lines, and the findings of this report supersede any answer given in the less accurate Indicative Atlas of Radon in Great Britain, which simplifies the data to give the highest risk within any given 1km grid square.

4.7 Coal Authority Consultation

The site lies in an area where the Law Society and Coal Authority recommends a mining consultation is undertaken due to past or current mining possible affecting the site.

A consultation was carried out with the Coal Authority, which is presented in *Appendix 5*, the main findings are outlined below.

Past Mining

The property is not within a surface area that could be affected by any past recorded underground coal mining.

Present Mining

The site is not within a surface area that could be affected by present underground mining.

Future Mining

The property is not in an area where the Coal Authority are determining whether to grant a licence to remove coal by underground workings.

The property is not in an area likely to be affected at the surface by any planned underground workings.

Reserves of coal exist in the local area that may be worked in the future.

No notice of the risk of land being affected by subsidence has been given under section 46 of the Coal Mining Subsidence Act 1991.

Mine Entries

There are no records of any mine entries on or within 20m of site boundary.

Coal Mining Geology

The Authority is not aware of any damage arising due to geological faults or lines of weakness that have been affected by coal mining.

Opencast Coal Mining

The property is not in an area affected by past or present coal mining extracted by opencast methods. The property is also not in an area affected by a proposed opencast coal mine.

Subsidence

The Coal Authority has not received a damage notice or claim for the subject property or within 50m since 31 October 1994.

Mine Gas

There is no record of mine gas emission requiring action by the Coal Authority within the boundary of the property.

Withdrawal of Support

The property is not in an area which notice of entitlement to withdraw support has been published.

Working Facilities Order

The property is not in an area where an order has been made, under the provisions of the Mines (Working Facilities and Support) Acts 1923 and 1966 or any statutory modification or amendment thereof.

5.0 CONCEPTUAL SITE MODEL AND RISK ASSESSMENT

5.1 Introduction

The potential level of risk posed by contaminants in soil and/or groundwater will be influenced by the type and concentration of the contamination at source, the likelihood of exposure occurring, the potential pollution linkages and the likely chronic or acute effects on the receptors.

A contaminant is defined as a substance that has the potential to cause harm, a risk is considered to exist if such a substance is present at sufficient concentrations to cause harm and if a pathway is present a receptor could be exposed to the contaminant.

Section 4.0 compiles the information from the previous sections to assemble a Conceptual Site Model to inform the risk assessment process. The potential sources identified on the site and off the site that are within influencing distance are assessed to determine if pollution linkages exist and an unacceptable risk is posed to human health and controlled waters. The assessment has been carried out on a qualitative basis and aims to produce a complete and comprehensive Preliminary Conceptual Site Model, the potential pollution linkages are displayed on Plan GRO-21252-P03 Illustrative Preliminary CSM.

Three potential types of impacts exist for a site and all three need to be considered in the qualitative preliminary risk assessment:

- *Impacts from sources on the subject site.*
- *Impacts to the surrounding area from the subject site.*
- *Impacts to the subject site from the surrounding area.*

5.2 Potential Contamination Sources

Onsite Sources and Associated Contaminants of Concern (CoC)

From the information obtained during the preliminary risk assessment there are several potential contaminative sources identified onsite which may affect the redevelopment of the site for commercial end use. These include the following:

- *General Made Ground*
- *Tin Plate Works*
- *Railway Line*
- *Tanks*
- *Engineering Works*
- *Chimneys*
- *Demolished buildings*
- *Mortuary*
- *Electricity Substation*
- *Petrol Filling Station*
- *Infilled pond*
- *Corporation Yard*
- *Perched Groundwater*
- *Existing stockpiles*

The relevant DoE Industry Profiles were consulted with regards to the sites historic industrial uses and the associated contaminants are presented below:

Industry Profile	Associated Contaminants of Concern	Required Testing
<i>Railway Lands</i>	<i>Fuel derived hydrocarbons, lubricating oils, creosote, herbicides, speciated PAHs PCBs, asbestos and ash.</i>	<i>Metals, speciated PAHs, Total Petroleum Hydrocarbons (TPH CWG), Volatile Organic Compounds (VOCs), Semi Volatile Organic Compounds (SVOCs), asbestos.</i>
<i>Tin Plate Works</i>	<i>Potassium stannate, tin metal, boric acid, sulphuric acid, sodium acetate, sodium stannate, phenol sulphonic or cresol sulphonic acid.</i>	<i>Metals, speciated PAHs, TPH CWG, VOCs, SVOCs.</i>
<i>Petrol Filling Station</i>	<i>Organic compounds, MTBE (Anti-Knocking Agent), chlorinated hydrocarbons, heavy metals, lubricating oils, and PAHs.</i>	<i>Metals, speciated PAHs, Total Petroleum Hydrocarbons (TPH CWG), Volatile Organic Compounds (VOCs), Semi Volatile Organic Compounds (SVOCs).</i>

General Made Ground has been recorded beneath the site and Contaminants of Concern identified were confirmed in subsequent laboratory testing. These contaminants include elevated tin leachate, cadmium leachate, mercury leachate, benzene, TPH Aromatic C16-C21, and asbestos.

Elevated levels of naphthalene, benzene, and TPH Aromatic C16-C21 identified from the previous investigations are spatially situated in the footprint of the former petrol filling station and are likely to be related.

Heavy metal contamination has been detected across the entire site, which is associated with the former tin plating works that occupied a large area in the south west of the site.

No elevated concentrations of Polychlorinated Biphenyls have been identified surrounding the electricity substation.

Potentially harmful volatile vapour emissions from shallow hydrocarbon impacted soils is likely, and PID screening results from the Quantum investigation indicate the potential for significant risk. The backfilled pond coupled with the tidal flat deposits are also sources of potentially harmful ground gases.

Offsite Sources and Associated Contaminants of Concern (CoC)

Several potential contaminative sources have been identified within influencing distance offsite, including:

- *Glanwalia Tin Plate Works immediately west.*
- *Slaughterhouse immediately east.*
- *Engineering Works c.90m east, c.50m south west, and c.75m south west.*
- *Pump house c.50m south.*
- *Garage c.50m southwest and c110m south west.*
- *Marshland immediately south east and c.100m west.*
- *Iron Foundry c.100m south west.*
- *Sawmill c.100m north east.*
- *Tyre depot c.100m east.*
- *Allotment gardens c.100m north west.*
- *Railway c.110m south.*
- *Wagon Works c.110m south east.*
- *Port Talbot Chemical Works c.150m north east.*
- *Swansea Bay Railway c.150m south west.*

- *Port Talbot Industrial Estate c.150m south east.*

The area surrounding the site has historically been associated with heavy industry such as railway land, sawmills, and chemical works, all of which are potential sources for metals, PAHs, VOCs, SVOCs, and asbestos. A slaughterhouse was present immediately to the east, which according to the DoE profile may be a source of solvents, acids, alkalis, detergents, bleaches, and fuel oils. According to the DoE profile, the garages to the south and southwest are both potential sources of fuel derived hydrocarbons.

The marshland immediately to the south east and 100m to the west are potential sources of harmful ground gases.

5.3 Pollution Linkages

The definition of a pollution linkage is a medium which allows a contaminant to impact a receptor. Potential pollution linkages have been recognised for the commercial development from the identified contamination sources that exist.

At this stage, the contaminants identified above are considered to potentially pose an unacceptable risk to human health and controlled waters through the following pollution linkages:

- *Direct soil and dust ingestion.*
- *Dermal contact with soil both indoors and outdoors.*
- *Indoor air inhalation from soil and vapour.*
- *Outdoor inhalation of soil and vapour.*
- *Migration and accumulation of ground gas into internal spaces.*
- *Impaction of groundwater from soil contamination (diffuse and point).*
- *Impaction of groundwater from groundwater plume.*
- *Migration of soil and groundwater contamination impacting surface waters.*

5.4 Receptors

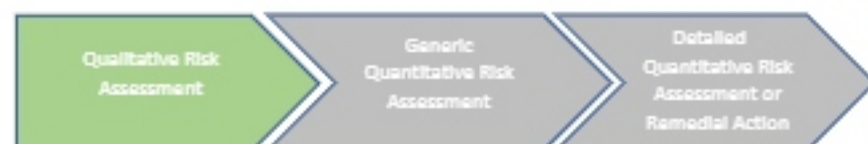
Receptors generally fall into the categories of human health or controlled waters within the river basin system. The recognised receptors are listed below:

- *River Afan c.86m south.*
- *Secondary A Aquifer (Bedrock).*
- *Future site end-users.*
- *Water supply pipes.*

5.5 Preliminary Conceptual Site Model (CSM)

The factual information obtained from the consultations and summarised in Section 2.0 and 3.0 has been used to compile a Preliminary CSM. Using Source-Pathway-Receptor assessment criteria that is applicable in the UK, a risk assessment has been completed to determine if a plausible pollution linkage exists between the identified contaminants and receptors. The risk classification has been estimated in accordance with the CIRIA C552 assessment criteria outlined in *Appendix 6*.

Human Health Pollution Linkage Assessment



- o The table below represents the first stage in the land quality risk assessment process - the Qualitative Risk Assessment.
- o In order for a development site to be deemed 'suitable for use' the level of risk needs to be reduced to an acceptable level - low to negligible risk. The purpose of each stage of risk assessment is to establish if there is a requirement for additional stages of assessment in order to have sufficient confidence to support a risk characterisation or remedial action.

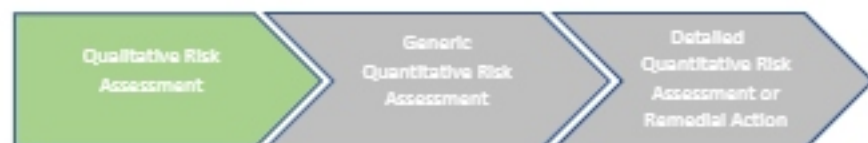
Conceptual Site Model					Qualitative Risk Assessment	
PL	Potential Source	Pollution Linkage	Likelihood	Consequence/ Severity	Risk Rating	Rationale and Action
PL1	Contaminated Soils	Ingestion of soil and dust. Dermal contact with soil.	Unlikely	Medium	Low	Pollution Linkage 1 refers to proposed site users encountering contaminated soils on the site. The site is currently vacant, but has been previously used as a Tin Plating Works, general Engineering Works, Railway, Petrol Filling Station, and an electricity substation is present in the south eastern corner of the site. Contaminated Made Ground is present on site as indicated from the previous Ground Investigations and the historical land uses highlighted in the desktop study. Tanks have been indicated to be present onsite both above ground and below ground. A wide range of materials may have been stored in the tanks including but not limited to fuel derived hydrocarbons, organic compounds, inorganic compounds, sulphur containing compounds, metals and metalloids. Any of these contaminants may have impacted the area as a result of potential spillages/leakages. Depending on the age of the electricity substation in the south eastern corner of the site, PCBs may have been used as a cooling agent within the transformers, however

Conceptual Site Model					Qualitative Risk Assessment	
PL	Potential Source	Pollution Linkage	Likelihood	Consequence/ Severity	Risk Rating	Rationale and Action
						due to the relative immobility, the small volume used and the substation situated on a concrete base - they are unlikely to have impacted the site significantly. Widespread asbestos has been identified across the site by the previous investigations by Quantum and Arcadis which pose a threat to human health and site end users. The proposed development is to be largely covered in hardsurfacing therefore breaking the pollution linkage and significantly reducing the risk posed to site end users from ingesting contaminated soils. In any areas of soft landscaping a cover system and a hard dig layer would likely be required to prevent ingestion or dermal contact with contamination.
PL2	Contaminated Soils	Inhalation of vapour.	Low likelihood to Likely	Medium to Severe	Moderate to High	This pollution linkage refers to volatile vapours migrating into confined spaces within the proposed development. The previous investigation by Arcadis found evidence for the shallow impaction of soils with hydrocarbons, and to mitigate against the risk of vapours, recommend that as a precaution gas/vapour protective measures alongside sub floor voids should be incorporated into the design of all buildings. A viable pollution linkage has been identified.

Conceptual Site Model					Qualitative Risk Assessment	
PL	Potential Source	Pollution Linkage	Likelihood	Consequence/ Severity	Risk Rating	Rationale and Action
PL3	Contaminated Soils	Inhalation of soil dust by adjacent site users.	Unlikely	Medium	Low	<i>Pollution Linkage 3 relates to contamination on the subject site affecting adjacent site users. All the contaminative sources identified on site are indicative of the surrounding area and potentially less impactful sources than the surrounding sources, therefore no plausible pollution linkage is considered to exist.</i>
PL4	Contaminated Soils	Attacking potable water supply pipe.	Likely	Medium	Moderate to High	<i>Pollution Linkage 4 refers to the possible contaminants permeating potable water pipes and consumption by the future site and users of the tainted water supply. Made Ground will be present at installation depth which is contaminated with a range of contaminants including hydrocarbons. New potable water supply pipes will be included as part of the development and a pollution linkage is considered to exist, standard PE pipe is unlikely to be suitable. A local water company risk assessment is required prior to construction to advise on the level of protection required for the potable water supply.</i>
PL5	Ground Gas	Migration and accumulation of ground gas in internal spaces.	Likely	Medium to Severe	Moderate to High	<i>Deep Made Ground is likely present beneath much of the site due to the presence of the historic Tin Plate Works, Engineering Works, Well and previously demolished buildings. Depending on the composition of the backfill material ground gases may be generated.</i> <i>The surrounding areas particularly to the south and west were historically marshland, and the decay of the organic material is a potential ground gas source including from the Tidal Deposits.</i>

Conceptual Site Model					Qualitative Risk Assessment	
PL	Potential Source	Pollution Linkage	Likelihood	Consequence/ Severity	Risk Rating	Rationale and Action
						Potential onsite and offsite sources of ground gases have been identified therefore the installation and subsequent monitoring of ground gas wells is required. The site is not within an area requiring radon precautions.

Controlled Waters Pollution Linkage Assessment



- o The table below represents the first stage in the land quality risk assessment process – **Qualitative Risk Assessment**.
- o In order for a development site to be deemed 'suitable for use' the level of risk needs to be reduced to an acceptable level - low to negligible risk. The purpose of each stage of risk assessment is to establish if there is a requirement for additional stages of assessment in order to have sufficient confidence to support a risk characterisation or remedial action.

Conceptual Site Model					Qualitative Risk Assessment	
PL	Potential source	Pollution linkage	Likelihood	Severity	Level of risk	Rationale
PL6	Contaminated Soils	Impection of groundwater from soil contamination (diffuse and point). Impection of groundwater from groundwater plume.	Unlikely	Medium	Low	<i>Pollution Linkage 6 refers to the impaction of the Secondary Undifferentiated Superficial Aquifer and the Secondary A Bedrock Aquifer on site.</i> <i>From previous investigations and the historical land use of the site, it is known that contaminated Made Ground is present on site. The main use for the site has been as a Tin Plating Works which is likely to have resulted in gross contamination from a range of contaminants including metals, organic acids, solvents, PCBs and hydrocarbons.</i> <i>Information obtained from the previous Ground Investigations indicate that although the perched groundwater within the Made Ground is contaminated with hydrocarbons, this groundwater is not mobile, nor indicative of the mobile groundwater within the Secondary Undifferentiated Superficial Aquifer on site.</i> <i>There is evidence for the local background impact of metal contamination on the groundwater in the area, and also the indication of slight impairment as water passes beneath and through the site. This is likely due to the sites historical use as a Tin Plating Works and the surrounding areas numerous historical metal plating works.</i>

Conceptual Site Model					Qualitative Risk Assessment	
PL	Potential source	Pollution linkage	Likelihood	Severity	Level of risk	Rationale
						Geological maps indicate and previous investigations confirm that the site is underlain by cohesive Estuarine Alluvium deposits overlying granular deposits. A pollution linkage is not considered to exist between potentially contaminated perched groundwater and the Secondary A Aquifer as the cohesive deposits encountered across the site will act as an aquitard preventing the downward migration of contaminated groundwater. The site is not within 500m of a SPZ and the groundwater is not considered to be a sensitive resource. There is not a recorded groundwater abstraction within 2000m of the site. The proposed development is to be largely covered in hard surfacing therefore further reducing the infiltration of water through the contaminated soils, reducing the leaching of potential contaminants. The risk to groundwater is Low.
PL7	Contaminated Soils	Migration of soil and groundwater contamination impacting surface waters.	Low Likelihood	Medium	Low	Pollution Linkage 7 refers to the impact of the River Afan c.86m south of the site from contaminated soils and groundwater. Sources of mobile contaminated have been identified in the desk-based consultations and through previous investigations by Quantum and Arcadis relating to the industrial history of the site. Based upon information from the previous ground investigations the majority of contamination is found to be perched in Made Ground, which is not mobile nor in continuity with the River Afan, and the migration of groundwater towards the coast will allow for significant dilution of contaminants. The risk to surface waters is Low.

6.0 SCOPE OF INVESTIGATION AND RATIONALE

6.1 Project Objectives

The aim of the fieldwork was to:

Determine the stratification beneath the site
Maintain a watching brief for visual and olfactory evidence of contamination
Obtain samples using methodology in current guidance for contamination analysis
Identify realistic pollution linkages to groundwater
Obtain relevant geotechnical parameters for preliminary foundation design to address both ULS and SLS conditions
Determine if targeted supplementary investigation in areas of concern is required and for remedial design
Install monitoring standpipes for gas and groundwater monitoring
Assess the identified pollution linkages in the CSM
Confirm the findings of the previous Ground Investigations
Achieve better coverage tailored to revised development layout
Locate below ground obstructions associated with previous development

6.2 Scope of Works

The following scope of works was completed between the dates of 29th of September and 4th of October:

- 4 No. cable percussive boreholes (CP01 to CP04) to a maximum depth of 7.0m bgl.
- 6 No. windowless sample boreholes (WS01 to WS06) to 4.0m bgl.
- 15 No. machine dug trial pits (TP01 to TP15) were excavated to a maximum depth of 3.4m bgl.
- 6 No. plate load tests were carried out at proposed formation level.

The exploratory hole locations are presented on Groundtech Plan GRO-21252-P04 and the exploratory hole logs are presented in Appendix 7.

The exploratory holes were positioned to establish the stratification beneath the site, and target any areas of concern as summarised in the table below:

Location	Target Rationale
TP03, TP04 WS06	Former Petrol Filling Station
TP03 to TP05, WS05, WS06, CP04	Above ground Tanks
TP02, TP13, TP15 WS03	Backfilled Pond
TP06, TP08, TP12 WS01 CP03	Former Tin Plating Works
TP06 WS01	Former railway
TP07, TP14	Electricity Substation
WS05	Former Corporation Yard

CP02	
CP01 – CP04	Proposed Aldi store building footprint

The exploratory holes were logged by a suitably experienced geo-environmental engineer in general accordance with the following current guidance:

- BS 5930 'Code of Practice for Site Investigations' 2015.
- BS EN 14688-1:2002 'Geotechnical Investigation and Testing – Identification and classification of soil'.

6.3 Soil Sampling

During the intrusive investigation, representative samples were taken at regular intervals, changes of strata and where evidence of contamination existed. Laboratory analysis was scheduled on the samples obtained.

The samples obtained are summarised in the table below:

Soil Sample	Number
Environmental Sample	101
Disturbed Sample	37
Undisturbed U100 Sample	3

The samples have been obtained in accordance with current environmental and geotechnical guidance. The sampling plan has been designed to obtain samples from all required strata using the correct methodology.

Disturbed samples of soil for geo-environmental testing were placed in the correct sampling containers as required by the laboratory in accordance with their MCERTS and UKAS Accreditation. Transportation was arranged in a timely manner and the samples were at the correct temperature.

The sample locations and depths are recorded on the exploratory logs.

6.4 Geo-Environmental Testing

To inform the Generic Quantitative Risk Assessment, the following geo-environmental testing was scheduled to assess the risk from contamination on the site. The testing is based on the potential sources identified in the PRA and observations during the Ground Investigation.

Contaminants of Concern	Matrix	Number
Arsenic, cadmium, chromium (total and hexavalent), copper, lead, mercury, nickel, selenium, zinc and pH	Soil	15
Speciated Polycyclic Aromatic Hydrocarbons (PAH16)	Soil	15
Asbestos Screening	Soil	15
Asbestos Quantification	Soil	4
Total Petroleum Hydrocarbons (TPH CWS) and BTEX	Soil	6
PolyChlorinated Biphenyls (PCBs)	Soil	2
Volatile Organic Compounds (VOCs)	Soil	6
Semi-volatile Organic Compounds (SVOCs)	Soil	6
Waste Acceptance Criteria (WAC)	Solid and Eluate	4

Arsenic, cadmium, chromium (total and hexavalent), copper, lead, mercury, nickel, selenium, zinc and pH.	Groundwater	4
Speciated Polycyclic Aromatic Hydrocarbons (PAH16)	Groundwater	4
Total Petroleum Hydrocarbons (TPH CWG) and BTEX	Groundwater	4
Volatile Organic Compounds (VOCs)	Groundwater	4
Dissolved Organic carbon	Groundwater	4
Hardness	Groundwater	4

The Geo-Environmental Laboratory Testing Results for the soils are presented in *Appendix 8* and the groundwater results are in *Appendix 9*.

Representative disturbed samples were obtained for all soil types encountered. Selected samples were scheduled for testing at an approved laboratory in accordance with BS 1377 'Method of Test for Soils for Civil Engineering Purposes' 1990. The following tests were scheduled:

British Standard	Test Method	Number
Part 2	Water Content	4
Part 2	Plasticity Index Analysis	4
Part 3	pH Value	5
Part 3	Water Soluble Sulphate Content	5
Part 7	Undrained Shear Strength in Triaxial Compression	4

The Geotechnical Laboratory Testing Results are presented in *Appendix 10*.

6.5 Gas and Groundwater Monitoring

Gas and groundwater monitoring installations were constructed in the boreholes. The standpipes consisted of polyvinyl chloride (PVC) and high-density polyethylene (HDPE) pipe - a bentonite seal was placed around the plain pipe and a clean gravel pack was placed around the slotted pipe. A summary of the installation construction is presented in the table below:

Location	Depth	Response Zone (m bgl)	Targeted Strata	Reason
CP01	6.0	5.0 - 6.0	Natural	Groundwater
CP02	7.0	6.0 - 7.0	Natural	Groundwater
CP03	6.0	5.0 - 6.0	Natural	Groundwater
CP04	6.0	4.0 - 6.0	Natural	Groundwater
WS02	4.0	1.0 - 4.0	Made Ground and Natural	Ground Gas
WS03	2.0	1.0 - 2.0	Made Ground	Ground Gas
WS05	4.0	1.0 - 4.0	Made Ground and Natural	Ground Gas
WS06	4.0	1.0 - 4.0	Made Ground	Ground Gas

Permanent gas and flow rate monitoring was carried out using a GFM 436 infrared gas monitor with integral electronic flow analyser. The measurements taken are listed below:

- Oxygen (O_2), carbon dioxide (CO_2) and methane (CH_4) as the percentage volume in air (%v/v).
- Hydrogen sulphide (H_2S) and carbon monoxide (CO) as the percentage volume in air (%v/v).
- Lower Explosive Limit (%LEL) of methane.

- *Atmospheric and borehole pressure, including pressure trend.*
- *Flow measurements (l/hr).*
- *Weather and ground surface conditions.*

Both peak and steady state conditions were monitored to understand the behaviour of the permanent ground gas, the steady state conditions were recorded by allowing the gas monitor to run for a minimum of 3 minutes.

Interim permanent gas and groundwater monitoring results are presented in *Appendix 11*.

6.6 Groundwater Sampling

Well development was carried out to ensure no cross contamination from the drilling activities remained in the water column in the well. The installations were purged to a minimum three times the volume of the water column in the borehole prior to sampling.

The method of sampling selected was by low flow pumping due to the contamination identified during the previous investigations. Where possible, a water meter was used to test the pH, temperature and conductivity before sampling until equilibrium conditions were met in accordance with BS 10175 guidelines.

Samples were sent to the UKAS Accredited laboratory the same day sampling was carried out in general accordance with BS 5930 and BS 5667.

6.7 Vapour Survey - Photo Ionisation Detector

Standard sampling protocol and preservation of samples was undertaken as described in the EA guidance on site investigation. The on-site monitoring was carried out in line CIRIA C6658 to aid targeting samples for VOC laboratory analysis.

Soil was collected for onsite testing, a plastic bag was half filled with soil allowing a suitably sized headspace. The bag was sealed and stored for at least 20 minutes before being tested for Total Volatile Organic Compounds (TVOCs) using a Photo Ionisation Detector (PID).

Results of the PID readings are presented on the exploratory hole logs.

7.0 GROUND MODEL

7.1 Made Ground

As part of the Groundtech Consulting investigation, Made Ground has been encountered to depths of between 1.0m and 2.9m bgl. Four main Made Ground populations were encountered during the investigation and are described below:

Locations	Depth	Thickness (m bgl)	Description
WS03 to WS05 TP01, TP06	GL – 0.25	0.25	Brown sandy gravelly topsoil with occasional cobbles of brick and concrete. Gravel is of concrete and brick.
CP01 to CP04 WS03, WS04, WS06 TP01 to TP05, TP07, TP08, TP10 to TP15	GL – 2.2	0.3 – 1.7	Brown sandy cobbly gravel of mixed lithologies including brick, coal and concrete.
WS01 to WS06 TP03, TP05, TP13, TP15	0.2 – 2.2	0.25 – 1.6	Black sandy gravel and variably gravelly sand. Gravel is of mixed lithologies including ash, clinker, coal, shale and slag.
WS01, WS05 TP07, TP08, TP12, TP15	0.75 – +2.0	0.2 – 2.8	Red brown locally silty, clayey variably gravelly sand. Gravel is of mixed lithologies including concrete, ash and clinker.

Concrete hardsurfacing was present from ground level within TP02, TP03 and TP05 to a maximum depth of 0.15m bgl – these locations were in the southern and eastern areas. The concrete was underlain by tarmac within TP02 to a depth of 0.2m bgl.



Exploratory Hole Locations

All Made Ground populations that were encountered across the site were granular in nature. Made Ground was found to a maximum depth of 2.9m bgl within CP03 comprising sandy gravel of brick and concrete. This borehole was situated within the footprint of the former Tin Plate Works. Generally, Made Ground was recorded to depths between 1.3m and 2.0m bgl.

Evidence of in-situ relic substructure recovered as cobbles of brick was present within TP06 likely associated with the former Tin Plate Works. Substructure was also encountered within TP07 and TP14, this largely comprised brick with subsidiary concrete, and were within the eastern site area.

7.2 Natural Ground

The natural strata encountered generally confirmed the published geological records. Three main natural stratification were encountered during the investigation and are described below:

Locations	Depth (m bgl)	Thickness (m bgl)	Description
WS02, WS04 TP01 to TP07, TP09, TP10, TP12, TP14, TP15	1.35 – ±4.0	0.1 – 2.2	<i>Soft to firm occasionally stiff grey variably brown sandy Clay.</i>
CP01 to CP04 WS03 - WS05, WS06 TP02, TP05, TP12, TP13	1.2 – 5.3	±0.1 – 3.8	<i>Soft grey variably brown silty Clay. Locally organic.</i>
CP01 to CP03 WS02, WS03 TP08, TP12	1.9 – ±7.5	0.4 – 2.1	<i>Dense brown fine to medium Sand and Gravel of mixed lithologies.</i>

7.3 Bedrock

Bedrock was not encountered in this investigation.

7.4 Groundwater

The table presented below summarises the groundwater encountered during the investigation:

Location	Depth to Groundwater Strike (m bgl)	Depth to Groundwater after 20 minutes (m bgl)	Strike/Perched	Strata
CP01	5.3	3.5	Strike	Sand and Gravel
CP02	5.0	4.3	Strike	Sand and Gravel
CP03	2.0	1.3	Perched	Made Ground
	5.0	3.5	Strike	Sand and Gravel
CP04	5.0	3.0	Strike	Sand and Gravel
TP05	4.2	-	Strike	Tidal Flat Deposits
TP06	1.0	-	Perched	Made Ground
TP07	1.3	-	Perched	Made Ground
TP08	2.8	-	Strike	Sand and Gravel
TP12	2.4	-	Seepage	Tidal Flat Deposits

Groundwater strikes were observed in the natural Sand and Gravel and sandy silty Clay deposits. Perched groundwater was very localised and was encountered within two of the trial pit locations within the Made Ground.

7.5 Watching Brief

A watching brief was maintained during the Ground Investigation for visual and olfactory evidence of contamination.

Most excavations had visual evidence of contamination including ash, coal and slag.

Discolouration and staining within the natural superficial deposits were noted within TP05 at 1.6m bgl, TP15 at 2.2m and 2.7m bgl, WS03 at 1.0m and 1.9m bgl.

Olfactory evidence of contamination was noted within TP01, TP06, TP10, TP13, and TP15 with a moderate to strong hydrocarbon odour.

In TP06, a moderate sheen was present within groundwater suggesting the presence of free phase hydrocarbon contamination.

7.6 Excavation Stability

Spalling was observed in the Made Ground in TP03 at 0.5m bgl, TP06 from 0.5m bgl spalling was observed and trial pits were eventually abandoned.

7.7 Excavation Progress

Slow progress while excavating the trial pits was not experienced.

7.8 Obstructions

The table presented below summarises the extent and nature of obstructions encountered during the trial pitting exercise.

Location	Nature of Obstruction	Depth to Top (m bgl)	Depth to Base (m bgl)
WS01	Concrete	2.0	Unknown
TP01	Concrete slab	0.2	0.3
	Relict tarmac surfacing	0.3	0.5
TP04	Concrete slab	0.5	0.7
TP06	Brick footings	0.5	1.1
	Concrete slab	1.6	1.7
TP07	Concrete slab	0.5	0.6
TP10	Concrete slab	0.8	0.9
TP11	Relict tarmac surfacing	0.4	0.45
	Concrete	1.0	+1.3
TP14	Brick wall with concrete footing	0.5	0.6

The locations of the obstructions are displayed on GRD-21252-P07.

8.0 GROUND ENGINEERING

8.1 Geotechnical Testing Results

A summary of the undrained shear strengths of the Clay strata from the triaxial testing results are summarised below:

Location	Depth (m bgl)	Undrained Shear Strength C_u (kPa)	Strength Description
CP01	3.0 – 3.45	9	Very low strength
CP02	4.0 – 4.45	22	Low strength
CP03	4.0 – 4.45	50	Medium strength
CP04	3.5 – 3.95	11	Very low strength

Comparison of water content and the value of 0.4 times the Liquid Limit in accordance with BRE Digest 412 'Desiccation in Clay Soils' suggests significant desiccation has taken place when 0.4 times the Liquid Limit is greater than the actual water measured water content. This is a rudimentary method but also a good guide.

Results of the plasticity testing and the volume change potential of the Clay is summarised in the table below:

Reference	Depth	Modified PI	Volume Change Potential	Significantly Desiccated Y/N
WS02	2.3	30	Medium	N
WS05	1.5	21	Medium	N
TP09	2.6	31	Medium	N
TP14	1.1	23.8	Medium	N

8.2 Assessment Background

The ground engineering investigation has been undertaken to formulate an accurate ground model to undertake preliminary foundation design. The ground model has been constructed with a moderate to high level of confidence and has evolved from the information obtained by the PRA.

It is proposed to construct a 3050 sqft commercial unit and a 2200 sqft drive thru unit with car parking areas in the eastern site area. To the south west a 1254 sqm Aldi retail store is to be constructed with a service yard to the north, and car parking areas to the east and the southeast.

Made Ground has been encountered to depths of between 1.0m and 2.9m bgl which in turn is underlain by superficial soft to firm very low to low strength Clay to depths of up to 5.3m bgl. Very dense Gravel has been encountered from depths between 3.9m and 5.3m bgl where the cable percussive boreholes were terminated after several hours of chiselling.

Perched groundwater was encountered in TP06 and TP07 at depths of 1.0m and 1.3m respectively within the Made Ground. Elsewhere across the site, groundwater strikes were identified in the natural ground at depths of between 4.2m bgl and 5.3m bgl.

The main limitation is the number of obstructions encountered associated with the developmental history of the site. The obstructions encountered during the Ground Investigation are discussed in Section 7.6 and presented on *GRO-21252-P06*. As part of the enabling works, all obstructions should be grubbed up. Obstructions were encountered at depths from 0.3m to a maximum proven depth of 1.7m bgl. A concrete obstruction was encountered within WS01 at a depth of 2.0m, the extent of this obstruction was not proven.

In addition, soft very low to low strength Clay is present to depths of up to 5.3m bgl which prevents shallow foundations being feasible. Deep foundations will be required and pile risk assessment is required to ensure a preferential pathway is not created for the contamination in the Made Ground and localised perched groundwater.

There is no risk to the proposed development from historic coal mining.

8.3 Geotechnical Parameters

The geotechnical test results have been evaluated to derive geotechnical parameters for the soils underlying the site. A 'depth to SPT N value' graph is presented as a Generalised Ground Model for the site on *GRO-21252-P06* in *Appendix 12*.

Characterisation of the geotechnical parameters above has been undertaken to select a characteristic value, which is a cautious estimate of the value affecting the occurrence of the limit state.

The characteristic values of the underlying strata have been selected based on correlation with SPT values and through direct measurement from laboratory testing. The characteristic values for Ultimate Limit State (ULS) selected are presented in the table below:

Stratum	Parameter	Selected Characteristic Value
<i>Very low strength Clay</i>	<i>Undrained Shear strength (C_u)</i>	<i>10kN/m²</i>
<i>Low strength Clay</i>	<i>Undrained Shear strength (C_u)</i>	<i>22kN/m²</i>
<i>Medium strength Clay</i>	<i>Undrained Shear strength (C_u)</i>	<i>50kN/m²</i>
<i>Very dense Sand and Gravel</i>	<i>Drained angle of friction (ϕ')</i>	<i>40°</i>

8.4 Preliminary Foundation Design

It is proposed to construct three commercial units cross the site which includes an Aldi store and a number of commercial units. Ultimate Limit State (ULS), Serviceability Limit State (SLS), and Equilibrium Limit State (EQU) conditions must be satisfied by the foundation and structural design.

Traditional shallow foundations are not considered suitable at the site due to Made Ground and natural very low to low strength Clay encountered beneath the proposed development area to depths up to 5.3m bgl. In addition, the very low strength of the clays will preclude the use of shallow reinforced foundations on Vibro Stone Columns (VSCs).

Driven Piles

The most suitable foundation solution is considered to be driven piles transferring loads through the Made Ground and Clay to end bear in the underlying very dense Gravel which has been encountered at depths between 3.9m and 5.3m bgl. A reinforced ring beam should be constructed to span between each pile cap and support loadings from the walls of the proposed store.

Obstructions have been encountered in the ground and they should be grubbed up prior to the construction phase.

The driven piles will need to be a minimum of 3m in length. The use of driven piles should be discussed with the piling contractor and good workmanship will be required when installing the piles to ensure the assumptions in the design by calculation are met.

Preliminary design by calculation has been carried out applying due skill and care using the global factor of safety method.

Design by Calculation

The preliminary design by calculation is based on the following ground model:

- *Made Ground to 2.8m*
- *Soft very low strength Clay to 5.3m*
- *Dense gravel to 6.5m*

For a single pre-cast concrete pile 225mm in diameter and 6.5m in length end bearing in the dense Gravel, an allowable load of 180kN is provided. If greater loads are associated with the proposed development, consideration should be given to larger diameter piles or pile groups. This design should be confirmed with the preferred piling contractor. Downdrag has not been considered as part of the preliminary pile design, this will depend on the finished site levels causing ground movement relative to the pile, this should be allowed for in the final detailed design.

The type of pile material to be used should be discussed with the piling contractor to ensure lateral stability is achieved through the very soft Clay. The type of pile should also be able to withstand hard driving in the very dense Gravel.

Detailed pile design should be undertaken by an experienced piling contractor and should take into account finished levels.

An appropriate working platform should be constructed in accordance with BR470 guidance.

Design Validation

Static load testing on working piles is recommended as a minimum to validate the design for ULS and SLS conditions in accordance with Eurocode 7. Due to the size of the development and the associated loadings, static load testing is not economical and an appropriate Factor of Safety should be used in the design. The piles are likely to be driven to sett using pile driving formulae.

All piling work should be carried out in accordance with BS EN 12699:2015 'Execution of special geotechnical works. Displacement piles'.

If the ground conditions encountered during the construction phase differ significantly to the conditions encountered during the Ground Investigation, work should cease and Groundtech Consulting contacted for further advice.

During the construction phase supervision should be on a continuous basis to check the design assumptions are correct and construction conforms to design. Supervision should include inspections, Control Ground Investigations and monitoring.

Controlled Modulus Columns

An alternative option would be reinforced strip footings over Controlled Modulus Columns (CMCs) or ground improvement with Vibro Stone Columns (VSC's). Discussions should be undertaken with a specialist vibro contractor to determine their suitability.

A preliminary design resistance for ultimate limit state and serviceability limit state conditions has not been calculated, this will be the responsibility of the specialist vibro contractor and will be dictated by their design. The specialist contractor should provide fitness for purpose cover for the treated zones and depth of treatment.

The integrity of the columns are not validated to 0.35m bgl and foundations should be taken below this depth. The reinforced concrete foundation should be designed to span between the centres of adjacent stone columns.

The above recommendations are preliminary and should be confirmed with liaison with a specialist piling and ground improvement contractor.

External Works

For the external works such as roadways, granular made Ground in excess of 2m in generally in place and will mitigate the risk of settlement relative to the buildings. For areas to be grubbed up, the granular soils should be replaced to an agreed earthworks specification.

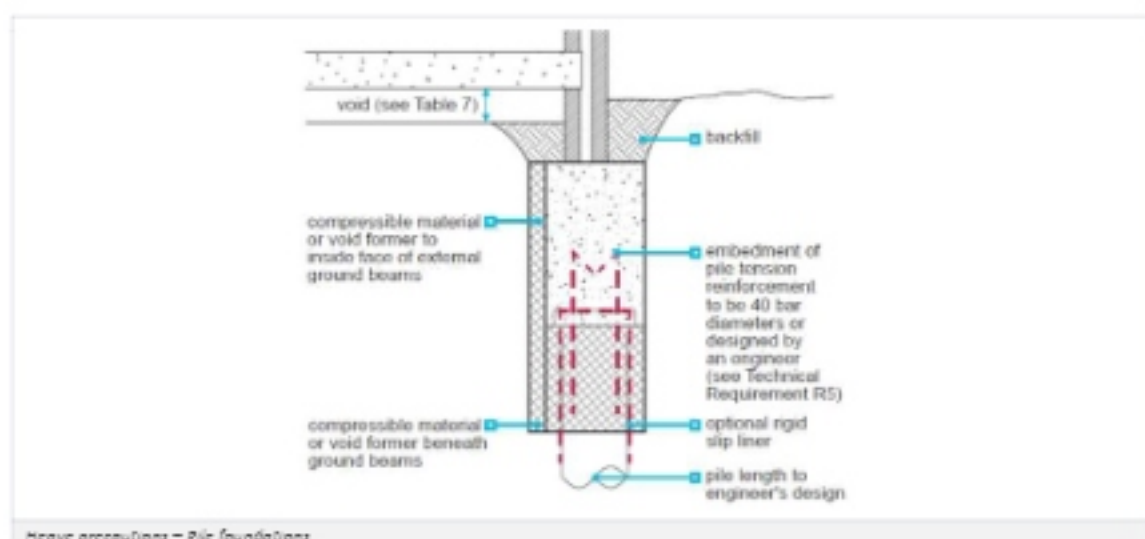
As a minimum, verification testing in the form of plate load tests using a 600mm plate should be undertaken across the site to confirm the engineered fill meets the required criteria. Plate load testing undertaken as part of the Ground Investigation are discussed in Section 8.9.

8.5 Building Near Trees

A small number of trees are situated off the eastern corner of the site, and Clay strata was encountered to between 1.6m and at least 4.1m bgl beneath this area. Foundation excavations in this area will encounter cohesive strata in the vicinity of existing, proposed or recently removed trees, foundations should be adjusted in full accordance with appropriate Guidance.

A survey of all trees and hedges on the site and within 30m of the site boundary should be undertaken to identify tree species, locations and heights. This information will be required in order to assess the effects of trees on the cohesive strata and inform a foundation schedule.

Where foundation depths due to trees already present or recently removed exceeds 1.5m there is a possibility for heave to occur on removal of the tree. Guidance states that precautions for pile foundations should be installed as detailed below.



8.6 Floor Slabs

A suspended floor slab will be required for the proposed store supported by the reinforced ring beam.

8.7 Construction

Instability of the Made Ground has been proven by the trial pitting and should be considered in the ground works method statement. Obstructions should be removed as a part of the enabling works.

Tracked high specification plant is recommended to maintain the build programme. Breaking equipment will also be required locally to penetrate obstructions identified by the Ground Investigation.

Localised dewatering of foundation excavations may be required depending on the time of year the groundworks are undertaken, perched groundwater was encountered locally in the Made Ground.

8.8 Concrete Classification

Made Ground

Water soluble sulphate testing was undertaken on thirteen samples of the Made Ground. The range of soluble sulphate (SO_4) recorded is between 14.4mg/l and 2020mg/l and associated pH values range between 7.2 and 10.0 indicating neutral to slightly alkaline conditions.

In a dataset where ten or more results are available, the mean of the highest 20% of water-soluble sulphate concentrations are taken as the characteristic value and the mean of the lowest 20% of the pH values is taken. Based on the above, the characteristic value for water soluble sulphate is 1977mg/l and the value for pH is 7.47.

Natural Strata

Water soluble sulphate testing was undertaken on four samples of natural ground. The range of soluble sulphate (SO_4) recorded is between 24.3mg/l and 558mg/l and associated pH values range between 6.4 and 9.4 indicating slightly acidic to slightly alkaline conditions.

In a dataset where less than five results are available, the highest measured sulphate concentration is taken as the characteristic value together with the lowest measured pH value. Based on the above, a characteristic value for water soluble sulphate is 558mg/l and the pH value is 6.4.

Granular soils are present beneath the site therefore the groundwater is considered to be mobile.

The results of laboratory pH and sulphate content indicate that ACEC Class AC-3 and sulphate class DS-3 conditions prevail in accordance with BRE Special Digest 1 "Concrete in aggressive ground" 2005. The specific concrete mixes (the Design Concrete Class) to be used on site will be determined by the site-specific concrete requirements in terms of the durability and structural performance. These are assessed in terms of the Structural Performance Level (SPL) and any need for Additional Protective Measures (APM) detailed in Part D of BRE Special Digest 1 with further guidance in Pt E and F.

Pyrite Potential

Additional testing was undertaken to determine if the underlying natural Clay is pyritic. Three samples of natural Clay were tested for total sulphur and total sulphate which was used to determine the total amount of oxidisable sulphides in the sample. If the amount of oxidisable sulphates is greater than 0.3% SO₄, pyrite is probably present. The total amount of oxidisable sulphates in the sample was determined to be between 0.033% and 0.26% SO₄ and it is therefore unlikely that the Clay is pyritic.

8.9 Highway Design

Plate load testing was carried out at PLT1 to PLT6 beneath the proposed car parking areas, service yard and access road, the results are presented in *Appendix 13*.

All plate load tests were undertaken at a depth of 0.2m bgl and CBR values of between 1.8% and 3.2% were recorded. The tests were undertaken at the assumed formation level of the proposed external areas, and therefore do not meet the minimum design criteria of at least 5%. The SPTs in the boreholes indicated the granular soils were medium dense to dense, therefore some reengineering is of the near surface Made Ground is required prior to pavement and road construction.

Untreated Made Ground should be assumed to have a CBR value of <2.5%, unless proven otherwise. Highways Agency document HD25 'Interim Advice Note 73/06 Revision 1' (2009) states that where a subgrade has a CBR value lower than 2.5%, it is considered unsuitable support for a pavement foundation since it would tend to deform under construction traffic, and must be improved.

Where highways are proposed in areas underlain by Made Ground, it is recommended that the Made Ground is excavated to a depth of 1.0m below subgrade level, sorted, and classified in accordance with Series 600 (Earthworks) of the Highways Agency "Specification for Highways Works". Following the above, any suitable material which can be used as part of highway construction shall be compacted in accordance with an earthwork's specification.

The soils are considered to be frost susceptible due to the fines content and highway construction should be a minimum thickness of 450mm to mitigate the risk.

8.10 Sustainable Urban Drainage System (SuDS)

Soil percolation testing has not been undertaken on the site due to the deep contaminated Made Ground and underlying impermeable natural Clay, in addition groundwater strikes were recorded directly below the Clay strata. It is understood that a new drainage system connected with the main drains will be adopted.

9.0 LAND QUALITY

9.1 Geo-Environmental Testing Results - Soils

Samples of Made Ground and natural strata have been tested for a range of relevant Contaminants of Concern. A Generic Quantitative Risk Assessment (GQRA) has been undertaken to determine the significance of the concentrations as derived through Geo-Environmental analysis.

The GQRA process comprises the comparison of the actual concentrations measured on site with Generic Assessment Criteria (GACs) for the protection of human health.

The GACs used for the assessment of soil concentrations have been derived using the CLEA model. The GACs used and their ranking of importance are listed below:

- *Soil Guideline Values (SGVs) which demonstrate minimal risk.*
- *LQM/CIEH S4ULs which use the same toxicological data as the SGVs but different exposure criteria.*
- *C4SLs which demonstrate low risk.*

In deriving the GACs for use on Brownfield sites, we have assumed a 1% Soil Organic Matter unless the results indicate otherwise.

The proposed end-use for the site is a commercial comprising the construction of a number of units which will be surrounded by areas of hardsurfacing. We have therefore undertaken the GQRA on the basis that the proposed development site falls under the Commercial land-use scenario as defined in SR3 (EA, 2009b).

The strata or sources of contamination targeted by the laboratory testing scheduled is summarised in the table below:

Strata	Number of Samples Tested	Locations
MG: Sand / Gravel (Population 1)	12	TP02, TP03, TP05, TP06, TP07, TP08, TP09, TP10, TP15, WS06
MG: Topsoil (Population 2)	1	WS05
Clay (Population 3)	2	TP01, TP05

Sources	Number of Samples Tested	Locations
Petrol Filling Station	2	TP03, WS06
Substation	1	TP07
Underground Tank	1	TP06
Corporation Yard	1	WS05
Former Pond	2	TP02, TP15

A summary of the Geo-Environmental Testing results is presented below and the GQRA Screening Values are presented in Appendix 14:

Contaminant	Metals			
	Range (mg/kg)	Screening Value	Exceedances	Locations
Arsenic	7.0 - 120	640	0	-
Baron	0.3 - 2.8	240000	0	-

Cadmium	<0.2 - 5.0	230	0	
Chromium	9.6 - 46	8600	0	-
Hexavalent Chromium	<4.0	49	0	-
Copper	16 - 910	68000	0	-
Lead	15 - 1400	2300	0	-
Mercury	<0.3 - 1.4	26	0	-
Nickel	10 - 57	1800	0	-
Selenium	<1.0	13000	0	-
Zinc	75 - 18000	730000	0	-

Polycyclic Aromatic Hydrocarbons (PAHs)				
Contaminant	Range (mg/kg)	Screening Value	Exceedances	Locations
Naphthalene	<0.05 - 0.61	190	0	-
Acenaphthylene	<0.05 - 1.3	83000	0	-
Acenaphthene	<0.05 - 4.1	84000	0	-
Fluorene	<0.05 - 2.9	63000	0	-
Phenanthrene	<0.05 - 19	22000	0	-
Anthracene	<0.05 - 6.1	520000	0	-
Fluoranthene	<0.05 - 46	23000	0	-
Pyrene	<0.05 - 36	54000	0	-
Benzo(a)anthracene	<0.05 - 35	170	0	-
Chrysene	<0.05 - 29	350	0	-
Benzo(b)fluoranthene	<0.05 - 21	44	0	-
Benzo(k)fluoranthene	<0.05 - 16	1200	0	-
Benzo(a)pyrene	<0.05 - 16	35	0	-
Indeno(123cd)pyrene	<0.05 - 9.5	500	0	-
Dibenzo(ah)anthracene	<0.05 - 3.9	3.6	1	TP02 @ 0.3m
Benzo(ghi)perylene	<0.05 - 9.6	3900	0	-

TPH CWG - Aliphatics				
Contaminant	Range (mg/kg)	Screening Value	Exceedances	Locations
>C5-C6	<0.001	3200	0	-
>C6-C8	<0.001	7800	0	-
>C8-C10	<0.001	2000	0	-
>C10-C12	<1.0 - 25	9700	0	-
>C12-C16	<2.0 - 230	59000	0	-
>C16-C21	<8.0 - 220	1600000	0	-
>C21-C35	<8.0 - 43	1600000	0	-
Total aliphatics C5-35	<10.0 - 510	-	-	-

TPH CWG - Aromatics				
Contaminant	Range (mg/kg)	Screening Value	Exceedances	Locations
>EC5-EC7	<0.001	26000	0	-
>EC7-EC8	<0.001	56000	0	-
>EC8-EC10	<0.001	3500	0	-
>EC10-EC12	<1.0 - 5.0	16000	0	-
>EC12-EC16	<2.0 - 160	36000	0	-

>EC16-EC21	<10 - 180	28000	0	-
>EC21-EC35	<10 - 42	28000	0	-
Total aromatics C5-35	<10 - 390	-	-	-
MTBE	<0.001	7900	-	-
Benzene	<0.001	95	-	-
Toluene	<0.001	4400	-	-
Ethylbenzene	<0.001	2800	-	-
m/p-Xylene	<0.001	3200	-	-
o-Xylene	<0.001	2600	-	-

PCBs				
Contaminant	Range (mg/kg)			
PCB Congener 28	<0.001			
PCB Congener 52	<0.001			
PCB Congener 101	<0.001			
PCB Congener 118	<0.001			
PCB Congener 138	<0.001			
PCB Congener 153	<0.001			
PCB Congener 180	<0.001			

Others				
Organic Matter	1.1 - 9.8%			
Total Cyanide	<1.0 - 58mg/kg			

Asbestos Screen				
Position	Depth (m bgl)	Result	Asbestos Type	Mass (%)
TP02	0.30	Detected	Chrysotile, Amosite & Crocidolite	0.003
TP03	1.00	Not Detected	-	-
TP05	0.50	Not Detected	-	-
TP05	3.00	Not Detected	-	-
TP06	1.60	Detected	Chrysotile	<0.001
TP07	1.20	Not Detected	-	-
TP07	0.25	Detected	Chrysotile & Amosite	0.040
TP08	1.20	Not Detected	-	-
TP08	1.60	Not Detected	-	-
TP09	0.50	Not Detected	-	-
TP10	0.60	Detected	Chrysotile	<0.001
WS05	0.10	Not Detected	-	-
WS06	0.90	Not Detected	-	-
TP15	1.00	Not Detected	-	-

Four samples of Made Ground were tested for a suite of VOCs and all were recorded at concentrations below the laboratory limits of detection.

The same four samples were tested for SVOCs, the majority of the compounds were recorded below the laboratory limits of detection with the exception of the following:

- 1,3-Dichlorobenzene – TP05 at 3.0m (below the commercial screening value of 30mg/kg)
- 1,4-Dichlorobenzene – TP05 at 3.0m (below the commercial screening value of 4400mg/kg)
- 2-Methylnaphthalene – TP08 at 1.2m
- Dibenzofuran - TP08 at 1.2m

The above compounds are generally linked to pesticides and insecticides which could be associated with the former railway land onsite and partial combustion of fuel sources.

9.2 Generic Quantitative Risk Assessment - Soils

Made Ground has been encountered beneath the entire site to a maximum depth of 2.9m bgl and generally consisted of granular soils. The site is thought to have been subject to tank removal in 2008.

Metals

There were no exceedances of heavy metal concentrations when compared to the screening values for commercial developments.

The previous Arcadis investigation found elevated concentrations of Arsenic, Lead, and Zinc, when compared to the Residential SSV. The soils tested were all derived from stockpiles on site, that are to be removed. They were not elevated above the Commercial SSV.

Speciated Polycyclic Aromatic Hydrocarbons

A single minor elevated level of Dibenzo(ah)anthracene was detected in TP02 at a depth of 0.2m bgl. This is likely derived from the incomplete combustion of fuels in engines through the coal coking process used in the steel production process, or associated with the railway that ran through the site.

Twenty-two exceedances were identified by the Quantum investigation when compared to the screening values for residential with plant uptake. There was also an exceedance in one sample when compared to the screening value for commercial developments.

The previous Arcadis investigation recorded elevated speciated PAHs (Naphthalene, Benzo(b)fluoranthene, Benzo(a)pyrene, and Dibenzo(a,h)anthracene) when compared to the residential with plant uptake SSV. When compared to the Commercial SSV, there were no recorded exceedances.

Total Petroleum Hydrocarbons (CWG)

There were no exceedances in Total Petrol Hydrocarbons speciations when compared to the screening values for commercial developments.

The Quantum investigation identified a single exceedance of the SSV for benzene out of 46 samples analysed in the residential area. There were two exceedances of the SSV in two samples of natural soils for TPH Aliphatic C8-C10 and TPH Aromatic C8-C10. A single exceedance in natural soil for TPH Aromatic C12-C16 was identified in the location of a suspected former tar tank. Further exceedances were identified in two samples of Made Ground for TPH Aromatic C16-C35 and TPH Aromatic C21-C35 in the western side of the site.

The Arcadis investigation identified two exceedances in Benzene and TPH C16-C21 when compared to residential screening values. Both of these samples were obtained in the vicinity of the former Petrol Filling Station.

It is understood that all known Underground Storage Tanks have been removed from site and any contamination encountered in this area is likely to be residual. The perched groundwater encountered within the Made Ground was highly localised and therefore the residual hydrocarbon contamination is also likely to be localised. The coverage by the previous investigations by Quantum and Arcadis supports this observation.

When compared to the commercial screening values there have been no recorded exceedances from the previous investigations.

VOCs and SVOCs

Of the six samples screened for elevated VOCs and SVOCs, there were no exceedances when compared to the commercial screening values.

There was a combined number of nine exceedances between the Quantum and subsequent Arcadis investigations when compared to the residential with plant uptake screening values. However, with the current development plans, there were no exceedances recorded when compared to the less stringent commercial screening values.

Polychlorinated Biphenyls (PCBs)

No elevated concentrations of Polychlorinated Biphenyls (PCBs) were recorded from sample tested in close proximity to the electricity substation. The substation is situated on a concrete slab, therefore reducing the chance of impaction of the underlying soils.

Asbestos

A mixture of Chrysotile, Amosite and Crocidolite asbestos fibres were detected in TP02, TP06, TP07 and TP10 within the granular Made Ground soils at concentrations of between <0.001 and 0.04 mass %. Spatially, the asbestos was identified in the central, southern and north western areas of the site.

The previous investigations undertaken by Quantum and Arcadis found widespread asbestos contamination across the site and within the stockpiled materials. Out of a combined total of 64 samples that were screened, 41 were found to contain asbestos.

Stockpiles

Six exceedances in speciated PAH testing from samples taken from waste mounds when assessed against residential end use. However, when compared to the commercial SSV's there were no exceedances. Two samples obtained from the stockpiles on site were elevated in metals when assessed against the residential end use SSV. However, when compared to the commercial SSV's there were no exceedances.

The stockpiles are suitable to be reused on the site if placed at depth under an MMP due to the asbestos content. If volume calculations identify a surplus the stockpiles should be removed to a suitably licensed waste disposal facility.

9.3 Groundwater Testing

Four samples of groundwater were taken from CP01 to CP04 and were tested for a similar suite of contaminants as the soils. The results were compared with reference to a selection of guidance documents as detailed at the rear of this report.

The implementation of the Water Framework Directive (WFD) is to protect and enhance the quality of groundwater and groundwater-dependent ecosystems. The objective of the WFD requires all groundwater

bodies (GWBs) are of 'good' status in terms of water quality. This status is based on thresholds for the chemical constituents of groundwater and their impact on ecosystems. Preventing pollution is by far the most sustainable and cost-effective way of maintaining good groundwater quality. The EA are committed to the 'prevent or limit' approach reflected in EU and domestic legislation.

Priority is under the Water Framework Directive to protect water supplies intended for human consumption and ensure protection of groundwater quality that supplies dependent ecosystems. After first guidance in 1992 the following significant guidance has been introduced:

- *Water Framework Directive (2000/60/EC) and the Water Act 2003.*
- *The State of Groundwater in England and Wales 2006.*
- *Second phase of the environmental permitting regime in 2010 replacing the Groundwater Regulations (1999, 2009).*
- *Groundwater Daughter Directive.*

Pollutants can be divided into those that break down easily (degradable pollutants) and those that do not (non-degradable pollutants). The Water Framework Directive introduced the concept of 'hazardous substances' and 'non-hazardous pollutants', which replaced the previous List I and List II of substances considered to pose the greatest threat to the environment.

- *Hazardous substances are the most toxic and must be prevented from entering groundwater. Substances in this list may be disposed of to the ground, under a permit, but must not reach groundwater. They include pesticides, sheep dip, solvents, hydrocarbons, mercury, cadmium and cyanide.*
- *Non-hazardous pollutants are less dangerous and can be discharged to groundwater under a permit but must not cause pollution. Examples include sewage, trade effluent and most wastes. Non-hazardous pollutants include any substance capable of causing pollution and the list is much wider than the previous List II of substances. For example, nitrate is now a non-hazardous pollutant whereas before it was not a List II substance.*

Polluting substances in groundwater can occur as a gas (gaseous phase) or dissolved in water (aqueous phase), or as a non-aqueous phase liquid (NAPL). Some pollutants include substances that dissolve readily in water. These are said to have high solubility; an example is MTBE. Substances that have low solubility (such as oil) are referred to as non-aqueous phase liquids (NAPLs). NAPLs behave differently in groundwater depending on whether they are lighter or heavier than water. Light non-aqueous phase liquids (LNAPLs) may float on the water table whereas dense non-aqueous phase liquids (DNAPLs) may sink through the aquifer until they reach an impermeable layer. They may then generate plumes of contamination. In both cases, the slowly dissolving pollutant may form a plume of dissolved contamination which moves with the groundwater flow.

A table summarising the groundwater testing results is presented below:

Contaminant	Metals			
	Range (ug/l)	EQS (ug/l)	Exceedances	Locations
Arsenic	<0.15 – 2.86	50	0	-
Boron	110 - 310	5	0	-
Cadmium	<0.02 – 0.07	0.08-0.25	0	-
Chromium	2.9 – 5.2	4.7	1	CP02

Hexavalent Chromium	<5.0	3.4	0	-
Copper	2.1 – 3.7	10 – 28	0	-
Cyanide	<10	1	0	-
Lead	<0.2 – 1.0	1.2	0	-
Mercury	<0.05	0.07	0	-
Nickel	3.0 – 5.5	20	0	-
Selenium	<0.6 – 1.1	10*	0	-
Zinc	7.8 – 22.0	75 – 125	0	-
Polycyclic Aromatic Hydrocarbons (PAHs)				
Contaminant	Range (ug/l)	EQS (ug/l)	Exceedances	Locations
Benzo(a)pyrene	<0.01	0.00017	0	-
Indeno(123cd)pyrene	<0.01	0.00017	0	-
Benzo(ghi)perylene	<0.01	0.00017	0	-
Benzo(b)fluoranthene	<0.01	0.00017	0	-
Benzo(b)fluoranthene	<0.01	0.00017	0	-
TPH CWG – Aliphatics				
Contaminant	Range (ug/l)	EQS (ug/l)	Exceedances	Locations
>C5-C6	<1.0	15,000	0	-
>C6-C8	<1.0	15,000	0	-
>C8-C10	<1.0	300	0	-
>C10-C12	<10.0	300	0	-
>C12-C16	<10.0	300	0	-
>C16-C35	<10.0	-	0	-
Total aliphatics C5-35	<10.0	-	0	-
TPH CWG – Aromatics				
Contaminant	Range (ug/l)	EQS (ug/l)	Exceedances	Locations
>C5-EC7	<1.0	10	0	-
>EC7-EC8	<1.0	74	0	-
>EC8-EC10	<1.0	300	0	-
>EC10-EC12	<10	90	0	-
>EC12-EC16	<10	90	0	-
>EC16-EC21	<10	90	0	-
>EC21-EC35	<10	90	0	-
Total aromatics C5-35	<10	-	0	-
Total aliphatics and aromatics(C5-35)	<10	-	0	-
MTBE	<1.0	15	0	-
Benzene	<1.0	10	0	-
Toluene	<1.0	74	0	-
Ethylbenzene	<1.0	300	0	-
m/p-Xylene	<1.0	30	0	-
o-Xylene	<1.0	30	0	-
Others				

*Total Hardness**217 – 558mg/l*

All of the VOCs tested for were recorded at concentrations below the laboratory limits of detection.

9.4 Generic Quantitative Risk Assessment - Groundwater

Controlled Waters Setting

Strata underlying the site consists of Made Ground over cohesive Estuarine Alluvium Deposits to depths of between 3.9m and 5.3m bgl where very dense Gravel was present. The solid geology is the South Wales Middle Coal Measures Formation, however it was not encountered during the Ground Investigation.

Perched groundwater was encountered in TP06 and TP07 at depths of 1.0m and 1.3m respectively within the Made Ground. Elsewhere across the site, groundwater strikes were identified in the natural ground at depths of between 2.4m and 5.3m bgl. Groundwater was encountered within the natural granular deposits at depths between 2.8m and 5.3m bgl. The likely flow direction of groundwater will be towards the River Afan which is circa 86m to the south.

The Estuarine Alluvium Deposits are classified as a Secondary Undifferentiated Aquifer and the solid geology is classified as a Secondary A Aquifer. There are no groundwater or potable water abstraction licenses within 2000m of site and the site is not located within 500m of a groundwater Source Protection Zone.

The River Afan is located approximately 86m to the south of the site and is therefore the receptor considered to be at risk. The contaminants tested for have been compared to EQS screening levels given the close proximity of the watercourse.

Heavy Metals

The groundwater laboratory testing results indicate that there was one exceedance in Chromium from groundwater obtained from CP02.

Very slightly elevated concentrations of dissolved Chromium were recorded within CP02 when compared to the EQS screening values, with a maximum concentration of 5.2ug/l. However, the more toxic Hexavalent Chromium (IV) was recorded at the Limit of Laboratory Detection (LOD) in all samples that were tested.

Copper, nickel and zinc concentrations were all below respective EQS screening values using the hardness values.

Polycyclic Aromatic Hydrocarbons (PAH)

There were no exceedances in any of the samples tested for speciated PAHs.

Total Petroleum Hydrocarbons (TPH CWG)

There were no exceedances in any of the samples tested for TPH CWG.

Although the dense Sand and Gravel are water bearing, they are overlain by impermeable Clay that has acted as an aquitard, and the laboratory testing has confirmed the confined aquifer has not been impacted by overlying Made Ground soils.

The perched water within the Made Ground soils is not considered to be a concern as it is highly localised and not in continuity with the underlying Secondary Undifferentiated Aquifer or River Afan. The proposed new drainage system will also provide further betterment.

Both the superficial Secondary Undifferentiated Aquifer and the bedrock Secondary A Aquifer are not sensitive resources. However, Hazardous substances should be prevented from entering groundwater in accordance with the Water Framework Directive. Therefore, free phase hydrocarbons should be removed as a minimum where encountered.

9.5 Permanent Ground Gases

One gas monitoring visit has been carried out to date on 18th November 2021. Monitoring wells were installed to assess whether gas protective measures are required for the proposed development.

Methane was detected at a maximum concentration of 4.0% v/v within WS06 only which is in the PFS area, no other methane was detected. A maximum carbon dioxide concentration of 4.2% v/v was recorded in WS02 with associated depleted oxygen levels (minimum of 4.3% v/v).

No positive gas flow rates were recorded.

The atmospheric pressure during the visit was 1027mb during a period of rising barometric pressure.

Groundwater was encountered within the standpipes at depths between 1.84m and 3.02m bgl. No groundwater was present within WS03.

Characterisation of the Gas Screening Value (GSV)

Based upon the results recorded, in accordance with CIRIA Report C665, the risk to the site from ground gases has been assessed by converting the results to gas screening values (GSV's) calculated by multiplying the typical maximum gas concentrations with the recorded maximum with the recorded maximum positive flow rates. In addition, individual "hazardous gas flow rates" (Q_{hg}) have been derived for each monitoring point.

$$GSV (l/hr) = \text{max borehole flow rate (l/hr)} \times \text{max gas concentration (\%)}$$

For this assessment, the maximum recorded concentration of methane of 4.0% v/v and carbon dioxide of 4.2% v/v has been used to calculate the GSV together with a gas flow rate of 0.1 l/hr (the limit of detection of the gas analyser). This is the worst-case scenario at this stage, and the scenario may be altered on completion of the monitoring.

$$\text{Carbon Dioxide GSV} = 0.042 (4.2\%) \times 0.1 = 0.0042 \text{ l/hr}$$

$$\text{Methane GSV} = 0.04 (4.0\%) \times 0.1 = 0.004 \text{ l/hr}$$

Assessment

When considering the initial results, in accordance with CIRIA C665 (Section A Development and Table 8.5 – Modified Wilson and Card Classification) the GSV values for methane correspond with CS1 criteria (GSV less than 0.07l/hr) and gas protection measures are not required based on the interim results. However, methane has been recorded at 4.0% v/v in WS06 which is situated in the footprint of the former Petrol Filling Station, and further consideration may need to be given relating to remedial action, or installing a vapour resistant membrane in this area.

Characteristic Situation 1

In order to assess the ground gas regime beneath the site and the need to incorporate ground gas precautions, guidance was taken from CIRIA C665 'Assessing risks posed by hazardous ground gases to buildings'. Based on the site being developed as a commercial retail store, the Wilson and Card method has been used to carry out the assessment.

The proposed commercial development is classified as a Building Type C in accordance with BS 8485:2015 and the site falls in CS1 in accordance with Table 2 of the above guidance.

At present, gas protection measures are not deemed necessary within the proposed structures at the site however, this will be confirmed on completion of the monitoring.

The site is not in an area requiring radon precautions. Vapour protection measures were not considered to be required based upon the PID screening results. However, based on observations and findings from the previous investigations, there are likely to be local pockets of free phase within shallow Made Ground soils, which may release harmful vapours, a vapour resistant membrane or remedial action is recommended in the vicinity of the PFS as demonstrated on *GRO-21252-P05*.

9.6 Revised Pollution Linkage Assessment

The pollution linkage assessment has been revised based on the Ground Investigation and testing to identify any realistic pollution linkages in order to quantify the risks to human health and controlled waters. An illustrative CSM is presented on *GRO-21015-P08*.

Human Health Pollution Linkage Assessment



- o The table below represents the second stage in the land quality risk assessment process - the Generic Quantitative Risk Assessment.
- o In order for a development site to be deemed 'suitable for use' the level of risk needs to be reduced to an acceptable level - low to negligible risk. The purpose of each stage of risk assessment is to establish if there is a requirement for additional stages of assessment in order to have sufficient confidence to support a risk characterisation or remedial action.

Conceptual Site Model					Generic Quantitative Risk Assessment	
PL	Potential Source	Pollution Linkage	Likelihood	Consequence/ Severity	Risk Rating	Rationale and Action
PL1	Contaminated Soils	Ingestion of soil and dust. Dermal contact with soil.	Unlikely	Medium	Low	Pollution Linkage 1 refers to proposed site users encountering contaminated soils on the site. Made Ground was encountered to a maximum proven depth of 2.9m bgl. Evidence of contamination was noted locally across the site associated with the historical industrial uses, however laboratory analysis has indicated that the only minor exceedance when compared to the screening values for a commercial development relates to Dibenzo(ah)anthracene within TP02 at a depth of 0.3m bgl. No other elevated CoC were recorded including from the previous investigation when compared to commercial screening levels. Asbestos was detected in four samples of Made Ground at depths between 0.25m and 1.6m bgl. In two instances, TP06 and TP10 at 1.6m and 0.6m bgl the asbestos was at trace concentrations. Within TP02 and TP07 at depths of 0.3m and 0.25m, asbestos was detected at concentrations between 0.003 mass % and 0.040 mass %. The JIWW assessment indicates that the combined hazard, exposure and receptor ranking is

Conceptual Site Model					Generic Quantitative Risk Assessment	
PL	Potential Source	Pollution Linkage	Likelihood	Consequence/ Severity	Risk Rating	Rationale and Action
						medium, however the Made Ground soils will be beneath hardsurfacing breaking the pathway. Asbestos was more widespread in the previous investigations. As the proposed development is to be predominantly covered with hardsurfacing, no plausible pollution linkage is considered to exist. In areas where soft landscaping will be present, a cover system will be required with a hard dig layer to prevent the disturbance of contaminated soils.
PL2	Contaminated Soils	Inhalation of vapour.	Unlikely	Medium to Severe	Moderate	This pollution linkage refers to volatile vapours migrating into confined spaces within the proposed development. Gross hydrocarbon contamination has not been identified beneath the site and generally the results of PID were low. In addition, the geo-environmental testing has not recorded any hydrocarbons in the volatile range. Based on the results of this investigation, a viable pollution linkage has not been identified. However, volatile contamination was identified by the previous investigation. A vapour resistant membrane or remedial action is recommended in the vicinity of the former PFS and will be discussed in the final gas assessment.

Conceptual Site Model					Generic Quantitative Risk Assessment	
PL	Potential Source	Pollution Linkage	Likelihood	Consequence/ Severity	Risk Rating	Rationale and Action
PL3	Contaminated Soils	Inhalation of soil dust by adjacent site users.	Unlikely	Medium	Low	<i>Pollution Linkage 3 relates to contamination on the subject site affecting adjacent site users. Significant mobile contamination has not been detected by the Ground Investigation and the subject site is indicative of the wider area. Therefore, a realistic pollution is not considered to exist.</i>
PL4	Contaminated Soils	Attacking potable water supply pipe.	Low Likelihood	Medium	Moderate	<i>This pollution linkage 4 refers to the possible contaminants permeating potable water pipes and consumption by the future site end users of the tainted water supply. Made Ground has been identified to a maximum depth of 2.9m bgl. Evidence of organic contamination has been identified.</i> <i>New potable water supply pipes will be included as part of the development and a local water company risk assessment should be carried out prior to construction to advise on the level of protection required for the potable water supply. The pipes are likely to be upgraded from standard PE.</i>
PL5	Ground Gas	Migration and accumulation of ground gas in internal spaces.	Unlikely to Low Likelihood	Medium to Severe	Moderate to Low	<i>Deep Made Ground is present beneath much of the site. The initial gas monitoring results indicate that methane has been detected within one of the standpipes at a maximum concentration of 4.0% v/v and the maximum carbon dioxide concentration is 4.2% v/v. No positive gas flow rates were recorded in any of the monitoring wells.</i> <i>The initial GSV places the site in CS1 and no gas protective measures are required as the methane in WSO6 is due to hydrocarbons in the soils. The level of precautions will be confirmed on completion of the gas monitoring.</i>

Conceptual Site Model					Generic Quantitative Risk Assessment	
PL	Potential Source	Pollution Linkage	Likelihood	Consequence/ Severity	Risk Rating	Rationale and Action
						The site is not in an area requiring radon precautions.

Controlled Waters Pollution Linkage Assessment



- o The table below represents the second stage in the land quality risk assessment process – Generic Quantitative Risk Assessment.
- o In order for a development site to be deemed 'suitable for use' the level of risk needs to be reduced to an acceptable level - low to negligible risk. The purpose of each stage of risk assessment is to establish if there is a requirement for additional stages of assessment in order to have sufficient confidence to support a risk characterisation or remedial action.

Conceptual Site Model					Generic Quantitative Risk Assessment	
PL	Potential source	Pollution linkage	Likelihood	Severity	Level of risk	Rationale
PL6	Contaminated Soils	Impection of groundwater from soil contamination (diffuse and point). Impection of groundwater from groundwater plume.	Unlikely	Medium	Low	Pollution Linkage 6 refers to the impacation of the Secondary A Aquifer (bedrock) beneath the site. The perched groundwater was highly localised and due to the proposed new drainage system is not considered to be a risk, there is also no pathway to the underlying confined aquifer. If free phase hydrocarbons are observed during the enabling and construction phase, it should be removed as a minimum. Water bearing Sand and Gravel was encountered beneath the Estuarine Clay Deposits. Groundwater sampling and testing confirmed that there was one slight exceedance in Chromium, from four samples that were tested, when compared to the EQS levels. This is likely to be at least somewhat impaired by the numerous historical industrial land uses in the surrounding area. The site is not within a groundwater SPZ and there are no potable water abstractions within 2000m. Therefore, the groundwater is not considered to be a sensitive resource.

Conceptual Site Model					Generic Quantitative Risk Assessment	
PL	Potential source	Pollution linkage	Likelihood	Severity	Level of risk	Rationale
						<i>A plausible pollution linkage to groundwater is not considered to exist.</i>
pL7	Contaminated Soils	Migration of soil and groundwater contamination impacting surface waters.	Unlikely	Medium	Low	<i>Pollution Linkage 7 refers to the impact of River Afan circa 86m south of the site from contaminated soils and groundwater.</i> <i>Significant mobile contamination has not been identified during the Ground Investigation and through the testing of soils and groundwater.</i> <i>Contamination from the previous investigations was found to be predominantly perched and immobile within the Made Ground soils.</i> <i>No migration pathway has been identified and a realistic pollution linkage does not exist.</i>

9.7 Outline Remedial Strategy

Soils

A single minor elevated concentration of dibenzo(ah)anthracene has been recorded within the Made Ground samples tested. Asbestos was detected in four samples of Made Ground at a maximum concentration of 0.04 mass %. The previous investigations undertaken by Quantum and Arcadis found asbestos to be prevalent across the site and within the stockpiled materials. The site will predominantly be covered with hard surfacing which will effectively act as a cover system.

A mixture of Chrysotile, Amosite and Crocidolite asbestos fibres were detected in TP02, TP06, TP07 and TP10 within the granular Made Ground soils at concentrations of between <0.001 and 0.04 mass %. Spatially, the asbestos was identified in the central, southern and north western areas of the site.

Where any soft landscaping is to be present, a cover system of 600mm of suitably clean subsoil and topsoil including a contamination demarcation barrier or a 100mm hard dig layer will be required. The imported soils used within the cover system should be tested to ensure that they are suitably clean for use. In addition, the thickness of the cover system should be validated.

It is understood that the waste mounds and stockpiles are to be removed off site. Where possible it would cost effective to reuse and retain as much material on site as possible, and this may require further testing in order to better characterise each individual mound and ensure that the maximum amount of material is retained and reused.

Controlled Waters

The results from the groundwater testing indicate that the main groundwater body beneath the site has not been impacted and remedial action is not required. A piling risk assessment is required to confirm no preferential pathway is created.

Perched groundwater is localised and if free phase is observed during enabling and groundworks, this should be removed offsite to an appropriately licenced waste disposal features.

Ground Gas and Vapours

The preliminary results indicate that gas precautions relating to carbon dioxide or methane within the development will not be necessary. However, this will be confirmed on completion of the monitoring. In addition, radon protective measures not required.

Based upon the information available from the previous investigations and the potential for vapour emissions within isolated pockets of hydrocarbon free phase in the shallow soils, a vapour resistant membrane in the vicinity of the former PFS and USTs should be installed or remedial action undertaken such as windrows.

Watching Brief and Regulatory Approval

During the enabling works, a watching brief should be maintained for previously unidentified visual or olfactory contamination. If identified, work should cease in that area and Groundtech Consulting contacted for advice.

It is understood that Underground Storage Tanks have been removed. This should be confirmed during the enabling works, and a watching brief should be maintained to assess the presence of any unidentified below ground tanks.

The Made Ground on site will require turning over, and all obstructions will require removing as part of the enabling works.

Potable Water Supply Pipes

A local water company risk assessment is required to determine the potable water pipe material, photographic validation of the installation will be required.

Regulatory Liaison

Regulatory approval should be obtained prior to the development to discharge pre-commencement planning condition and prevent delays during the construction phase.

9.8 Asbestos in Soils

Asbestos fibres were detected within four samples of the granular Made Ground soils that were screened from beneath the site to a maximum concentration of 0.04 mass %. From the previous investigations, asbestos was detected within 41 out of 64 samples that were screened. Nine of the samples with asbestos were from stockpiles that are to be removed off site.

Based on the Joint Industry Working Group (JIWG) assessment, the work at the site will be non-licensed however, the following will be required during construction work. It is the responsibility of the contractor to put control measures in place to their satisfaction:

- *RPE – EN140 with P3 filter half mask*
- *Localised mechanical dust suppression*
- *Localised and enhanced personal decontamination facilities*

Where possible, it is advised that any Made Ground soils containing asbestos are left in the ground undisturbed. Where soils will be disturbed as part of the ground works, in accordance with the Joint Industry Working Group (JIWG) decision support tool for CAR2012 work categories, the combined hazard and exposure ranking is medium.

The JIWG assessment tables are in *Appendix 15*. An asbestos management plan is recommended as part of the enabling works.

9.9 Health and Safety - Construction and Ground Workers

During the reclamation and construction phases of the site development it will be necessary to protect the health and safety of site personnel. The risk to construction and ground workers is assessed in the table below:

PL Ref	Potential Source	Pollution Linkage	Likelihood	Severity	Level of Risk
PL8	Made Ground	Ingestion, direct contact, inhalation of dusts.	Low Likelihood	Medium	Moderate to Low
PL8	Asbestos	Ingestion, direct contact, inhalation of dusts.	Likely	Medium	Moderate

Localised speciated PAHs, asbestos and evidence of hydrocarbon contamination has been noted. The contractor should communicate the risks with site personnel through a site induction and via information on noticeboards. The contractor should also implement control measures to their satisfaction.

General guidance on these matters is given in the Health and Safety Executive (HSE) document "Protection of Workers and the General Public during the Redevelopment of Contaminated Land". In summary, the following measures are suggested to provide a minimum level of protection:

- *All ground workers should be issued with the relevant protective clothing, footwear and gloves. These protective items should not be removed from the site and personnel should be instructed as to why and how they are to be used.*
- *Hand-washing and boot-washing facilities should be provided.*
- *Care should be taken to minimise the potential for off-site migration of contamination by the provision of dust suppression control and wheel cleaning equipment during the construction works.*
- *Good practices relating to personal hygiene should be adopted on the site.*
- *The contractor shall satisfy the Health and Safety Executive with regard to any other matters concerning the health, safety and welfare of persons on the site.*

9.10 Waste Classification by Assessment

We have reviewed the testing results and inputted them into the HazWasteOnline model which allows users to code and classify waste as defined in the EWC (European Waste Catalogue 2002) based on EC Regulation 1272/2008 on the Classification, labelling and packaging of substances and mixtures (CLP) and latest Environment Agency guidance (WM3 "Guidance on the classification and assessment of waste (1st edition 2015)-Technical Guidance").

This is a useful tool as waste producers have the legal responsibility to classify any waste they produce.

Fifteen samples were tested to assess whether they contained any contaminants in the hazardous range when screened against assessment criteria within WM3. The results are in the Waste Classification Report presented in *Appendix 16*.

Sample Name	Depth (m bgl)	Classification Result	Stratum	Hazardous Property
TP01	2.50	Non-Hazardous	Clay	
TP02	0.30	Hazardous	MG Gravel	Zinc - Carcinogenic
TP03	1.00	Hazardous	MG Gravel	Zinc and Lead - Carcinogenic and Ecotoxic
TP05	0.50	Hazardous	MG Gravelly sand	Zinc - Carcinogenic and Ecotoxic
TP05	3.00	Non-Hazardous	Clay	
TP06	1.60	Hazardous	MG Gravel	Zinc - Carcinogenic and Ecotoxic
TP07	1.20	Non-Hazardous	MG Sand	
TP07	0.25	Hazardous	MG Gravelly sand	Zinc - Carcinogenic
TP08	1.20	Non-Hazardous	MG Gravel	
TP08	1.60	Non-Hazardous	MG Sand	
TP09	0.50	Non-Hazardous	MG Sand	
TP10	0.60	Hazardous	MG Gravel	Zinc - Carcinogenic
TP15	1.00	Hazardous	MG Gravelly sand	Zinc - Carcinogenic

Sample Name	Depth (m bgl)	Classification Result	Stratum	Hazardous Property
WS05	0.10	<i>Hazardous</i>	<i>MG Topsoil</i>	<i>Zinc – Carcinogenic and Ecotoxic</i>
WS06	0.90	<i>Hazardous</i>	<i>MG Gravelly sand</i>	<i>Zinc – Carcinogenic</i>

Based on the HazWasteOnline assessment tool, nine of the fifteen samples have been classified as being *Hazardous* for waste disposal purposes and relate to all the Made Ground Populations encountered. The hazardous properties are associated with the concentrations of lead and zinc within the Made Ground, this will be linked to the historic use as a tin plating works.

The Made Ground is generally granular in nature and will be difficult to segregate therefore, it is assumed that all of the Made Ground would be classified as being *Hazardous* for waste disposal purposes. Where possible, it is recommended that the Made Ground is kept onsite beneath areas of hardsurfacing.

Asbestos was detected within four samples (TP02, TP06, TP08 and TP09). The concentrations from all previous investigations were found to be below the Hazardous threshold of 0.1 mass %.

Previous testing undertaken by Arcadis on the waste mounds and stockpiles indicate that of 6 samples tested, two are designated as 'Hazardous' due to heavy metal concentrations and TPH concentrations. It is recommended that further testing is undertaken on the mounds to obtain a better resolution of spatial contamination and characteristics prior to either reuse and retention, or disposal.

9.11 Waste Acceptance Criteria (WAC) Results

The Landfill Directive (Directive 1999/31/EC on the landfilling of waste) led to the establishment of a methodology for classifying wastes. Wastes can only be accepted at a landfill if they meet the relevant Waste Acceptance Criteria (WAC) for that type of landfill. There are three different WAC, these are for:

- *Inert waste*
- *Non-hazardous waste*
- *Hazardous waste*

Wastes should first be classified based on their total concentrations as detailed in the previous section. WAC testing is then required if the end disposal route is a landfill. Solid and eluate WAC analysis was undertaken on three samples of Made Ground, the findings of which are presented in the table below.

Reference	Depth (m)	Strata Type	Classification	WAC Analysis	Landfill Disposal
TP07	1.20	<i>MG Sand</i>	<i>Non-Hazardous</i>	<i>Inert</i>	<i>Inert</i>
TP08	1.20	<i>MG Gravel</i>	<i>Non-Hazardous</i>	<i>Inert</i>	<i>Inert</i>
TP10	0.60	<i>MG Gravel</i>	<i>Hazardous</i>	<i>Stable Non-reactive</i>	<i>Hazardous</i>

The results above further confirm segregation of the Made Ground soils will be difficult and they would need to go off as *Hazardous* waste and should be left in-situ where possible.

The possibility of automatic inert classification of the natural soils should be explored in accordance with Section 4.3 of the EA guidance document. The Council Decision includes a list of wastes in Section 2.1.1 of the document that are assumed to be inert and therefore acceptable at a landfill for inert waste without testing, this is the case if:

- *They are single stream waste of a single waste type (although different waste types from the list may be accepted together if they are from a single source)*
and
- *There is no suspicion of material or substances such as metals, asbestos, plastics, chemicals, etc to an extent which increases the risk associated with the waste sufficiently to justify contamination and they do not contain other their disposal in other classes of landfill.*

If any organic contaminated material is encountered during the construction phase, it is possible that this may be classified as *Hazardous* and testing should be undertaken at that time.

Materials should be segregated and where necessary sufficient time is allowed to further classify the material properly, including discussion with landfill sites and waste transfer stations to find the best disposal route. It is recommended that where possible that the soils could be recycled at a suitable local waste treatment plant or transfer station rather than a landfill disposal route.

The reuse of soils on the site this should be done in accordance with the CL:AIRE "Development Industry Code of Practice for the Definition of Waste" (CL:AIRE CoP). Any re-use scheme should be designed to minimise disposal costs.

After a cut and fill balance plan/volume calculation has been carried out, a U1 and T5 exemption could be registered. This will allow the use of the following soils without a waste permit or under Dow CoP MMP:

- *1,000 tonnes (c.600m³) of non-hazardous soil*
- *5,000 tonnes (c.3,000m³) of natural sand and gravels.*
- *50,000 tonnes (c.25,000m³) of bituminous material to be used in roadways.*
- *5,000 tonnes (c.3,000m³) of crushed concrete / stone.*

10.0 FINAL APPRAISAL

10.1 Land Quality

The site has historically been a tin plating works, railway terminus, engineering works, petrol filling station and a mortuary and has included features such as a well, tanks, chimneys and a substation.

Made Ground has been encountered across the site to a maximum depth of 2.9m bgl and predominantly comprised Sand and Gravel. Minor constituents included ash, slag and coal.

The site has relatively low levels of hydrocarbon contamination given the previous usage as a petrol station, and generally low levels of contamination considering the sites historical land usage. There was one exceedance when compared to commercial screening values. The exceedance is relating to benzo(a)anthracene in a sample obtained from TP03 at a depth of 0.3m bgl. No other elevated Contaminants of Concern were recorded based on the proposed commercial end use. Asbestos was detected in four samples of Made Ground at a maximum concentration of 0.04 mass %. In the previous investigations asbestos was found within the Made Ground soils to a maximum concentration of 0.075 mass % and a maximum concentration of 0.018 mass % within the stockpiled material.

The site is to be predominantly covered with hardsurfacing which will break the pathway from site end users to potentially contaminated soils. The risk to human health is considered to be *Low*.

Elevated levels of dissolved Chromium were recorded within one sample of groundwater within CP02 when compared to the EQS screening values, with a maximum concentration of 5.2ug/l. The concentrations of the more toxic hexavalent chromium were at the limit of laboratory detection, and there were no further exceedances when compared to the EQS screening values. The risk to controlled water is *Low*.

Preliminary gas monitoring indicates that the site is within CS1 and gas protection measures will not be required in the proposed development. The level of protection will be confirmed on completion of the gas monitoring. The site lies in an area not requiring radon protective measures. However, if remedial action is not undertaken in the PFS area, vapour membranes should be installed within buildings in this area due to the potential for residual pockets of free phase hydrocarbon within the shallow soils.

Nine samples of the granular Made Ground soils have been classified as *Hazardous* for waste disposal purposes. This material is present across the majority of the site, and it will be difficult to segregate, therefore all of the granular Made Ground should be assumed to be *Hazardous*. It is recommended that where possible, these materials are retained on the site under an MMP and covered with hardsurfacing.

10.2 Ground Engineering

The most suitable foundation solution is considered to be driven piles transferring loads to the underlying very dense Gravel which were encountered at depths between 3.9m and 5.3m bgl.

An alternative foundation solution is the use of Controlled Modulus Columns (CMC's) this should be confirmed with a specialist contractor.

Due to the depth of Made Ground, the contamination beneath the site and the underlying natural Clay, the use of a Sustainable Urban Drainage System is not considered feasible at this site.

10.3 Required Further Work

The following further work is considered necessary to progress the site to construction phase:

Completion of gas monitoring programme and issue gas assessment.

Design of Remedial Specification.

Detailed foundation design.

Confirmation of the recommendations made within this report with the Regulators.

11.0 RELEVANT INDUSTRY REFERENCES

- British Standards Institution. *Investigation of Potentially Contaminated sites - code of practice*. BS 10175:2017.
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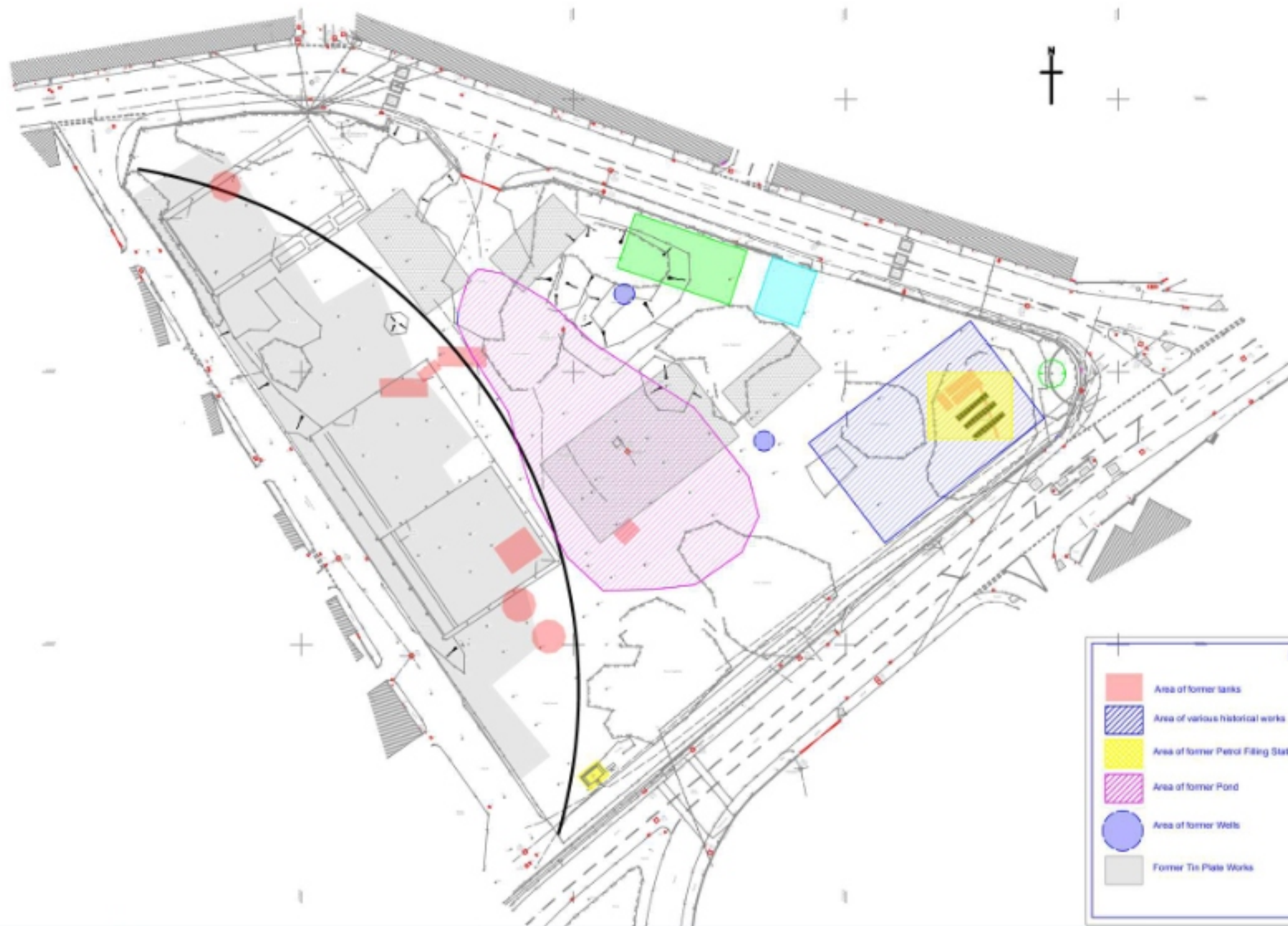
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APPENDIX 1 - Plans





LEGEND	
	Area of former tanks
	Area of various historical works
	Area of former Petrol Filling Station
	Area of former Pond
	Area of former Wells
	Former Tin Plate Works
	Former residential buildings
	Former Mortuary
	Substation
	Former Cooperation Depot
	Historical Railway

A. Contaminated soils / Made Ground.
B. Ground gas.

- P1. Ingestion of soil and dust.
- P2. Inhalation of vapour.
- P3. Inhalation of soil dust by adjacent site users.
- P4. Attacking of potable water supply pipe.
- P5. Migration and accumulation of ground gas in internal places.
- P6. Impaction of groundwater from soil contamination.
- P7. Migration of soil and groundwater contamination impacting surface waters.

W. River Afan c.86m south.
X. Groundwater within the underlying Secondary A Aquifers.
Y. Site end users.
Z. Adjacent site users.

