



Environmental Site Assessment

**Former Monckton Coking
Works,
Lund Hill Lane,
Royston,
Barnsley,
South Yorkshire,
S71 4BD**

For

**Monckton Developments
Limited**

July 2020

20.B0010.4.1

Geo² Remediation Limited

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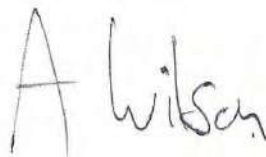
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Revision Log

Version	Date	Author	Approved By
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1.0 Introduction

Geo² Remediation Limited have been commissioned by Monckton Developments Limited to conduct a Environmental Site Assessment of Former Monckton Coking Works, Lund Hill Lane, Royston, Barnsley, S71 4BD (the site).

The site comprising a former coal stockyard, colliery and coking plant has been subject to previous limited investigation as part of licence conditions in the past. Cessation of operations and subsequent demolition of the site have allowed a more thorough investigation to be undertaken.

This assessment comprised a site investigation which was undertaken to assess the condition of the underlying soils, groundwater and ground gases in order to refine and delineate the extent and severity of previously identified land contamination and assess conditions where no data is currently available at the site.

This report provides a factual report of conditions and contamination encountered onsite and will be supplemented by a Quantitative Risk Assessment (QRA).

The Site Investigation was conducted between 28th April 2020 and 20th July 2020. The investigation was undertaken in accordance with Geo² Remediation Ltd Method Statement SMS SI 1015.

At the time of writing the site has ceased trading and has largely been demolished to slab level; in preparation of a proposed redevelopment programme.



2.0 Site Setting

2.1 Site Location

The site is located on Lund Hill Lane, Royston, to the northeast of Barnsley, South Yorkshire; at a National Grid reference of 437460, 412020, as shown on Figures 1 and 2 in Appendix A.

At the time of writing, most of the site has been reduced to slab, or sub slab level, with few structures remaining associated with the historical workings of the site.

The former engineering workshop remains on the eastern boundary and a portion of the land, beyond the eastern boundary has been redeveloped into offices and car parking for Hargreaves Industrial Services plc.

The site is accessed from two main entrances along the eastern boundary, from Lund Hill Lane, the northernmost entrance allowing access through a weighbridge to the former stockyard and Engineering Workshops, the southern entrance allowing access to the Hargreaves property (which will be considered as offsite in this assessment) and an effluent treatment plant in the far south of the site. A photographic log of the site and the works undertaken are presented in Appendix B.

2.2 Site Areas

For convenience many of the historic reports have separated the site into three key areas, divided by the current and historical activities which have taken place. These area designations and names will be adopted herein. The extents of each of these areas is shown on Figure 3, in Appendix A.

- Stockyard and Colliery Area

The northernmost portion of the site; formerly occupied by the coke and coal stockyards. This area was the hub of the former colliery operations including numerous buildings and rail tracks.

- Former Production and By-Products Area

This forms the centre of the site including the Combined Heat and Power (CHP) infrastructure, coking ovens and conveyors. This area includes plant associated with production of tar, benzole and ammonia.

- Southern Site Section

This area contains the effluent treatment plant and is predominantly wooded with coarse vegetation and semi-mature trees. Much of this area slopes steeply to the south.

- Western Land Parcel

This area lies to the west of the railway lines. This parcel of land is understood to be out-with the boundaries of this site. It is understood that this area was formerly linked with a bridge to the main site and historically has been used for deposition of colliery spoil and more recently gas purification, storage and distribution.

This area of the site has been reported separately.

2.3 Site Levels

The ground levels are generally highest in the Process Area / Southern Area (near the footprint of the Combined Heat and Power (CHP) plant), the remainder of the site gently falls towards the north. The western and southern boundaries, slope steeply downwards into the railway cutting and road bridge level. In the north, northeast and northwest, the land level has been cut into the hillside where rudimentary retaining walls of tyres have been constructed.

An earthen is present in the northeast, and around the site boundary in this area.

2.4 Site Setting

The site is situated in an area characterised by former coal mining activities, at the time of writing little of this infrastructure remains active. Current nearby landuses are summarised on Table 1, below.

North	Agricultural land and commercial facility, approximately 120m to the north. Beyond which lie disused industrial and agricultural land.
East	Lund Hill Lane (B6428), beyond which lies grassed disused industrial land and a timber recovery facility.
South	Lund Hill Lane (B6428), beyond which lies former industrial land now Rabbit Ings Country Park.
West	Railway Cutting, beyond which lies agricultural land and residential properties approx. 120m beyond the site boundary. The Barnsley Canal lies approximately 200m to the west.

Table 1: Surrounding Land Uses

2.5 Sensitive Receptors

Reports have not identified any land use designations, such as SSSIs or similar. Areas of green belt are present in the surrounding land and the site falls within a Nitrate Vulnerable Zone.

2.6 Proposed Development

The Client is looking to redevelop the site as a residential development including circa 400 homes, areas of public open space and roadways.

Due to the current topography of the site, it is understood that areas of the Stockyard and Southern areas are likely to include significant land level rises, to match the surrounding landscape and access routes more closely.

The development aims to locate historical mine shafts in public open space areas and utilise the topographically lower southern area to incorporate public open space and utility areas.

A site layout plan is incorporated in Figure 3, in Appendix A.

3.0 Historical Site Operations

This section of the reports outlines the historical operations undertaken at the site in each of the site areas.

3.1 Previous Reports

Numerous historical site investigation have been undertaken at the site, the findings, conclusions and limitation of which are detailed in the following report, the key findings of which have been reproduced here for convenience of the reader.

Geo². Gap Analysis and Data Review. 19.B0010.1.2, October 2019

3.2 Stockyard and Former Colliery

This area is currently level and largely demolished to slab level, with the exceptions of the Engineers Workshop building and occasional small structures. The former structures in this area were used as workshops, mobile plant refuelling, effluent handling and storage.

The bulk of the stockyard was used for the storage of coal, with approximately 100No. twenty tonne lorry movements delivering coal and removing coke from the site daily during operations. Tipped coal was lifted from stock and conveyed to a 1,300-tonne storage bunker, before being conveyed to a 500-tonne bunker and into the coke ovens. This area appears surfaced with a thin layer of black coke dust 'breeze'.

In the northwest corner of the site remain a series of Quench Ponds which appear to remain intact and are holding water.

Three mine shafts are understood to be present in this area, records indicate these have been capped.

A portion of the stockyard area, in the east, is present at within a bund, matching the height of the surrounding land beyond the northern boundary. This area appears to be vegetated.

The engineering workshop was situated adjacent to a waste storage and collection area. A substation is also indicated to be in this area.

Currently large stockpiles of high silica content brickwork associated with the demolition of structures onsite remain present on the site.

3.3 Production and By-Products Area

The central section of the site forms the Production and By-Products area. This area is understood to have been used for the production of coke and associated products for over a century.

3.3.1 Coke Production

This process comprised coal carbonisation and was undertaken in the central part of the site. Carbonisation is the thermal process for the conversion of coal into coke, involving a sustained high temperature in ovens for eighteen hours in the absence of air. On this site five batteries of ovens (42 in total) were located at the northern boundary of this area, adjacent to the stockyard giving access to coal.

The coal is heated indirectly through heat transferred through the refractory walls from flues running along each long wall, in which coal gas is burnt under controlled conditions in air. The coal gas produced is collected in a gas collection main. Recovered gas used to

fire the ovens is a portion of that drawn from the coal during carbonisation. Recovered gas is purified and added to a preheated air stream back into the ovens.

Once heating is complete, coke is pushed by a ram into a rail mounted coke car. Exposure to the atmosphere allows the coke to burn, which is extinguished using a quenching rig at the rear of the ovens. Coke is screened and cut to size at the Coke Wharf before transport back to the Stockyard area.

3.3.2 By-Product Processing

Pre-treatment of coal gas results in the generation of a series of by-products, used in the coke works process.

Gases recovered are treated in the Concentrated Ammoniacal Liquor plant. The gas collected from the main is cooled using five heat exchangers (Primary coolers), this separates out the tar and ammoniacal liquor. Tar is separated from gas using an electrostatic detarrer for storage and resale. Ammoniacal liquor is separated by ammonia washers, spraying water through the gas. The gas then passes through Benzole Scrubbers where wash oil recovers the benzole (a mix of benzene, toluene and xylenes). The wash oil is distilled with steam to recover the benzole as a saleable commodity. Vapours are condensed to give a saleable product with approximately 20% ammonia and 2% sulphide.

60% of the cleaned gas is used onsite in the CHP supplying steam and power for the works. Surplus power is sold on the National Grid. Treated gas was stored onsite in a 1,400m³ capacity gas holder.

Treatment is understood to have comprised mixing effluent with biological sludge and oxygen to degrade organic compounds to carbon dioxide.

More recent reports suggest that an electric substation may also be present close to an area of removed Ammoniacal Liquor tanks near to the gasholder.

3.4 Southern Site Section

This area has generally had few industrial applications and contains the Biological Effluent Treatment Plant.

The stripped liquor is pumped to a biological effluent treatment (BET) plant, which is used to treat drainage prior to discharge to sewer. It is understood that this plant also treated water from Lineside Dyke on the western boundary of the site.

3.5 Western Land Parcel

This parcel of land falls out with the boundary of the site, although records indicate the deposition of colliery spoil and uses in the purification, storage and distribution of gas produced on the site.

As previously mentioned, the Western Land Parcel is reported separately.

4.0 Environmental Setting

Information regarding the environmental setting of the site was obtained from the Data Review and Gap Analysis report by Geo², October 2019. A summary of the data review is outlined below.

4.1 Site Geology

4.1.1 Made Ground

Made ground has been encountered across the entire site in all earlier investigation works to a thickness of between 0.2-4.0mbgl.

In the Coal Stockyard a coal breeze was present at between 0.2 to 1.1m in thickness associated.

The east of the stockyard is underlain in parts by reworked topsoil, which are also present across much of the production and by products area. This material is noted to include fragments of coke, coal and brick.

Made ground mainly constitutes a very loose, medium dense ash based gravelly sand, with variable content of clinker, cinder, coke, brick, concrete, mudstone and sandstone (colliery spoil).

Cohesive areas of clayey made ground were encountered within the bulk of the granular made ground deposits.

4.1.2 Superficial Geology

Limited information is available detailing the presence of natural soils beneath the site, likely due to the degree of industrialisation which has occurred on the site over the years. As a result, natural superficial deposits have only been encountered in the extreme northern and southernmost parts of the site at depths of between 0.4-3.0mbgl.

These deposits generally comprised firm to stiff gravelly clays, however soft organic clays were proven in the extreme north of the site.

Limited evidence of natural granular soils was reported, where encountered there are considered to be the result of insitu weathering of underlying coal measures.

4.1.3 Bedrock Geology

The underlying bedrock geology has been reported as Undifferentiated Carboniferous Middle Coal Measures, comprising Mexborough Rock sandstone, beneath the majority of the site, apart from the north and southernmost parts where mudstone is present. The Mexborough Rock sandstone bedrock is dipping towards the north which underlies the mudstone bedrock identified in the north of the site.

The Royston Coal Seam outcrops beneath the site in the south of the site at a shallow depth. This area has been reported as falling within a Development High Risk Area, with reference to potential historic shallow mining.

Intrusive investigations undertaken by various parties encountered Bedrock at depths of between 0.5-4.5mbgl, placed directly underlying Made Ground deposits. Bedrock primarily comprises Sandstone, however Mudstone was encountered in the northeast, south and central eastern parts of the site.

Records indicate excavation of clays have occurred in the north of the site, with Sandstone quarrying in the southeast (understood to be beneath the existing Hargreaves Industrial Services plc premises located to the south-east of the Production Area).

Rotary drilling demonstrated interbedded sequences of sandstone and mudstone to a maximum achieved depth of 30mbgl. The presence of coal shafts in the north of the site, is suggestive of productive seams at a greater depth in this area.

4.2 Site Hydrogeology

The underlying bedrock has been designated as a Secondary A aquifer, there is no designated groundwater within any superficial deposits.

Groundwater vulnerability mapping indicates that the site has a high leachability potential, although it should be noted that this is due to poor data coverage in the area and is a worst-case scenario.

The Data Review and Gap Analysis report by Geo² indicates that the shallow groundwater encountered is not considered to be a continuous body across the site.

Deeper boreholes suggest a potential groundwater flow direction within the deeper groundwater within the sandstone bedrock towards the north assuming a single continuous water body is present beneath the site. However, other reports that have been reviewed as part of the Data Review and Gap Analysis report suggest no clear groundwater flow direction and the potential for multiple groundwater bodies.

Dense Non-Aqueous Phase Liquid (DNAPL) was encountered in BH203 in the Production Area in 2013, with a response zone targeting the mudstone, this was not noted in 2011. Following removal of approximately 25 litres of NAPL from BH203, this was observed to recharge to a similar thickness within 24 hours. This product has been tentatively identified as Coal Tar.

4.3 Site Hydrology

The Geo² report identified the following the surface waters, presented in Table 2, from its Data Review.

Water Feature	Quality	Distance	Direction
Lineside Dyke	Unclassified	Adjacent to the northern part of the western boundary of the main coking works site. Flows in a generally southerly direction joining Cudworth Dyke approximately 140m to the south of the site.	
Wakefield Brook	Unclassified	Within 10m of the western boundary of the former gas purification area (the western parcel of land), approx. 100m from the current site boundary, close to the Barnsley Canal. Flows in a southerly direction, joining Cudworth Dyke, approximately 220m south of the site.	
Cudworth Dyke	Unclassified	Located approximately 140m to the south of the site. This flows in a southerly direction, joining the Sandybridge Dyke to become Poole Dyke. Eventually flows into the River Dearne approximately 5km south of the site.	
Barnsley Canal (disused)	'F' or 'poor'	35m	West

Table 2: Surface Water Features

Reports suggest that abstractions had been made from these water courses during the operational life of the site, none of which remain active currently.

5.0 Site History

A summary of the of the site history is provided in Table 3a-3b that has been taken from the Data Review and Gap Analysis report by Geo², October 2019.

Year	Description
1854	The site and surrounding land are shown as undeveloped agricultural land. A railway is present in its current location and the Barnsley Canal is shown.
1874	Monckton Main Coal Colliery Limited is established.
1875	A 'Clay Mill' was established and sinking operations associated with two shafts started, completed in 1878.
1879	Twelve beehive ovens were established.
1884	The by-products plant and ten ovens were established.
1886	Erection of gas plant occurs.
1893	<p>Monckton Main Colliery occupies the northern part of the site, comprising coke ovens, shafts and railway tracks. A gasworks is located to the southwest of the site (described as being in the location of the current effluent storage tanks).</p> <p>A mineral railway is present in the east of the site which runs to the northeast corner of the site.</p> <p>Two powder magazines are noted in the central portion of the site. A small old quarry is located in the south east part of the site.</p> <p>Deposited colliery spoil is marked in the north of the site and waste materials have been tipped in the area of the current By-Products area.</p> <p>The southern end of the site is shown as containing terraced housing and a Methodist Church.</p> <p>At this time the western parcel of land is shown as a Spoil Heap and is connected to the Main site by a railway line. Spoil is also shown as having been tipped across much of the low-lying area in the west of the site.</p>
1906	<p>Monckton Main colliery has expanded within the northern part of the subject site. Additional coke ovens and rail lines have been developed with filter beds (in two locations close to the railway), above ground tanks and a waste spoil heap also present. The powder magazines are no longer shown.</p> <p>The gas purification area is now occupied by a gasometer and spoil heaps.</p> <p>The northeastern area is no longer shown as a brick works, although kilns are still present.</p> <p>Offsite, the western parcel of land shows a single gasholder.</p>

Table 3a: Site History

Year	Description
1917-18	<p>The coke ovens are shown in their current location, with a number of features in the by-products area labelled as tanks. A railway line indicated on earlier plans is shown as running within a tunnel.</p> <p>In addition to the two mine shafts a third air shaft is shown close to the centre of the site. The gasworks is no longer shown on the site, or on the western parcel of land.</p>
1932-33	<p>Spoil heaps are shown associated with the onsite colliery, which extend offsite to the east, onto the Rabbit Ings site and to the north.</p> <p>Two circular features are shown on the southern part of the western parcel of land.</p>
1962	<p>The northern part of the site is labelled as a mine, with a large building with railway track connections located on the northern boundary. This is linked to the Works in the centre of the site. Water tanks are shown on this plan, consistent with the location of the existing Quench ponds in the North West.</p> <p>The mine appears connected with buildings to the East of Lund Hill Lane. The western parcel of land has become annotated as Works also. Distinct areas of tipping have expanded into the neighbouring land to the north and east.</p>
1970	The Benzole Rectification Plant closed and demolished, and shafts infilled and concrete capped.
1980	The Biological Effluent Treatment Plant is constructed.
1981	<p>The site has been rationalised, with a number of buildings and railway lines associated with the mine no longer apparent. The mine itself is listed as disused. Residential properties in the south are no longer present.</p> <p>Spoil heaps offsite, to the north are now labelled as active workings and land to the east of Lund Hill Lane is now shown as a drift mine.</p>
1990	The number of structures on the site is shown to decrease, with buildings in the north of the site shown to have been removed.
1994	The railway lines have been removed from the site.
2006	The office block and CHP plant (built 1998) are shown in their current configuration. Offsite spoil heaps are now shown as wooded or parkland and the drift mine is no longer shown.
2014 onwards	The site is largely in its current configuration, with demolition and stockpiling of materials from the coke ovens.

Table 3b: Site History

6.0 Preliminary Conceptual Site Model

UK legislation and guidance on assessing potentially contaminated land recommends the use of a risk assessment process based on a review of source/pathway/receptor relationships for various environmental media. The first stage of any risk assessment is to identify, using the desk study data and site information, the presence and extent of any hazard at the site, theoretical or demonstrable.

A key component of the overall risk assessment process is identification of “relevant pollutant linkages” between contaminants and receptors. This can be accomplished through development of a site-specific conceptual model in which the potential contaminants, pathways and receptors identified on-site are described.

Each element can be defined as follows:

- **Contaminant source:** A substance either on or under the land and which has the potential to cause harm or pollution to human or environmental receptors.
- **Pathway:** A route or means by which a receptor can be exposed to or affected by a source.
- **Receptor:** A living organism or an ecological system or, controlled water, or property including buildings, crops and livestock.

The presence of all three of the above elements identifies a relevant pollutant linkage and a potentially unacceptable risk. To ensure that any risk present to, or, from the site can be appropriately managed each of these contamination linkages will be targeted by the investigation.

The Conceptual Site Model below has been based upon the findings of the Data Review and Gap Analysis Report by Geo², October 2019 which has reviewed all available historical reports.

6.1 Sources

The key identified contaminant sources on the site are as follows:

6.1.1 Combustible Shallow Soils and Asbestos

Assessment to date indicates that almost the entire Stockyard area and a small portion in the northwest corner of the Production and By-Products area is surfaced with a mantle of ‘breeze’ a black, coke dust rich substrate, which appears to be predominantly of a high calorific value and potentially flammable. This material appears to have originated from use of this area for storage of coal and coke products.

Additional testing of the top 0.5m of this material has identified Chrysotile asbestos within this material, however, due to a low density of sampling at this depth, it is unclear as to whether this impact is localised, sporadic or widespread.

6.1.2 PAH, Metal and Asbestos Contamination within Made Ground

Made Ground is present across almost the entire site and makes up most of the superficial soil deposits identified, this predominantly comprises granular fill of rubble, coke, and ash. This material has been deposited from the demolition and deposition of rubble associated with multiple generations of plant and equipment over with the industrial heritage of the site. As a result, this forms a highly variable substrate.



Due to the nature of this material testing has encountered hotspots of PAH and metals from coking wastes in numerous locations spread across the Stockyard and Production and By-Product areas of the site.

In addition, potential infilling of materials, namely in the untested 'Unused Area' in the Stockyard poses a potential hazard due to the unknown nature of its composition.

This material is likely to remain variable throughout its entire volume, further characterisation would be unlikely to alter the classification of this material.

6.1.3 Hydrocarbon and Tar / Oil Contamination

The walkover of the Production and By-Products area indicated numerous potential point sources for spills and leaks of a wide range of contaminants, by-products and wastes, frequently in leachable liquids with the potential to have entered into the underlying ground and groundwater from leaks, spills and historical waste management practices.

Due to restrictions placed on earlier investigations, as the site was still active at the time, the number of samples and detail of the investigation in this area is of a relatively low density compared with the very high number of potential contaminant sources. Much of this area is poorly understood with little reliable information on the groundwater regime in this area. Existing trial pit logs have indicated a significant number of buried obstructions in this area.

Available testing from the Made Ground and Groundwater in the Production and By-Products areas of the site has identified potentially significantly elevated concentrations of PAH contamination which are considered likely to be associated with leaks and spills from these processes (rather than due to the composition of the rubble matrix), based on a review of corresponding trial pit and borehole logs.

Visual and olfactory evidence of coal tar on the surface of much of the central and western parts of the Production Area were noted. In addition, one location, along the western boundary of the site identified what is likely to be Coal Tar, as a DNAPL, close to the old boiler plant, whilst this has not been identified elsewhere, it is likely to be connected to wider source in the area as suggested by the visual identification of tars and NAPLs within soils in BH204, BH205, MW5 and MW6.

6.1.4 Silica Bricks

Stockpiled bricks onsite are understood to contain an elevated amount of Silica, which if processed may present a human health risk. These are currently formed into a stockpile in the former Stockyard and Production areas of the site.

These are considered as suitable for reuse onsite provided, they are processed appropriately and as such will not be considered a contaminant source.

6.1.5 Ground Gases

Ground gases are understood to have been sampled from numerous locations, however limited data has been made available to Geo². Ground gases may emanate from numerous sources including contaminated land, infilled materials and coal deposits.

Projected areas of infill such as the Clay pit in the north, do not appear to contain significant volumes of infilled materials.

The area of the former sandstone quarry, beneath the current Hargreaves building is unknown, however this will be considered as offsite for this assessment.

6.2 Pathways

The key pathways by which contaminants might pose a risk on the site are as follows:

6.2.1 Direct Contact, Inhalation and Ingestion

Shallow contamination, either at the current or future land levels, may pose a risk through exposure at surface to future land users. Laboratory testing to date, has indicated potentially unacceptable contamination is present in shallow soils.

6.2.2 Groundwater Migration

Groundwater beneath the site is quite poorly understood, with no clear flow direction or clear waterbodies established across large areas. Broadly the groundwater is present within the underlying bedrock beneath the site.

In the Stockyard area, which appears better understood, groundwater appears to display limited evidence of contamination.

However, in the Production and By-Products area, clear evidence of DNAPL and potentially gross groundwater impact has been noted, which demonstrates that this pathway may carry contamination offsite, downgradient.

6.2.3 Accumulation of Vapours or Gases

This may occur indoor in enclosed spaces and might result from vapours emanating from hydrocarbons or ground gases which might cause harm should these migrate into properties on, or off the site. This pathway includes the potential for the tainting of water supply pipes.

6.3 Receptors

The key receptors on and nearby the site have been identified as the following:

6.3.1 Future Residential Site Users

It is understood that the site has a proposed residential end use, with a proposed final layout included on Figure 4 in Appendix A.

It is understood that the Client proposed to increase the final site levels to reflect the surrounding land and to achieve this a degree of import or releveling will be required. Consideration must be given to the vulnerability of this receptor at the final site levels, from any potentially contaminated materials.

No assessment is made here for construction workers, who should be made aware of potential hazards on the site and take appropriate steps through a Site-Specific Health and Safety Working Plan and Environmental Statement to ensure potential impacts during redevelopment can be minimised or mitigated.

6.3.2 Offsite Land Users

These take the form of nearby industrial neighbours of the site, the Timber Yard to the West and former Coal Yard to the north. Residential land users have been identified at a distance in excess of 100m from the site boundary.

For the purposes of this assessment the Hargreaves office building on the eastern boundary will be considered as offsite and must be considered as a viable receptor, through close proximity to the site.

On the basis of current site data there is little evidence to indicate a potential hazard to offsite land users, however they should be considered in the event of any proposed remediation or redevelopment works.

6.3.3 Controlled Waters

The underlying aquifer is classified as a Secondary A aquifer, within the bedrock although the site is not noted as falling within a Source Protection Zone. The permeability of the sandstone bedrock and degree of identified impact within this water body does indicate that this waterbody may have already become impacted. There is currently insufficient evidence to demonstrate whether there is any form of contamination plume in the groundwater.

Nearby surface water channels are located along the western site boundary, namely Lineside Dyke and Wakefield Brook, located topographically downgradient, and running close to the railway line. These watercourses may be ephemeral or relatively minor, however, these may act as a receiving water for migrating contamination. Sampling has been undertaken of surface waters although the locations of these samples is unclear.

Additionally, the presence of relict drainage, most likely in the Production and By-Products area, may allow transmission of contaminants into surface waters or drainage channels through preferential pathways, currently unidentified.

6.3.4 Sensitive Land Use

A review of supplied desk study data has not indicated any sensitive nearby land uses beyond those detailed above. This will not be considered further in this assessment.

6.3.5 Structures Onsite

As all onsite structures are to be removed, the risks from aggressive ground conditions to future buildings should be considered at design stage. Due to the proposed releveling works structural implications should be addressed once final levels and imported material characteristics are understood.

6.4 Contaminant Linkages

Each of the identified plausible contamination linkages in the conceptual site model is reviewed based upon the findings of the site investigation which allows a greater understanding of the ground conditions at the site, site observations, soil and groundwater quality and chemical analysis.

A qualitative risk assessment is undertaken in line with guidance provided in *Guidance for the Safe Development of Housing on Land Affected by Contamination* (EA / NHBC, 2008). The purpose of this assessment is to determine the relative significance of the identified contamination linkages by assessing the probability of an impact occurring and by assessing the perceived severity of an impact to a receptor.

Those linkages considered of low risk or less on the basis of the additional site data will not be considered any further in this assessment. Linkages considered to be more significant are identified as presenting the potentially significant hazard, which may present a potentially unacceptable risk to the identified receptor. In these instances, further works may be considered necessary to characterise these risks adequately.

The contaminant linkage table below has been updated and adopted historical reports during the Geo² data review.

Potential Source	Potential Pathway	Potential Receptor	Likelihood	Severity	Risk
Combustible Shallow Soils	Direct contact, exposure, plus instability risk in event of fire	Future residential site users.	Likely	Severe	High risk
PAH, Metal and Asbestos Contamination within Made Ground	Direct contact, ingestion and inhalation.	Future residential site users	Low Likelihood	Medium	Moderate Risk
Hydrocarbon and Tar / Oil Contamination	Direct contact, ingestion and inhalation.	Future residential site users	Low Likelihood	Medium	Moderate Risk
	Groundwater Migration	Controlled Waters	Likely	Medium	Moderate Risk
		Offsite Landusers	Low Likelihood	Mild	Low Risk
Ground Gases	Accumulation of Vapours or Gases	Future residential site users	Likely	Medium	Moderate Risk
		Offsite Landusers	Low Likelihood	Mild	Low Risk

Table 4: Qualitative Risk Assessment

7.0 Site Investigation

7.1 Investigation Objectives

This investigation has been undertaken, with respect to the Monckton Coking Works site (not the Gas Purification Facility), in accordance with the agreed scope as presented in the Envestigate Ltd Site Investigation Strategy (ESG/FG2/SoW). The key objectives of which are to:

- To identify the three mine caps located above the three mine shafts within the stockyard area.
- To investigate stockyard for the presence of a historic underground railway tunnel which is potentially connected to a clay pit in the north of the stockyard through the use of excavation and dynamic probing.
- To investigate the north of the stockyard area and unexplored area in the northeast for presence of a historic clay pit through the use of excavation.
- To investigate the extent of combustible shallow ground associated with breeze material in the Coal Stockyard and Production area.
- To investigate the made ground across the site for impacts of PAH, Metals and Asbestos.
- Investigate the whole site for any Coal Tar or NAPL impacts, especially in the Production Area where data is limited.
- Assess the deeper groundwater for any potential impacts that maybe present within the Production Area by installation of eight deep boreholes to a maximum depth of 20m: and,
- Investigate and monitor the potential of ground gases associated with the ground in the across the whole site.
- Identify, if present, and mark the location of any potential Japanese knotweed that may be on site.

7.2 Investigation Works Undertaken

In order to provide an assessment of each of the identified contamination linkages an intrusive investigation was specified to obtain further information regarding the geology of the site and the quality of the soils and groundwater.

A total of ninety-eight trial pits (TP1 to TP98) and thirty boreholes were completed across the whole of the site. Of the thirty boreholes twenty-two were advanced using window sampling (WS20-01 to WS20-10) techniques and eight deeper boreholes were advanced using rotary techniques (BH19-1 to BH19-8).

Sixteen monitoring wells were installed across the site with eight shallow monitoring wells installed during the window sampling across Production Area, Coal Stockyard and Southern Area. The remaining eight monitoring wells were installed in the Production Area to investigate the deeper groundwater. Four Monitoring wells were installed to 12m and the remaining four to 20m.

The locations of all trial pits, boreholes, window samples, probeholes is shown on Figure 6, in Appendix A. These locations have been plotted against historical features identified in previous topographic survey work. Surviving historical boreholes have also been identified at the site and are also included on Figure 6.

Borehole logs and trial pit logs for all locations are included Appendix C.

7.2.1 Japanese Knotweed

It should be noted that during the site investigation Japanese Knotweed was not identified anywhere across the site and will not be discussed any further in this report.

7.3 Soils Investigation – Production Area

7.3.1 Investigation Method – Production Area

Trial pitting was used in order to further assess the shallow soil conditions across the production area, in particular in the areas where limited investigation and been conducted to date to assess ground conditions beneath the site.

Forty-six trial pits (presented in Figure 6 in Appendix A) were constructed to depths of up to 4.0m below ground level (m bgl). The trial pits were excavated using an excavator with a breaker and bucket. The trial pits allowed collection of soil samples from beneath the site and for logging of ground conditions encountered.

Field analysis comprised the examination of each of the samples for visual and olfactory indications of contamination. Headspace analysis was also conducted for volatile hydrocarbons using a photo-ionisation detector (PID).

Fifteen window sample locations were advanced to a maximum of 4.4m.

Eight deep boreholes were drilled to a maximum depth of 20m bgl to assess the conditions of the deeper sandstone aquifer. Soil samples were taken, where necessary, from the shallow and deeper ground during trial pitting and rotary drilling.

7.3.2 Ground Conditions – Production Area

Ground conditions encountered across this area of the site comprised either hardstanding concrete or open ground consisting of either gravel or grass and topsoil.

Made ground was identified to a maximum depth of 3.6m, deeper areas being associated with historic infrastructure. Where structures were not historically present the made ground was found to be much shallower, typically circa 1m. Made ground consisted of a varying degree of gravelly sands or sandy gravels with numerous inclusions of cobbles of concrete and bricks. Historic infrastructure associated with the production area such a metal pipes that were stained with coal were present throughout.

Bedrock was found across the Production area in all trial pits where obstructions were not present and was identified between 0.75m and 3.8m bgl. Bedrock comprised yellow beige sandstone which was weaker at the top (returns of gravel). Deeper drilling identified the inclusion of mudstone bedrock between 11.50m and 20.00m bgl.

Historical borehole, BH305, located in the east of this area, was located and sampled. This well targets a deeper horizon of sandstone encountered beneath the mudstone from a depth of 25mbgl (45.37mAOD).

7.3.3 Evidence of Contamination – Production Area

Visually impacted soils were identified across the Production Area, predominately associated with historic underground infrastructure. Figure 7 presents the area that have been impacted through the historic use of the site as a coking works. It was noted that predominately made ground was impacted with visible tar being identified on the surface, around pipework and underground structures, however, in places natural bedrock was also noted to be stained and to contain a coal tar odour.

Impacts were identified at the following locations:

- TP9, TP10 (Process area near the former gas holder) and TP22 (former Above Ground Storage Tank area) identified blue staining associated with cyanides.
- TP21 (near former water tanks and vertical tanks), TP25-28 (near quench ponds associated with tar sumps), TP31-39, TP41-46 and TP49 (all in tanks and benzole plant areas) identified visible coal tar and or/staining with a coal tar odour.
- BH19-02 and BH19-05 (near former gasholder), BH19-06 and BH19-07 (benzole area) identified visual and olfactory evidence of coal tar in the deeper ground.
- TP48 and BH19-07 identified a solvent odour (benzole area).

During the trial pitting exercise features such as two underground tunnels were identified in TP23 and TP24 and a sump containing coal tar was present directly south of TP24.

The logs of the soil bores, which are presented in Appendix C, detail the ground conditions and the sampling depths together with any visual and olfactory indications of contamination.

7.3.4 Obstructions

The vast majority of the Production Area is surfaced with concrete, where plant areas have been reduced to slab level. Concrete typically comprises 200-400mm thick reinforced layers, frequently a second layer is present underlying the surface by approximately 500mm.

One coal tar sump was identified directly north of TP24 in the production that was full of tar at the time of the investigation. Other coal tar sumps are also likely to be found in this area.

Additional concrete and obstructions were present associated with deeper infrastructure, basements, underground tunnels and basement slabs, with much substantial concrete noted in pits near the coke ovens, gas holder tanks and quench tanks.

Frequently coal tar is present around and within porous concrete in former process areas.

7.4 Soils Investigation – Coal Stockyard

7.4.1 Investigation Method – Coal Stockyard

The following works were undertaken in the Coal Stockyard area:

- Forty-eight trial pits to assess the ground conditions beneath the site were advanced to a maximum depth of 4.1m bgl.

- Six window samples locations were advanced to a maximum depth of 4.0m.
- Four trial trenches were advanced to identify the three mine shaft caps located in the Coal Stockyard area.
- Two trial trenches and nineteen dynamic probe holes were advanced to identify an historic train tunnel below ground level.

7.4.2 Ground Conditions – Coal Stockyard

The Coal Stockyard area comprised of a mixture of concrete hardstanding and a thin layer of coal breeze (max 0.4m thick – TP55) across the area. The breeze is variable in thickness typically between 0.2-0.4m in thickness and extends up to the northern boundary bund wall and down to the fencing by the engineering compound in the east. The breeze extends to the northwestern and western boundaries and extends up into the northwest of the Production Area. It is also noted that coal rich soils, were noted within the top metre, across the Stockyard, often present beneath concrete surfacing.

This is significantly lower than previously encountered by historical investigations and suggests that much of this has been removed during or post demolition.

This was underlain by made ground which was proven to a maximum depth of 4.0m bgl comprising predominately sandy gravels or gravelly sand which the occasional horizon of clay. Frequent cobbles of concrete and brick were present throughout with occasional brick walls or manholes identified.

Beneath the made ground natural ground was identified between 0.2m and 3.1m which included occasional gravelly clay that were not laterally consistent across the Coal Stockyard. Beneath the gravelly clay or made ground was a bedrock of sandstone in the south or mudstone in the north of the Coal Stockyard area.

Along the northern site boundary and in the north eastern corner an earthen and tyre bund wall is located. Excavation found these to be approximately 15m wide and approximately 5m in height over the surrounding land level, the bunds comprised gravelly clay made ground, similar in composition to that encountered across the stockyard area. Beyond the bund in the north eastern corner the land level falls back to the level of the stockyard and the area has become wooded, this area was targeted with TP77-79.

7.4.3 Evidence of Contamination – Coal Stockyard

Visual and/or olfactory evidence of contamination was identified in TP61 and TP80 close to the western boundary identified Coal tar impact that is likely to be associated with Production Area processes, evidence of pipework and infrastructure was encountered in each location.

Coke breeze, present as a black sand / gravel across much of this area and considered likely to be of high calorific value.

No other visual or olfactory evidence of contamination was noted in this area.

7.4.4 Mine Shaft Locations

Four trial pits (TP1 – TP4) were advanced to identify the three mine shaft caps within the coal stockyard area. Historic reports state the caps are 20m x 20m x 2m concrete covers over the top of three historic mine shafts. TP2 – TP4 identified the concrete caps and the

location of these are identified on Figure 6. The caps were identified at between 2.9 and 3.5m bgl.

Mine shaft caps have been proven at the following locations:

- SE 37505 12187. N412187, E 437503; beneath the fence line of the Engineering Workshop in the east of the Stockyard.
- SE 37431 12221. N412217, E437432, in the centre of the Stockyard.
- SE 37430 12159. N412154, E437430, in the south of the Stockyard.

7.4.5 Train Tunnel

Two trenches (Trench 1 – Trench 2), shown on Figure 8, in Appendix A, were advanced in the location of an historic railway tunnel. Trench 1 located to the south-western part of the Coal Stockyard identified the tunnel with brick walls and metal railway lines still present beneath the ground. The railway lines were a small gauge and limited evidence of wood or concrete sleepers was noted to a depth of 1.5m. Infill was noted to comprise a loose, fine red / brown sandy material and is likely to be geotechnically variable.

Trench 2 was advanced further to the north-east of trench one to identify the tunnel, however, no railway tunnel was identified. It is thought that this area may have been re-worked in the past or that the railway tunnel may be present above the current ground level.

Dynamic probe holes (PH1-PH19) were also advanced around the area of the tunnel to identify the route of the tunnel. Dynamic probe results are presented in Appendix D and the location of the probe holes are presented in Figure 6 in Appendix A. Probe results did identify areas of softer ground within the potential tunnel route, however, it is still uncertain whether the tunnel present in the location of probe holes.

Another potential historical railway tunnel was identified in the bund at the east of the Coal Stockyard in TP77. Infill was a brown red gravelly sand as noted in Trench 1 and railway lines were present in an east-west direction.

7.4.6 Obstructions – Coal Stockyard

Concrete surfacing remains across the surface of much of the Coal Stockyard, frequently present beneath the breeze deposits. There is limited evidence of concrete at depth with the exception of the mine shaft caps.

TP80, located on the western site boundary, was located in the area of a former Effluent Tank. This encountered loose gravels overlying a former bund structure, at 4.10m bgl.

7.5 Soils Investigation – Southern Area

In the Southern Area of the site, the Biological Effluent Treatment Plant remains, limiting access in this area, due to substantial concrete pool structures.

Five trial pits (TP72-TP76) were advanced in the Southern Area to a maximum of 3.8m bgl and one window sample was advanced to a maximum depth of 4.4m.

The Southern Area generally comprised a grass cover with a small amount of concrete hardstanding to the east of the site. Beneath this, made ground was identified to a maximum

depth of 2.0m bgl that comprised of gravelly sands and gravelly clays. At one location, TP72, abundant brick fill was noted between 0.1m and 0.7m bgl.

Beneath the made ground sandy clays were present between 1.3m and >4.4m bgl that were underlain by mudstone bedrock. No coal deposits were identified during the trial pitting or window sampling investigation in the Southern Area.

No significant visual or olfactory evidence of potentially contaminated material was identified during the investigation of the Southern Area.

7.6 Groundwater Investigation

7.6.1 Groundwater Data Obtained

Twenty-six groundwater monitoring wells (historic and newly installed) were monitored across each of the three areas at the site. Where groundwater was present, selected wells were sampled for laboratory analysis. Results of the groundwater monitoring are presented in Table 5, below. All locations have been topographically levelled against Ordnance Datum.

Borehole logs for all wells, including wells installed in historical investigations (where a log is available) have been included in Appendix C. Figure 6 in Appendix A presents the location of the installed monitoring wells.

Location	Depth to NAPL (m bgl)	Depth to Water (m bgl)	Depth to Water AOD (m)	Depth to Base (m bgl)	Response Zone (m)	Target Strata
Production Area						
BH203	-	-	-	2.3	-	-
BH305	-	15.096	55.672	>30m	22m-30	Sandstone
RBH4	-	10.137	56.391	17.53	14-18	Sandstone
RBH4A	-	9.995	56.401	19.09	14.5-19.5	Sandstone
WS20-05C	-	-	-	1.657	0.5-1.5	Made Ground
WS20-06B	-	-	-	2.8	1-2	Made Ground
WS20-09E	-	-	-	1.337	0.5-1.0	Gravel
BH19-01	-	4.372	61.182	12.218	4.5-12	Sandstone
BH19-02	-	1.941	66.257	12.259	4-12	Sandstone
BH19-03	-	2.425	67.417	12.299	4-12	Sandstone
BH19-04	-	6.831	64.485	12.43	3-12	Sandstone/Mudstone
BH19-05	-	4.803	64.004	20.361	5-20	Sandstone/Mudstone
BH19-06	-	8.145	63.619	19.104	5.5-20	Sandstone/Mudstone
BH19-07	-	6.492	65.566	20.345	4-20	Sandstone/Mudstone
BH19-08	-	9.337	59.462	20.331	4-20	Sandstone/Mudstone
Coal Stockyard						
RBH1	-	7.451	55.854	15.41	12-16	Sandstone
RBH1D	-	7.396	55.899	15.78	11.5-15.5	Sandstone and Mudstone
RBH2	-	7.421	55.921	15.688	12-16	Sandstone
RBH2A	-	7.25	55.963	17.774	13-17	Mudstone
WS4	-	-	-	3.141	1-3	Made Ground and Sand
WS20-01	-	-	-	1.504	0.6-1.6	Made Ground
WS20-02B	-	-	-	1.527	0.6-1.6	Made Ground and Clay
WS20-03	-	3.79	58.259	3.945	1-4	Made Ground and Clay
WS20-04	-	-	-	-	1-3	Made Ground, Silt and Gravel
Southern Area						
WS9	-	2.497	59.513	3.792	2-5	Clay
WS20-10	-	3.327	-	4.16	1-4	Weathered Mudstone
(* product not recorded on the Interface probe, however, 6.245m of product present on the interface probe – potential DNAPL)						

Table 5. Borehole Dip Data

Wells target various discrete strata and have been sampled to allow characterisation of conditions throughout across the wider site.

7.6.2 Measured DNAPL in bedrock

Evidence of DNAPL was observed in BH19-07, in the former benzole area, observed within the sandstone as a smear of NAPL was identified on the interface probe, however, the interface probe was not detecting any NAPL.



BH203, reported in the historic reports as containing NAPL, was found to have been unserviceable and blocked at a shallow depth, it was not possible to determine whether NAPL remains in this area, although the nearby BH19-05 and BH19-01 each demonstrated a strong odour present throughout the water column.

7.6.3 Sandstone Outcrop

It is considered that the sandstone may contain a dual porosity, with fracture planes observed in nearby outcrops and in the railway cutting located to the west of the site. This cutting, which displays an outcrop at approximately 16-19m below Production Area site level, can be seen to weep along fracture planes.

It is anticipated that locally groundwater may flow to the west and also that groundwater flow within fractures may not necessarily represent the wider hydraulic regime.

7.6.4 Groundwater Level and Flow Direction

Groundwater monitoring was undertaken on all the newly installed monitoring wells and historic monitoring wells. It was found that within the deep aquifer the groundwater table is approximately 7 – 9m lower in the Coal Stockyard than the Production Area. This is considered to be due to the geology of the site. In the Production Area sandstone bedrock is recorded at a shallow depth and within the Coal Stockyard (southern half) sandstone is recorded much deeper suggesting the bedrock is dipping to the north. Geological maps also show that the sandstone bedrock is also dipping to the north.

As groundwater was predominantly encountered within the bedrock, to understand the hydraulic regime of the site the geological strata have been levelled against mAOD. Whilst the land levels in the stockyard have been significantly altered, the broad geological structure of the site agrees with the 1:10,000 scale British Geological Survey maps, which show Pennine Middle Coal Measures (PMCM) to be located in the northeast and south of the site. The bulk of the Stockyard and Process Area are underlain by Mexborough Sandstones. The depth to bedrock has been plotted over the geological map as shown on Figure 10a.

The sandstone is anticipated to act as the key pathway for migration of contaminants over the underlying, low permeability mudstone. Plotting of this mudstone horizon, which outcrops in the Southern Area, demonstrates that this slopes gently towards the north, beneath the Production Area, as shown on Figure 10b.

A groundwater contour plot is presented in Figure 11 in Appendix A. This shows a significant correlation with the slope of the underlying mudstone and indicates a flow in a northerly direction.

Historic reports suggest that more than one groundwater body may be present across the site. However, with a larger amount of data than was previously available, Geo² consider there to be one water body present beneath the site within the Mexborough Rock Sandstone, moving north through this strata over the low permeability mudstones.

BH305, installed to a depth of 30m during 2015 investigation in installed to target a sandstone horizon from 25mbgl, below the Pennine Middle Coal measures. It is observed that the ground water level (mAOD) in this location matches very closely with the nearby shallower wells. Whilst connectivity between these horizons cannot be ruled out, Geo² suggest that the 10m of observed mudstone in the borehole log (included in Appendix C) would be sufficient to act as a break layer between the sandstone horizons. It is considered that the similarity in groundwater level may suggest a degree of 'leaking' within this installation.

7.6.5 Hydraulic Conductivity Testing

Groundwater permeability ('slug') testing was undertaken on a selection of the wells on two occasions, using mini divers and analysed using Bouwer and Rice methodology.

The hydraulic testing was conducted in boreholes with known geology and without clear evidence of NAPL. The results of the testing varied significantly between the wells likely associated with local variations of permeability in the shallow deposits. Hydraulic conductivity from BH19-01, BH19-08, RBH4 and RBH4A ranged between 0.192 – 6.71m/day, with an average of 2.6199m/day.

Testing from BH305, installed into a deeper sandstone body (although potentially in connectivity with the shallower horizon), produced an average value of 1.5m/day.

The values were checked with literature sources (Domenico and Schwartz, 1990) the lower values for sandstone was 0.0003m/d and the higher value is 5m/d which correspond with the site-specific values and the geology. The impact of any dual porosity is not clearly reflected in this assessment.

7.7 Surface Water Investigation

In addition to collection of groundwater, four surface water samples (two upstream and two downstream) were also collected over five sample rounds from Wakefield Beck, to the west of the former Gas Production Facility, located approximately 100m west of the sites western boundary and Lineside Dyke, immediately beyond the sites western boundary.

Lineside Dyke was found to comprise a culvert stream, present within a pipe accessed via numerous grates and manholes. Very limited flow to no flow was observed during all sample visits. A notable hydrocarbon odour was reported in the downstream, southerly sample pit on all occasions.

Wakefield Brook was similarly found to display very low to no flow, with no sample obtainable from the downstream sample point during several visits. No visual or olfactory evidence of contamination was reported in any visit.

7.8 Ground Gas Investigation

Geo² have undertaken a programme of ground gas monitoring works at the site comprising six ground gas sampling visits over a 12 week period. Monitoring over this duration has been specified to provide an understanding of baseline conditions, it is likely that in the event of a development proposal, a further period of monitoring would be required in accordance with Ciria C665 guidance.

The gas monitoring took place between 18.05.20 and 17.07.20. Full details of the ground gas monitoring are included in Appendix E. All visits were undertaken by Geo² and monitoring was undertaken using a calibrated Geo-Technical Instruments GA5000. Gas monitoring was accompanied with measurements of hydrocarbon vapours using a photo-ionisation detector (PID) and measurements of the depths to groundwater (using an interface meter).

It should be noted that the following wells were recorded for ground gas, however, the data obtained from these wells is considered not viable for a ground gas assessment because the water level in the monitoring well was above the screening level in all of the monitoring rounds. This approach also includes monitoring wells where the screening levels are unknown. These wells are:

- RBH1
- RBH1D
- RBH2
- RBH2A
- RBH4
- RBH4A
- BH305
- BH201 – Screening level unknown
- BH201A – Screening level unknown

7.8.1 Atmospheric Pressure

Atmospheric pressure was recorded on site between the days of the ground gas monitoring round to assess whether the site was experiencing falling or rising pressure. Table 6 summarises the atmospheric pressures at the time of each monitoring round.

Atmospheric pressure data was recorded using a data logger installed onsite for the duration of the programme. Graphs showing the trends in atmospheric pressure across the monitoring period are included in Appendix E. Atmospheric pressure monitoring shows that the sampling period covers at least 2 full atmospheric cycles and that sample points cover a range of atmospheric pressure including at least 2 of falling or low pressure.

Date	Atmospheric Pressure (mbar)	Trend
18.05.20	1013	Average, falling
05.06.20	989	Low, rising
18.06.20	1005	Low, falling
29.06.20	994	Low, rising
09.07.20	1008	Average, falling
17.02.20	1013	Average, rising

Table 6. Atmospheric Pressure Trends

7.8.2 Methane

Methane was found to be present at three locations with a maximum concentration of 1% being recorded in WS20-10. The only other two recordings of methane were at WS9 and BH203 with a concentration of 0.1%. All positive recordings of Methane were taken from the first monitoring round on 18th May 2020.

CH ₄	WS20-01	WS20-02	WS20-03	WS20-04	WS20-05	WS20-06	WS20-09	WS20-10	WS4	WS9	BH203
18.05.20	0	0	0	0	0	0	0	1	0	0.1	0.1
05.06.20	0	0	0	0	0	0	0	0	0	0	0
18.06.20	0	0	0	0	0	0	0	0	0	0	0
29.06.20	0	0	0	0	0	0	0	0	0	0	0
09.07.20	0	0	0	0	0	0	0	0	0	0	-
17.02.20	0	0	0	0	0	0	0	0	0	0	0

Table 7. Summary of CH₄ % v/v Data

7.8.3 Carbon Dioxide

Elevated sustained concentrations of carbon dioxide were present in all of the Geo² WS20 monitoring wells. The maximum concentration identified was 11.6% v/v in WS20-03, which was recorded on 05th June 2020.

CO ₂	WS20-01	WS20-02	WS20-03	WS20-04	WS20-05	WS20-06	WS20-09	WS20-10	WS4	WS9	BH203
18.05.20	0.6	0.3	5.1	3.1	0.5	3.6	1.5	1	1.6	0.1	0.7
05.06.20	6	0.6	11.6	6.7	3.1	7	2	0.9	2.7	2	2
18.06.20	4.8	4.8	9.5	6.7	2.6	7.4	0.5	1.1	1.8	0.5	0.9
29.06.20	0.5	2.3	7.7	6.6	2.6	3.1	0.6	0.6	0.5	0.5	4.3
09.07.20	1.5	1.4	11.2	5.9	2.5	6.2	2.4	0.8	0.8	0.5	-
17.02.20	0.5	1.9	10.8	2.3	1.9	7.5	2.6	0.6	1.1	0.2	0.5

Table 8. Summary of CO₂ % v/v Data

7.8.4 Oxygen

Depleted levels of oxygen were reported (<17%v/v) in all locations during the monitoring rounds, however, not during some visits some monitoring reported concentrations of oxygen above 17%v/v. The lowest recorded concentration of oxygen was recorded at 0.7%v/v in WS20-02 (05th June 2020) and WS20-03 (09th July 2020). Both these locations can be found in the northern part of the Coal Stockyard.

O ₂	WS20-01	WS20-02	WS20-03	WS20-04	WS20-05	WS20-06	WS20-09	WS20-10	WS4	WS9	BH203
18.05.20	19.8	19.8	13.3	15.7	19.2	13.4	19.1	19.2	17.6	20.4	19.6
05.06.20	11.3	14.5	2.6	13.2	15.8	5.6	17.9	19.4	13.6	21.4	17.3
18.06.20	10.2	0.7	3.8	10.6	16.4	6.5	21.4	16.2	16.4	20.1	19.3
29.06.20	20.7	1.2	8.3	16.2	17.8	13.1	20.5	19.2	21.2	20.8	14.8
09.07.20	13.5	1.7	0.7	14.7	17.9	8.6	17.3	18.5	18.3	20.3	-
17.02.20	19.4	1.9	1.2	13.8	16.8	3.2	14.1	18.7	17.4	20.7	19.6

Table 9. Summary of O₂ % v/v Data

The data suggests oxygen depletion appears correlated to carbon dioxide elevation.

7.8.5 Other Measurements

Trace concentrations of carbon monoxide (CO) were found in all wells during at least one monitoring visit. A maximum concentration of 3ppm was found in WS20-06, WS20-10 and WS9 on 17th July 2020.

Concentrations of hydrogen sulphide were recorded at a maximum of 1ppm in monitoring wells across the site throughout each of the six monitoring rounds.

PID readings were mainly low across all wells with WS9 recording a maximum of 10.6ppm on the 17th July 2020, all other readings from this location show low to no VOC readings.

In general, it is considered that a PID reading below 15ppm can be attributed to natural factors, such as humic acid or natural degradation of organic compounds, or in this case degradation of capping soils. As such, 15ppm has been used as a trigger value during analysis of results during the monitoring period.

7.8.6 Flow Rates

Air flow rates in and out of the installed boreholes were monitored using the flow cell built-into the GA-5000 gas meter. This was found to be variable across the site and across visits with an average range from -3.2l/hr to 0.3l/hr being recorded.

Flow Rate	WS20-01	WS20-02	WS20-03	WS20-04	WS20-05	WS20-06	WS20-09	WS20-10	WS4	WS9	BH203
18.05.20	0	-0.1	0	0	-0.1	-0.1	-0.1	-0.1	0	-0.1	-0.1
05.06.20	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0
18.06.20	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-3.2	0.1
29.06.20	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0	0.1	0.1
09.07.20	0.2	0.3	0.2	0.2	0.2	0.2	-0.1	0.1	0.2	-0.1	-
17.02.20	0.3	0.3	0.2	0.2	0.3	0.2	0.3	0.2	0.3	0.2	0.2

Table 10. Summary of Flow (l/hr) Data

In addition, it should also be noted that number of factors are outlined in CIRIA C665 which may influence the generation and behaviours of ground gases and vapours, which may be referred to as 'seasonal' factors. Factors considered to be pertinent to this site are:

- High rainfall may result in a reduction in soil pore space or temporary sealing of the ground surface, likely meaning an increase in gas concentrations.
- Any gas contained within liquid is likely to become more mobile in higher temperatures.
- Pressure gradients can be formed between gas in the ground and in the atmosphere during high winds, resulting in movement of gas from soil to atmosphere.
- Rapid changes in barometric pressure.
- Rises or falls in groundwater level.

For the purpose of any gas risk assessment, these factors should be considered, and on any given monitoring event, one, or a number of these factors may be present and affecting the behaviour of any generated ground gas at the site.

Table 11 shows the variation in depth to water in the monitoring wells.

Wells which are within lower permeability strata show little variation. Wells which have an active response zone in permeable strata tend to show greater variation in groundwater levels. Little variation in groundwater is likely one of the reasons for the similar trend in gas readings. Changes in depth of groundwater can affect movement of gases within the subsurface.

During the monitoring rounds it was noted that WS9 between approximately 0.4m and 1.3m available screen. It is thought with changing groundwater levels that ground pressures may affect the ground gas flow in and out of the small amount of screened section within the monitoring well. This could be responsible for the very low negative flow recorded on 18th June 2020.

Depth to Water	WS20-01	WS20-02	WS20-03	WS20-04	WS20-05	WS20-06	WS20-09	WS20-10	WS4	WS9	BH203
18.05.20	-	-	3.79	-	-	-	-	3.327	-	2.497	-
05.06.20	-	-	3.859	-	-	-	-	3.209	-	2.578	-
18.06.20	1.179	1.394	2.491	-	-	-	-	2.922	-	2.47	-
29.06.20	1.432	-	3.161	-	-	-	-	2.763	-	2.539	-
09.07.20	1.43	1.396	3.025	2.763	-	-	-	2.68	-	-	-
17.02.20	1.421	-	3.03	2.761	-	-	-	2.389	-	2.218	-

Table 11. Summary of Water Dip Data (m bgl)

7.8.7 Assessment of Results

The gas flow measurement, together with the gas concentrations as a percentage volume, is used as a basis for classifying a site's gas regime. The highest gas flow rates and gas readings are used to generate a Gas Screening Value (GSV) for carbon dioxide and methane. In order to provide the highest degree of confidence the highest CO₂ and CH₄ values will be used in this assessment with the highest viable flow rate.

The GSV calculated are then compared with tables in the CIRIA Report - C665 (2007), which provides a framework for classifying sites into Characteristic Situations (CS) between 1 (very low risk) and 6 (very high risk) based upon the sites GSV.

Using the Wilson and Card Classification and procedure described in Ciria C665, a gas screening value (GSV) has been calculated to determine the 'Worst Credible' site conditions, which are shown in Table 12, overleaf.

Location	CH ₄	CO ₂	Flow	GSV	CS	Location
WS20-01	0	6	0.3	0.0180	2	Coal Stockyard
WS20-02	0	4.8	0.3	0.0144	1	Coal Stockyard
WS20-03	0	11.6	0.2	0.0232	2	Coal Stockyard
WS20-04	0	6.7	0.2	0.0134	2	Coal Stockyard
WS20-05	0	3.1	0.3	0.0093	1	Coal Stockyard
WS20-06	0	7.5	0.2	0.0150	2	Production Area
WS20-09	0	2.6	0.3	0.0078	1	Production Area
WS20-10	1	1.1	0.2	0.0022	1	Southern Area
WS4	0	2.7	0.3	0.0081	1	Coal Stockyard
WS9	0.1	2	0.2	0.0040	1	Southern Area
BH203	0.1	4.3	0.2	0.0086	1	Production Area

Table 12. Worst-Credible Gas Screening Values on any Individual Site Visit

Table 12 uses the worst-case flow and gas concentration to assess each location, this assumes the max flow (either positive or negative) and reports minimal flow as 0.1, the level of detection on the probe. These values have been amended to take into consideration the additional factors (such as elevated CO₂), listed in the Wilson and Card classification.

Ground gas monitoring identifies that four of the monitoring wells, WS20-01, WS20-03, WS20-04 and WS20-06) across the site returned a Characteristic Situation of 2 (low risk). These wells are located within the coal stockyard with the exception of WS20-06 which is located in the production area. All other ground gas results returned a Characteristic Situation of 1 (very low risk).

	Maximum Measurements	GSV (l/hr)	Characteristic Situation
Flow	0.3 l/hr	-	
CH ₄	0.1	0.0030	1
CO ₂	11.6	0.0348	2

Table 13. Worst-Case Gas Screening Values

Table 13 takes the worst-case data from across the entire site and compares this against the worst-case flow from the entire data set, to produce an absolute worst-case example. The worst-case scenario for monitoring wells across the site is a Characteristic Situation 2 (low) due to carbon dioxide being recorded above 5%v/v.

This assessment is considered insufficient to suitably approve the risk to residential developments. This would require a greater programme of monitoring including twelve visits over a six-month period. However, the proposed change in land level at the site may influence the gas regime.

7.9 Geotechnical Analysis

Samples were collected from the Production Area, Coal Stockyard and Southern Area for Geotechnical analysis. The results of the geotechnical testing are presented in Appendix D. In addition, in-situ geotechnical testing was undertaken during the window sampling investigation. These results are also presented in Appendix D.

8.0 Laboratory Analysis

8.1 Analysis Rationale

Soil samples were selected for laboratory analysis following field screening, via visual and olfactory methods and using a Photo-Ionisation Detector (PID). The soil samples were collected from depths of 0.1m to 14.0m below ground level (m bgl).

Samples were analysed for a broad range of parameters to assess the condition of the soils, groundwater and surface water currently at the site. Sample selection for laboratory analysis is shown in Appendix F.

Samples found to contain elevated concentrations of contaminants have been identified on Figure 7, in Appendix A.

8.2 Soils Analysis – Production Area

The analysis, conducted by a Gas Chromatography / Flame Ionisation Detector (GC/FID) and Gas Chromatography / Mass Spectrometry (GC / MS) comprised fractionation and speciation of hydrocarbons including analysis for benzene, toluene, ethylbenzene and xylenes (BTEX) and MTBE compounds. Selected samples were analysed for:

- Heavy metals and Sulphate by IRIS emission spectroscopy;
- Cyanide by colorimetric determination using Automated Flow Injection Analyser;
- Volatile and semi volatile components (including PAHs and Phenols), by GC/MS; and
- Asbestos by microscopy.

The analytical results were analysed for contaminants based on historic site investigation findings. The results of soil analysis were compared using the following UK guidance:

- Suitable for Use Levels (S4ULs) or LQM/CIEH's Category 4 Screening Levels (C4SLs); or.
- EIC Soil Generic Assessment Criteria for Human Health (2010).

Even though land levels are likely to change during redevelopment GAC values assume a hypothetical and conservative scenario of a residential end user, assuming plant uptake and a TOC of 1%; whilst this represents an overconservative assessment, this does aid identification of key impacts.

A summary of the results of laboratory analysis on the soil samples are presented overleaf in Tables 14, 15, 16, 17 and 18 and the results are documented in Appendix F.

Determinand	Min	Max	GAC	No. > GAC
BTEX (mg/kg)				
Benzene	<0.01	197	0.08	13/31
Toluene	<0.01	185	47	2/31
Ethylbenzene	<0.01	31	130	0/31
m- & p- Xylenes	<0.01	114	59	3/31
o-Xylenes	<0.01	86.9	60	1/31
MTBE	<0.01	-		0/31
Aliphatic (mg/kg)				
Aliphatic C5-C6	<0.01	0.42	42	0/31
Aliphatic >C6-C8	<0.01	2.51	100	0/31
Aliphatic >C8-C10	<1	128	27	1/32
Aliphatic >C10-C12	<1	711	130	5/32
Aliphatic >C12-C16	<1	950	1100	0/32
Aliphatic >C16-C21	<1	1,270	65000	0/32
Aliphatic >C21-C35	<1	3,690	65000	0/32
Aromatics (mg/kg)				
Aromatic C5-C7	<0.01	197	70	5/31
Aromatic >C7-C8	<0.01	185	130	2/31
Aromatic >C8-C10	<1	7,170	34	12/32
Aromatic >C10-C12	<1	109,000	75	17/32
Aromatic >C12-C16	<1	91,700	140	19/32
Aromatic >C16-C21	<1	105,000	260	18/32
Aromatic >C21-C35	<1	101,000	1100	15/32

Table 14. Results of Laboratory Analysis for Hydrocarbons in Soils

With the exception of MTBE, all BTEX and TPH-CWG analysis returned results with concentrations above the human health General Assessment Criteria (GAC) for a residential with plant uptake setting. The most elevated concentrations of TPH-CWG were generally within the aromatic range and consisted of the longer chained hydrocarbons between C10 and C35.

Out of thirty-one samples concentrations of MTBE were always below the laboratory detection limit.

Figure 7 presented in Appendix A shows the distribution of hydrocarbon impact. In the southern and eastern portions of the production areas there is low to nil impact associated with hydrocarbons. The main impact is located in the centre of Production Area where historic by-product activities associated with the coking works were undertaken.

The results of the heavy metal analysis of soil samples are shown overleaf, in Table 15.

Determinand	Min	Max	GAC	No. > GAC
Arsenic	<1	31	37	0/19
Barium	16	329	1,300	0/15
Beryllium	<0.5	3.5	1.7	1/15
Boron (water soluble)	<1.0	<1.0		0/4
Cadmium	<0.5	2.6	22	0/19
Copper	3	239	2,400	0/19
Chromium	3	6,340	910	2/19
Lead	5	584	200	5/19
Mercury	<0.17	24.9	1.2	8/19
Nickel	<1	90	180	0/19
Selenium	1	9	250	0/19
Vanadium	3	492	410	1/15
Zinc	17	347	3,700	0/19

Table 15. Results of Heavy Metals Analyses Screening in Soils
(in mg/kg unless stated otherwise)

All metal analysis returned samples above the laboratory detection limit other than boron, however, only Beryllium, Copper, Lead, Mercury and Vanadium returned concentrations above their respective human health GAC for a residential with plant uptake setting.

Contaminant (ug/kg)	Min	Max	GAC	No. > GAC
Hexachlorobenzene	<100	-	-	-
Diethyl phthalate	<100	-	-	-
Dimethyl phthalate	<100	-	-	-
Dibenzofuran	278	2,930,000	-	-
Carbazole	<100	1,530,000	-	-
Butylbenzyl phthalate	<100	-	-	-
Bis(2-ethylhexyl)phthalate	<500	-	2,700	0/10
Bis(2-chloroethoxy)methane	<100	-	-	-
Bis(2-chloroethyl)ether	<100	-	-	-
4-Nitrophenol	<1000	-	-	-
3+4-Methylphenol	9330	581,000	-	-
4-Chloro-3-methylphenol	<100	-	-	-
2-Nitrophenol	<100	-	-	-
2-Methylphenol	<100	578,000	-	-
2-Chlorophenol	<100	-	-	-
2,6-Dinitrotoluene	<100	-	-	-
2,4-Dinitrotoluene	<100	-	-	-
2,4-Dimethylphenol	<100	437,000	21,000	1/10
2,4-Dichlorophenol	<100	-	-	-
2,4,6-Trichlorophenol	<100	-	-	-
2,4,5-Trichlorophenol	<100	-	-	-
2-Chloronaphthalene	<100	-	-	-
2-Methylnaphthalene	361	7,610,000	-	-
Acenaphthylene	<100	1,140,000	170,000	3/10
Acenaphthene	1300	6,020,000	210,000	4/10
Anthracene	<1000	>2,090,000	2,400,000	0/10
Benzo(a)anthracene	<100	987,000	7,200	4/10
Benzo(b)fluoranthene	<100	1,720,000	2,600	5/10
Benzo(k)fluoranthene	<100	604,000	77,000	2/10
Benzo(a)pyrene	<100	971,000	2,200	5/10
Benzo(ghi)perylene	<100	599,000	320,000	2/10
Chrysene	<100	1,730,000	15,000	5/10
Fluoranthene	<100	1,740,000	280,000	4/10
Fluorene	659	4,810,000	170,000	5/10
Indeno(1,2,3-cd)pyrene	<100	649,000	27,000	2/10
Phenanthrene	<1000	5,240,000	95,000	4/10
Pyrene	<100	1,490,000	620,000	3/10
Naphthalene	1210	>8,530,000	2,300	9/10
Dibenzo(ah)anthracene	<100	214,000	240	2/10
Bis(2-chloroisopropyl)ether	<100	-	-	-
Phenol	<100	1,090,000	280,000	1/10
Pentachlorophenol (SVOC)	<100	-	-	-
n-Nitroso-n-dipropylamine	<100	-	-	-
n-Dioctylphthalate	<500	-	-	-
n-Dibutylphthalate	<100	-	-	-
Nitrobenzene	<100	-	-	-
Isophorone	<100	-	-	-
Hexachloroethane	<100	-	-	-
Hexachlorocyclopentadiene	<100	-	-	-
Perylene	<100	335,000	-	-

Table 16. Summary of the Results of the SVOC Analysis of Soils (µg/kg)

Numerous SVOC compounds were recorded above the human health GAC for a residential with plant uptake setting. The main impact is located in the centre of Production Area where historic by-product activities associated with the coking works were undertaken, with maximum reported concentrations indicative of coal tar within samples

Figure 7 presented in Appendix A shows the distribution of the elevated SVOC compounds. In the southern and eastern areas of the production areas there is low to nil impact associated with SVOC.

Contaminant (µg/kg)	Min	Max	GAC	No. > GAC	Contaminant (µg/kg)	Min	Max	GAC	No. > GAC
Dichlorodifluoromethane	<1	-	-	-	Dibromochloromethane	<3	-	-	-
Chloromethane	<10	-	-	-	1,2-Dibromoethane	<1	-	-	-
Vinyl Chloride (Chloroethene)	<1	-	-	-	Chlorobenzene	<1	54	-	-
Bromomethane	<1	-	-	-	1,1,1,2-Tetrachloroethane	<1	-	-	-
Chloroethane	<1	-	-	-	Ethylbenzene	<1	9,030	47,000	0/10
Trichlorofluoromethane	<1	-	-	-	m & p Xylene	<1	44,500	59,000	0/10
1,1-Dichloroethene	<1	-	-	-	o-Xylene	<1	26,000	60,000	0/10
Carbon Disulphide	<1	79	140	0/10	Styrene	<1	12,500	-	-
Dichloromethane	<5	-	-	-	Bromoform	<1	-	-	-
trans 1,2-Dichloroethene	<1	-	-	-	Isopropylbenzene	<1	664	12,000	0/10
1,1-Dichloroethane	<1	-	-	-	1,1,2,2-Tetrachloroethane	<1	3	-	-
cis 1,2-Dichloroethene	<1	-	-	-	1,2,3-Trichloropropane	<1	-	-	-
2,2-Dichloropropane	<1	-	-	-	Bromobenzene	<1	-	-	-
Bromochloromethane	<5	-	-	-	n-Propylbenzene	<1	992	40,000	0/10
Chloroform	<1	-	-	-	2-Chlorotoluene	<1	-	-	-
1,1,1-Trichloroethane	<1	-	-	-	1,3,5-Trimethylbenzene	<1	14,700	-	-
1,1-Dichloropropene	<1	-	-	-	4-Chlorotoluene	<1	-	-	-
Carbon Tetrachloride	<1	-	-	-	tert-Butylbenzene	<2	-	-	-
1,2-Dichloroethane	<2	-	-	-	1,2,4-Trimethylbenzene	<1	6,910	410	6/10
Benzene	<1	113,000	87	6/10	sec-Butylbenzene	<1	-	-	-
Trichloroethene	<1	-	-	-	4-Isopropyltoluene	<1	1,370	-	-
1,2-Dichloropropane	<1	66	-	-	1,3-Dichlorobenzene	<1	-	-	-
Dibromomethane	<1	-	-	-	1,4-Dichlorobenzene	<1	-	-	-
Bromodichloromethane	<10	-	-	-	n-Butylbenzene	<1	18	-	-
cis 1,3-Dichloropropene	<1	-	-	-	1,2-Dichlorobenzene	<1	-	-	-
Toluene	<1	62,100	130,000	0/10	1,2-Dibromo-3-chloropropane (DCBP)	<2	-	-	-
trans 1,3-Dichloropropene	<1	-	-	-	1,2,4-Trichlorobenzene	<3	-	-	-
1,1,2-Trichloroethane	<1	-	-	-	Hexachlorobutadiene	<1	-	-	-
1,3-Dichloropropane	<1	-	-	-	1,2,3-Trichlorobenzene	<3	-	-	-
Tetrachloroethene	<1	-	-	-					

Table 17. Summary of the Results of the VOC Analysis of Soils (µg/kg)

Benzene and 1,2,4-Trimethylbenzene were recorded above the human health GAC for a residential setting with plant uptake in the Production Area. Numerous VOCs were also detected above the laboratory detection limit but were recorded below the human health GAC. The main impact is located in the centre of Production Area where historic by-product activities associated with the coking works were undertaken.

In the southern and eastern areas of the production areas there is low to nil impact associated with VOC.

Figure 7 presented in Appendix A shows the distribution of the elevated SVOC compounds.

Contaminant (mg/kg)	Min	Max
PCB BZ 81	<0.005	-
PCB BZ 105	<0.005	-
PCB BZ 114	<0.005	-
PCB BZ 118	<0.007	-
PCB BZ 123	<0.005	-
PCB BZ 126	<0.005	-
PCB BZ 156	<0.005	-
PCB BZ 157	<0.005	-
PCB BZ 167	<0.005	-
PCB BZ 169	<0.005	-
PCB BZ 189	<0.005	-
PCB BZ 77	<0.005	-
Total Speciated PCB-WHO 12	<0.007	-

Table 18. Summary of PCB Compounds(mg/kg)

A sample was collected close to the historical electrical substation building in the east of the Production Area. The sample returned concentrations below the laboratory detection limit for each PCB compound.

Determinand	Units	Min	Max
pH	-	4.84	12.56
Cyanide (free)	Mg/kg	<0.1	173
Cyanide (total)	Mg/kg	<1	7,880
Thiocyanate	Mg/kg	<5	9
Calorific Value	MJ/kg	4.5	16
Sulphate (water sol.)	g/l	0.03	0.19
Sulphate (acid sol.)		770	3,200
Sulphur (total)	Mg/kg	239	1,700
TOC	%	<0.4	45.6
Asbestos	%w/w	<0.001	0.017

Table 19. Summary of Inorganic compounds

Table 19, summarises the inorganic soil analysis for the Production Area. pH was found to range between 4.84 and 12.56 across the Production Area.

Cyanide (free), Cyanide (total) and Thiocyanate were detected in the Production Area with the most elevated concentrations located at TP9, TP10 and TP22 in the west of the Production Area.

Three samples analysed for calorific value returned concentrations between 4.5 and 16 MJ/kg. TOC ranged from below laboratory detection limit (<0.4%) and 45.6%. Asbestos was identified in three samples, however, only one sample returned concentrations of asbestos (amosite and chrysotile) above the laboratory detection limit of 0.001%w/w.

8.3 Soils Analysis – Coal Stockyard

Data from the Coal Stockyard are of the site is summarised below. Full laboratory analysis along with certificates are included within Appendix F.

Determinand	Min	Max	GAC	No. > GAC
BTEX (mg/kg)				
Benzene	<0.01	0.14	0.08	1/16
Toluene	<0.01	0.07	47	0/16
Ethylbenzene	<0.01	0.1	130	0/16
m- & p- Xylenes	<0.01	0.17	59	0/16
o-Xylenes	<0.01	0.22	60	0/16
MTBE	<0.01	0		0/16
Aliphatic (µg/kg)				
Aliphatic C5-C6	<0.01	0.06	42	0/16
Aliphatic >C6-C8	<0.01	0.17	100	0/16
Aliphatic >C8-C10	<1	22	27	0/16
Aliphatic >C10-C12	<1	11	130	0/16
Aliphatic >C12-C16	<1	357	1100	0/16
Aliphatic >C16-C21	<1	498	65000	0/16
Aliphatic >C21-C35	2	290	65000	0/16
Aromatics (µg/kg)				
Aromatic C5-C7	<0.01	0.14	70	0/16
Aromatic >C7-C8	<0.01	0.07	130	0/16
Aromatic >C8-C10	<1	62	34	1/16
Aromatic >C10-C12	<1	4,640	75	1/16
Aromatic >C12-C16	<1	23,900	140	1/16
Aromatic >C16-C21	<1	4,780	260	1/16
Aromatic >C21-C35	4	746	1100	0/16

Table 20. Results of Laboratory Analysis for Hydrocarbons in Soils

One exceedance of the human health GAC for residential with plant uptake setting was recorded from a sample from WS20-03 (0.8m). All other samples for BTEX and MTBE analysis were recorded below the human health GAC.

TPH Aromatic C8 – C21 were recorded above the human health GAC in one sample from TP61 (1.2m) associated with infrastructure from the west. All other samples recorded concentrations below the human health GAC.

The results of the heavy metal analysis of soil samples are shown overleaf, in Table 14.

Determinand	Min	Max	GAC	No. > GAC
Metals (mg/kg)				
Arsenic	7	36	37	0/18
Barium	65	1,990	1,300	1/14
Beryllium	0.6	2	1.7	1/14
Cadmium	<0.5	2.5	22	0/15
Copper	14	121	2,400	0/18
Chromium	8	28	910	0/18
Lead	9	237	200	1/18
Mercury	1.23	5.02	1.2	2/18
Nickel	9	40	180	0/18
Selenium	<1	2	250	0/18
Vanadium	19	42	410	0/14
Zinc	21	1,040	3,700	0/18

Table 21. Results of Heavy Metals Analyses Screening in Soils
(in mg/kg unless stated otherwise)

All samples were detected above the laboratory detection limit, however, there was one exceedance of the human health GAC for Barium (TP86 -0.5m), Beryllium (TP81 - 0.4m) and Lead (TP95 – 0.2m). There were also two exceedances above the human health GAC for Mercury at TP88 (0.2m). All other samples were below the human health GAC for a residential setting with plant uptake.

Contaminant (mg/kg)	Min	Max	GAC	No. > GAC	Contaminant (mg/kg)	Min	Max	GAC	No. > GAC
Hexachlorobenzene	<100	-	-	-	Anthracene	<100	67,900	2,400,000	0/5
Diethyl phthalate	<100	-	-	-	Benzo(a)anthracene	<100	21,600	7,200	1/5
Dimethyl phthalate	<100	-	-	-	Benzo(b)fluoranthene	<100	14,100	2,600	1/5
Dibenzofuran	195	1,370,000	-	-	Benzo(k)fluoranthene	<100	207	77,000	0/5
Carbazole	<100	18,600	-	-	Benzo(a)pyrene	<100	13,700	2,200	1/5
Butylbenzyl phthalate	<100	-	-	-	Benzo(ghi)perylene	<100	380	320,000	0/5
Bis(2-ethylhexyl)phthalate	<500	-	2,700	0/5	Chrysene	119	17,900	15,000	1/5
Bis(2-chloroethoxy)methane	<100	-	-	-	Fluoranthene	130	52,900	280,000	0/5
Bis(2-chloroethyl)ether	<100	-	-	-	Fluorene	<100	786,000	170,000	1/5
4-Nitrophenol	<100	-	-	-	Indeno(1,2,3-cd)pyrene	<100	338	27,000	0/5
3+4-Methylphenol	<100	-	-	-	Phenanthrene	380	334,000	95,000	1/5
4-Chloro-3-methylphenol	<100	-	-	-	Pyrene	121	38,400	620,000	0/5
2-Nitrophenol	<100	-	-	-	Naphthalene	101	940,000	2,300	1/5
2-Methylphenol	<100	-	-	-	Dibenzo(ah)anthracene	<100	185	240	0/5
2-Chlorophenol	<100	-	-	-	Bis(2-chloroisopropyl)ether	<100	-	-	-
2,6-Dinitrotoluene	<100	-	-	-	Phenol	<100	-	280,000	1/10
2,4-Dinitrotoluene	<100	-	-	-	Pentachlorophenol (SVOC)	<100	-	-	-
2,4-Dimethylphenol	<100	-	21,000	0/5	n-Nitroso-n-dipropylamine	<100	-	-	-
2,4-Dichlorophenol	<100	-	-	-	n-Dioctylphthalate	<100	-	-	-
2,4,6-Trichlorophenol	<100	-	-	-	n-Dibutylphthalate	<100	-	-	-
2,4,5-Trichlorophenol	<100	-	-	-	Nitrobenzene	<100	-	-	-
2-Chloronaphthalene	<100	-	-	-	Isophorone	<100	-	-	-
2-Methylnaphthalene	189	358,000	-	-	Hexachloroethane	<100	-	-	-
Acenaphthylene	<100	-	170,000	0/5	Hexachlorocyclopentadiene	<100	-	-	-
Acenaphthene	<100	1,580,000	210,000	1/5	Perylene	<100	117	-	-

Table 22. Summary of the Results of the SVOC Analysis of Soils (µg/kg)

Numerous SVOC compounds were recorded above the laboratory detection limit for the samples taken from the Coal Stockyard, however, one sample (TP61) was significantly more elevated than the other samples and recorded concentrations of SVOCs above the human health GAC.

Contaminant (µg/kg)	Min	Max	GAC	No. > GAC	Contaminant (µg/kg)	Min	Max	GAC	No. > GAC
Dichlorodifluoromethane	<1	-	-	-	Dibromochloromethane	<3	-	-	-
Chloromethane	<10	-	-	-	1,2-Dibromoethane	<1	-	-	-
Vinyl Chloride (Chloroethene)	<1	-	-	-	Chlorobenzene	<1	-	-	-
Bromomethane	<1	-	-	-	1,1,1,2-Tetrachloroethane	<1	-	-	-
Chloroethane	<1	-	-	-	Ethylbenzene	<1	26	47,000	0/5
Trichlorofluoromethane	<1	-	-	-	m & p Xylene	<1	45	59,000	0/5
1,1-Dichloroethene	<1	-	-	-	o-Xylene	<1	40	60,000	0/5
Carbon Disulphide	<1	2	140	0/5	Styrene	<1	-	-	-
Dichloromethane	<5	-	-	-	Bromoform	<1	-	-	-
trans 1,2-Dichloroethene	<1	-	-	-	Isopropylbenzene	<1	2	12,000	0/5
1,1-Dichloroethane	<1	-	-	-	1,1,2,2-Tetrachloroethane	<1	-	-	-
cis 1,2-Dichloroethene	<1	-	-	-	1,2,3-Trichloropropane	<1	-	-	-
2,2-Dichloropropane	<1	-	-	-	Bromobenzene	<1	-	-	-
Bromochloromethane	<5	-	-	-	n-Propylbenzene	<1	2	40,000	-
Chloroform	<3	-	-	-	2-Chlorotoluene	<1	-	-	-
1,1,1-Trichloroethane	<1	-	-	-	1,3,5-Trimethylbenzene	<1	68	-	-
1,1-Dichloropropene	<1	-	-	-	4-Chlorotoluene	<1	-	-	-
Carbon Tetrachloride	<1	-	-	-	tert-Butylbenzene	<2	-	-	-
1,2-Dichloroethane	<2	-	-	-	1,2,4-Trimethylbenzene	<1	171	410	0/5
Benzene	<1	15	87	0/5	sec-Butylbenzene	<1	-	-	-
Trichloroethene	<1	-	-	-	4-Isopropyltoluene	<1	2	-	-
1,2-Dichloropropane	<1	-	-	-	1,3-Dichlorobenzene	<1	-	-	-
Dibromomethane	<1	-	-	-	1,4-Dichlorobenzene	<1	-	-	-
Bromodichloromethane	<10	-	-	-	n-Butylbenzene	<1	7	-	-
cis 1,3-Dichloropropene	<1	-	-	-	1,2-Dichlorobenzene	<1	-	-	-
Toluene	<1	10	130,000	0/5	1,2-Dibromo-3-chloropropane (DCBP)	<2	-	-	-
trans 1,3-Dichloropropene	<1	-	-	-	1,2,4-Trichlorobenzene	<3	-	-	-
1,1,2-Trichloroethane	<1	-	-	-	Hexachlorobutadiene	<1	-	-	-
1,3-Dichloropropane	<1	-	-	-	1,2,3-Trichlorobenzene	<3	-	-	-
Tetrachloroethene	<1	-	-	-					

Table 23. Summary of the Results of the VOC Analysis of Soils (ug/kg)

VOC samples from the Coal Stockyard were detected above the laboratory detection limit, however, they were not recorded above the human health GAC.

Contaminant (mg/kg)	Min	Max
PCB BZ 81	<0.005	-
PCB BZ 105	<0.005	-
PCB BZ 114	<0.005	-
PCB BZ 118	<0.007	-
PCB BZ 123	<0.005	-
PCB BZ 126	<0.005	-
PCB BZ 156	<0.005	-
PCB BZ 157	<0.005	-
PCB BZ 167	<0.005	-
PCB BZ 169	<0.005	-
PCB BZ 189	<0.005	-
PCB BZ 77	<0.005	-
Total Speciated PCB-WHO12	<0.007	-

Table 24. Summary of the Results of the PCB Analysis of Soils (mg/kg)

Two samples from the Coal Stockyard were analysed for PCBs. However, both samples returned concentrations below the laboratory detection limit.

Determinand	Units	Min	Max
pH	-	5.15	8.97
Cyanide (free)	Mg/kg	<1	10
Cyanide (total)	Mg/kg	<1	338
Thiocyanate	Mg/kg	<5	-
Calorific Value	MJ/kg	8	25
Sulphate (water sol.)	g/l	0.05	1.04
Sulphate (acid sol.)		1,200	13,000
Sulphur (total)	Mg/kg	336	5,330
TOC	%	0.49	29
Asbestos	%w/w	<0.001	0.127

Table 25. Summary of Inorganic compounds

Table 25, summarises the inorganic soil analysis for the Production Area.

pH was to range between 5.15 and 8.97 across the Coal Stockyard. Cyanide (free), Cyanide (total) and Thiocyanate were detected in the Coal Stockyard with the most elevated concentrations located at TP51 close to where blue staining was noted in the north-west part of the Coal Stockyard.

Seven samples from the coal stockyard analysed for calorific value returned concentrations between 8.0 and 25 MJ/kg. TOC ranged from 0.49 and 29%.

Asbestos was identified in two samples (TP53 0.5m and TP69 0.7m), however, only one of these samples (TP69 0.7m) returned a concentration of asbestos above the laboratory detection limit at 0.127%w/w.

8.4 Soils Analysis – Southern Area

Data from the Southern Area of the site is summarised below. Full laboratory analysis along with certificates are included within Appendix F.

Determinand	Min	Max	GAC	No. > GAC
BTEX (µg/kg)				
Benzene	<0.01	0.04	0.08	0/7
Toluene	<0.01	0.02	47	0/7
Ethylbenzene	<0.01	<0.01	130	0/7
m- & p- Xylenes	<0.01	<0.01	59	0/7
o-Xylenes	<0.01	<0.01	60	0/7
MTBE	<0.01	<0.01		0/7
Aliphatic (mg/kg)				
Aliphatic C5-C6	<0.01	0	42	0/7
Aliphatic >C6-C8	<0.01	0	100	0/7
Aliphatic >C8-C10	<1	0	27	0/7
Aliphatic >C10-C12	<1	0	130	0/7
Aliphatic >C12-C16	<1	2	1100	0/7
Aliphatic >C16-C21	<1	4	65000	0/7
Aliphatic >C21-C35	<1	25	65000	0/7
Aromatics (mg/kg)				
Aromatic C5-C7	<0.01	0.04	70	0/7
Aromatic >C7-C8	<0.01	0.02	130	0/7
Aromatic >C8-C10	<1	4	34	0/7
Aromatic >C10-C12	<1	2	75	0/7
Aromatic >C12-C16	<1	7	140	0/7
Aromatic >C16-C21	<1	39	260	0/7
Aromatic >C21-C35	<1	179	1100	0/7

Table 26. Results of Laboratory Analysis for Hydrocarbons in Soils

Some BTEX and TPH were recorded in the soil samples taken from the Southern Area, however, the recorded concentrations are below the human health GAC for a residential setting with plant uptake.

The results of the heavy metal analysis of soil samples are shown overleaf, in Table 27.

Determinand	Min	Max	GAC	No. > GAC
Metals (mg/kg)				
Arsenic	<1	16	37	0/5
Barium	77	555	1,300	0/4
Beryllium	0.5	1.6	1.7	0/4
Cadmium	<0.5	0.7	22	0/5
Copper	9	57	2,400	0/5
Chromium	15	355	910	0/5
Lead	10	137	200	0/5
Mercury	<0.17	0.5	1.2	0/5
Nickel	18	198	180	1/5
Selenium	<1	1	250	0/5
Vanadium	14	31	410	0/4
Zinc	33	104	3,700	0/5

Table 27. Results of Heavy Metals Analyses Screening in Soils
(in mg/kg unless stated otherwise)

All samples were detected above the laboratory detection limit, however, only one sample (TP75 0.4m) recorded Nickel above the human health GAC for a residential setting with plant uptake.

Contaminant	Min	Max	GAC	No. > GAC	Contaminant (mg/kg)	Min	Max	GAC	No. > GAC
Hexachlorobenzene	<100	-	-	-	Anthracene	<100	-	2,400,000	0/2
Diethyl phthalate	<100	-	-	-	Benzo(a)anthracene	<100	-	7,200	0/2
Dimethyl phthalate	<100	-	-	-	Benzo(b)fluoranthene	<100	-	2,600	0/2
Dibenzofuran	<100	-	-	-	Benzo(k)fluoranthene	<100	-	77,000	0/2
Carbazole	<100	-	-	-	Benzo(a)pyrene	<100	-	2,200	0/2
Butylbenzyl phthalate	<100	-	-	-	Benzo(ghi)perylene	<100	-	320,000	0/2
Bis(2-ethylhexyl)phthalate	<500	955	2,700	-	Chrysene	<100	-	15,000	0/2
Bis(2-chloroethoxy)methane	<100	-	-	-	Fluoranthene	<100	-	280,000	0/2
Bis(2-chloroethyl)ether	<100	-	-	-	Fluorene	<100	-	170,000	0/2
4-Nitrophenol	<100 0	-	-	-	Indeno(1,2,3-cd)pyrene	<100	-	27,000	0/2
3+4-Methylphenol	<100	-	-	-	Phenanthrene	<100	-	95,000	0/2
4-Chloro-3-methylphenol	<100	-	-	-	Pyrene	<100	-	620,000	0/2
2-Nitrophenol	<100	-	-	-	Naphthalene	<100	-	2,300	0/2
2-Methylphenol	<100	-	-	-	Dibenzo(ah)anthracene	<100	-	240	0/2
2-Chlorophenol	<100	-	-	-	Bis(2-chloroisopropyl)ether	<100	-	-	-
2,6-Dinitrotoluene	<100	-	-	-	Phenol	<100	-	280,000	0/2
2,4-Dinitrotoluene	<100	-	-	-	Pentachlorophenol (SVOC)	<100	-	-	-
2,4-Dimethylphenol	<100	-	21,000	0/2	n-Nitroso-n-dipropylamine	<100	-	-	-
2,4-Dichlorophenol	<100	-	-	-	n-Dioctylphthalate	<500	-	-	-
2,4,6-Trichlorophenol	<100	-	-	-	n-Dibutylphthalate	<100	-	-	-
2,4,5-Trichlorophenol	<100	-	-	-	Nitrobenzene	<100	-	-	-
2-Chloronaphthalene	<100	-	-	-	Isophorone	<100	-	-	-
2-Methylnaphthalene	<100	-	-	-	Hexachloroethane	<100	-	-	-
Acenaphthylene	<100	-	170,000	0/2	Hexachlorocyclopentadiene	<100	-	-	-
Acenaphthene	<100	-	210,000	0/2	Perylene	<100	-	-	-

Table 28. Summary of the Results of the SVOC Analysis of Soils (µg/kg)

One sample from the Southern Area returned a concentration of Bis(2-ethylhexyl)phthalate above the laboratory detection limit, however, this concentration is below the human health GAC. All other SVOC concentrations were recorded as below laboratory detection limit.

Contaminant (µg/kg)	Min	Max	GAC	No. > GAC	Contaminant (µg/kg)	Min	Max	GAC	No. > GAC
Dichlorodifluoromethane	<1	-	-	-	Dibromochloromethane	<3	-	-	-
Chloromethane	<10	-	-	-	1,2-Dibromoethane	<1	-	-	-
Vinyl Chloride (Chloroethene)	<1	-	-	-	Chlorobenzene	<1	-	-	-
Bromomethane	<1	-	-	-	1,1,1,2-Tetrachloroethane	<1	-	-	-
Chloroethane	<1	-	-	-	Ethylbenzene	<1	-	47,000	0/2
Trichlorofluoromethane	<1	-	-	-	m & p Xylene	<1	-	59,000	0/2
1,1-Dichloroethene	<1	-	-	-	o-Xylene	<1	-	60,000	0/2
Carbon Disulphide	<1	-	140	0/2	Styrene	<1	-	-	-
Dichloromethane	<5	-	-	-	Bromoform	<1	-	-	-
trans 1,2-Dichloroethene	<1	-	-	-	Isopropylbenzene	<1	-	12,000	0/2
1,1-Dichloroethane	<1	-	-	-	1,1,2,2-Tetrachloroethane	<1	-	-	-
cis 1,2-Dichloroethene	<1	-	-	-	1,2,3-Trichloropropane	<1	-	-	-
2,2-Dichloropropane	<1	-	-	-	Bromobenzene	<1	-	-	-
Bromochloromethane	<5	-	-	-	n-Propylbenzene	<1	-	40,000	0/2
Chloroform	<1	-	-	-	2-Chlorotoluene	<1	-	-	-
1,1,1-Trichloroethane	<1	-	-	-	1,3,5-Trimethylbenzene	<1	-	-	-
1,1-Dichloropropene	<1	-	-	-	4-Chlorotoluene	<1	-	-	-
Carbon Tetrachloride	<1	-	-	-	tert-Butylbenzene	<2	-	-	-
1,2-Dichloroethane	<2	-	-	-	1,2,4-Trimethylbenzene	<1	-	410	0/2
Benzene	<1	-	87	0/2	sec-Butylbenzene	<1	-	-	-
Trichloroethene	<1	-	-	-	4-Isopropyltoluene	<1	-	-	-
1,2-Dichloropropane	<1	-	-	-	1,3-Dichlorobenzene	<1	-	-	-
Dibromomethane	<1	-	-	-	1,4-Dichlorobenzene	<1	-	-	-
Bromodichloromethane	<10	-	-	-	n-Butylbenzene	<1	-	-	-
cis 1,3-Dichloropropene	<1	-	-	-	1,2-Dichlorobenzene	<1	-	-	-
Toluene	<1	-	130,000	0/2	1,2-Dibromo-3-chloropropane (DCBP)	<2	-	-	-
trans 1,3-Dichloropropene	<1	-	-	-	1,2,4-Trichlorobenzene	<3	-	-	-
1,1,2-Trichloroethane	<1	-	-	-	Hexachlorobutadiene	<1	-	-	-
1,3-Dichloropropane	<1	-	-	-	1,2,3-Trichlorobenzene	<3	-	-	-
Tetrachloroethene	<1	-	-	-					

Table 29. Summary of the Results of the VOC Analysis of Soils (µg/kg)

VOCs were not detected in any of the soil samples sent for analysis in the Southern Area.

Determinand	Units	Min	Max
pH	-	5.59	8.39
Cyanide (free)	Mg/kg	<1	1
Cyanide (total)	Mg/kg	<1	42
Thiocyanate	Mg/kg	<5	-
Sulphate (water sol.)	g/l	0.05	0.1
Sulphate (acid sol.)		430	430
Sulphur (total)	Mg/kg	179	289
TOC	%	0.27	2.76
Asbestos	%w/w	<0.001	0

Table 30. Summary of Inorganic compounds

Table 30 summarises the inorganic soil analysis for the Southern Area. pH was to range between 5.59 and 8.39 across this area. Cyanide (free) and Cyanide (total) and were detected in one sample but Thiocyanate was not detected in any of the samples analysed.

TOC ranged from 0.27 and 2.76%. Asbestos was not detected in any of the soil samples taken from the Southern Area.

8.5 Groundwater Analysis – Production Area

The analysis, conducted by a Gas Chromatography / Flame Ionisation Detector (GC/FID) and Gas Chromatography / Mass Spectrometry (GC / MS) comprised fractionation and speciation of hydrocarbons including analysis for hydrocarbons, benzene, toluene, ethylbenzene and xylenes (BTEX) compounds, MTBE and metals.

The analytical results were analysed for contaminants associated with use of the site as a PFS, maintenance garage, historical industrial use as part of a slate works and offsite fuel storage. The results of analyses of the water samples were compared to screening criteria sourced from the following legislation:

- Water Supply (Water Quality) Regulations 2000.
- Standards for Hazardous Substances (from the WFD, 2006/60/EC), 2013.
- Drinking Water Quality Standards England and Wales, 2000 (Amended 2004, DWS).
- Environmental Quality Standards (EQS) as presented in the River Basin Districts Typology, Standards and Groundwater Threshold Values (England and Wales) Directions 2010.
- WHO Guidelines for Drinking Water Quality. Third edition (2004)

A summary of the analytical results is presented in Table 31-34. The laboratory certificates are presented in Appendix F.

Determinand	Min	Max	GAC	No. > GAC
BTEX (µg/l)				
Benzene	<1	4203	10	6/10
Toluene	<1	1848	74	3/10
Ethylbenzene	<1	77	300	0/10
m- & p- Xylenes	<1	874	500	2/10
o-Xylenes	<1	326	500	0/10
MTBE	<1	<1	-	-
Aliphatic (µg/l)				
Aliphatic C5-C6	<1.0	<1.0		-
Aliphatic >C6-C8	<1	17	15000	0/10
Aliphatic >C8-C10	<5	250	300	0/10
Aliphatic >C10-C12	<5	352	300	1/10
Aliphatic >C12-C16	<5	865	300	1/10
Aliphatic >C16-C21	<5	718	NA	-
Aliphatic >C21-C35	<5	360	NA	-
Aromatics (µg/l)				
Aromatic C5-C7	<1	4203	1	8/10
Aromatic >C7-C8	<1	1848	70	3/10
Aromatic >C8-C10	<5	7100	300	4/10
Aromatic >C10-C12	<5	47700	90	5/10
Aromatic >C12-C16	<5	64100	90	7/10
Aromatic >C16-C21	9	4900	90	7/10
Aromatic >C21-C35	<10	989	90	4/10

Table 31. Summary of the results of hydrocarbon analyses of water samples from the Production Area.

Multiple exceedances of the general assessment criteria (DWS/EQS/WHO) were recorded for Benzene, Toluene, m and p Xylene and aromatic TPH. Only one exceedance of TPH aliphatic was recorded above the waters GAC at BH19-05.

Figure 7 presented in Appendix A shows the distribution of impacted groundwater.

Determinand	Min	Max	GAC	No. > GAC
Metals				
Arsenic (dissolved)	<1	64	50	1/5
Boron (dissolved)	102	420	1000	0/5
Cadmium (dissolved)	<0.2	2.8	5	0/5
Copper (dissolved)	<1	8	20	0/5
Chromium (dissolved)	<1	3	50	0/5
Iron (dissolved)	85	8520	300	3/7
Ferrous iron FeII (w)	<0.1	4.4	-	-
Ferric iron FeIII (w)	<0.1	8.5	-	-
Lead (dissolved)	<1	4	0.05	1/5
Manganese (dissolved)	78	18300	300	6/7
Mercury (dissolved)	<0.1	0.1	1	0/5
Nickel (dissolved)	2	226	50	2/5
Selenium (dissolved)	<1	5	10	0/5
Zinc (dissolved)	5	413	500	0/5
Manganese IV (w)	130	2400	-	-
Manganese II (w)	120	18000	-	-

Table 32. Summary of the results of Metal analyses of water samples from the Production Area (ug/l)

Concentrations of Arsenic, dissolved Iron, Lead, Manganese and Nickel were recorded above the waters GAC. All other concentrations of metals were detected below the GAC for waters.

Contaminant	Min	Max	GAC	No. > GAC
Acenaphthene (w)	0.17	3,080	-	-
Acenaphthylene (w)	0.02	37.6	0.1	3/4
Anthracene (w)	0.06	43.3	-	-
Benzo(a)anthracene (w)	0.02	7.01	-	-
Benzo(a)pyrene (w)	<0.01	4.22	0.00017	3/4
Benzo(b)fluoranthene (w)	<0.01	4.83	-	-
Benzo(ghi)perylene (w)	<0.01	1.35	-	-
Benzo(k)fluoranthene (w)	<0.01	1.78	-	-
Chrysene (w)	0.02	5.8	-	-
Dibenzo(ah)anthracene (w)	<0.01	0.42	-	-
Fluoranthene (w)	0.05	25	0.01	4/4
Fluorene (w)	0.04	794	-	-
Indeno(123-cd)pyrene (w)	<0.01	2.17	-	-
Naphthalene (w)	7.08	>11,100	10	3/4
Phenanthrene (w)	<0.01	295	-	-
Pyrene (w)	0.03	16.4	-	-
Total PAH 16MS (w)	7.56	11,100	-	-
Total Phenols	14	67.1	0.0077	3/5

Table 33. Summary of the results of PAH and Phenol analyses of water samples from the Production Area (µg/l)

Concentrations of PAH compounds were recorded above the GAC for waters in all four groundwater samples. Total Phenol concentrations were recorded above the GAC for waters in three (BH19-02, BH19-05 and BH305) of the five samples sent to the laboratory.

Determinand	Units	Min	Max	GAC	No. > GAC
pH	-	3.72	8.28	-	-
Cyanide (free)	mg/l	<0.005	0.049	-	-
Cyanide (total)	mg/l	0.061	4.335	0.05	5/6
Thiocyanate	mg/l	0.6	25	0.05	5/5
Ammoniacal Nitrogen	mg/l	6.46	134	-	-
Nitrite	mg/l	<0.1	3.7	-	-
Nitrate	mg/l	4.8	216	-	-
Total Hardness	Mg/l CaCO ₃	428	1,420	-	-
Redox Potential	mV	60.3	238	-	-
Electrical Conductivity	µs/cm	1551	4430	-	-

Table 34. Summary of the results of Inorganic compounds

Groundwaters samples from the Production Area recorded a pH range of 3.72 to 8.28.

Total Cyanide and Thiocyanate were recorded above the GAC for water in five samples sent to the laboratory.

Ammoniacal nitrogen was recorded between 6.46mg/l and 134mg/l and total hardness was ranged between 428 mg/l CaCO₃ and 1,420 mg/l CaCO₃.

8.5.1 Possible Product BH19-07

One groundwater sample contained gross impact suggestive of NAPL which was analysed at the laboratory. Table 35 details the laboratory results of the NAPL TPH and BTEX results.

Determinand	BH19-07
BTEX	
Benzene	>1,330
Toluene	>1,030
Ethylbenzene	>430
m- & p- Xylenes	>851
o-Xylenes	>673
MTBE	<2.50
Aliphatic	
Aliphatic C5-C6	19
Aliphatic >C6-C8	277
Aliphatic >C8-C10	4,030
Aliphatic >C10-C12	19,000
Aliphatic >C12-C16	19,300
Aliphatic >C16-C21	2,590
Aliphatic >C21-C35	<1
Aromatics	
Aromatic C5-C7	>1,330
Aromatic >C7-C8	>1,030
Aromatic >C8-C10	81,300
Aromatic >C10-C12	507,000
Aromatic >C12-C16	350,000
Aromatic >C16-C21	104,000
Aromatic >C21-C35	63,800

Table 35. Summary of the results of possible NAPL TPH and BTEX results from BH19-07 mg/kg

The results of the possible NAPL analysis show highly elevated concentrations of BTEX and TPH with highest concentrations predominately in the aromatic range.

8.5.2 Product Sump

An analysis of NAPL from the sump located at the north end of TP24. Tables 36 and 37 summarise the NAPL VOC and SVOC results. The product oil analysis identified the NAPL to have carbon banding of C12-C21.

Determinand	SUMP	Determinand	SUMP
Dichlorodifluoromethane (Freon/CFC-12)	<25	1,2-Dibromoethane (1,2-EDB; 1,2-Ethylene Dibromide)	<25
Chloromethane	<250	Chlorobenzene	<25
Vinyl Chloride	<25	1,1,1,2-Tetrachloroethane	<25
Bromomethane	<25	Ethylbenzene	90
Chloroethane	<25	m & p Xylene	1,530
Trichlorofluoromethane (Freon/CFC-11)	<25	o-Xylene	628
1,1-Dichloroethene (1,1-DCE) (vinylidene chloride)	<25	Styrene	85
Carbon Disulphide	379	Bromoform (Tribromomethane)	<25
Dichloromethane (methylene chloride)	<125	Isopropylbenzene	<25
trans 1,2-Dichloroethene (trans-1,2-DCE)	<25	1,1,2,2-Tetrachloroethane	<25
1,1-Dichloroethane (1,1-DCA)	<25	1,2,3-Trichloropropane	<25
cis 1,2-Dichloroethene (cis-1,2-DCE)	<25	Bromobenzene	<25
2,2-Dichloropropane	<25	n-Propylbenzene	<25
Bromochloromethane	<125	2-Chlorotoluene	<25
Chloroform (Trichloromethane)	<25	1,3,5-Trimethylbenzene	457
1,1,1-Trichloroethane (1,1,1-TCA)	<25	4-Chlorotoluene	<25
1,1-Dichloropropene	<25	tert-Butylbenzene	<50
Carbon Tetrachloride (Tetrachloromethane)	<25	1,2,4-Trimethylbenzene	1,160
1,2-Dichloroethane (1,2-DCA)	<50	sec-Butylbenzene	<25
Benzene	361	4-Isopropyltoluene	29
Trichloroethene (TCE)	<25	1,3-Dichlorobenzene	<25
1,2-Dichloropropane	<25	1,4-Dichlorobenzene	<25
Dibromomethane	<25	n-Butylbenzene	<25
Bromodichloromethane	<250	1,2-Dichlorobenzene	<25
cis 1,3-Dichloropropene	<25	1,2-Dibromo-3-chloropropane	<50
trans 1,3-Dichloropropene	<25	1,2,4-Trichlorobenzene	<75
1,1,2-Trichloroethane (1,1,2-TCA)	<25	Hexachlorobutadiene	<25
1,3-Dichloropropane	<25	1,2,3-Trichlorobenzene	<75
Tetrachloroethene (PCE)A151:A181A181	<25	Toluene	490
Dibromochloromethane	<75		

Table 36. Summary of the results of NAPL VOC results from SUMP sample (ug/kg)

Results of the NAPL VOC analysis show multiple concentrations of SVOCs above the laboratory detection limit.

Determinand	SUMP	Determinand	SUMP
2,4,5-Trichlorophenol	<25,000	Bis(2-ethylhexyl)phthalate	<125,000
2,4,6-Trichlorophenol	<25,000	Butylbenzyl phthalate	<25,000
2,4-Dichlorophenol	<25,000	Carbazole	46,300
2,4-Dimethylphenol	<25,000	Chrysene	62,200
2,4-Dinitrotoluene	<25,000	Dibenzo(ah)anthracene	<25,000
2,6-Dinitrotoluene	<25,000	Dibenzofuran	703,000
2-Chloronaphthalene	<25,000	Diethyl phthalate	<25,000
2-Chlorophenol	<25,000	Dimethyl phthalate	<25,000
2-Methylnaphthalene	208,000	n-Dibutylphthalate	<25,000
2-Methylphenol	<25,000	n-Dioctylphthalate	<125,000
2-Nitrophenol	<25,000	Fluoranthene	193,000
4-Bromophenyl phenyl ether	<25,000	Fluorene	975,000
4-Chloro-3- methylphenol	<25,000	Hexachlorobenzene	<25,000
3+4-Methylphenol	<25,000	Hexachlorocyclopentadiene	<25,000
4-Nitrophenol	<25,000	Hexachloroethane	<25,000
Acenaphthene	1,440,000	Indeno(1,2,3-cd)pyrene	40,800
Acenaphthylene	57,700	Isophorone	<25,000
Anthracene	106,000	Naphthalene	370,000
Benzo(a)anthracene	74,100	Nitrobenzene	<25,000
Benzo(a)pyrene	63,200	n-Nitroso-n-dipropylamine	<25,000
Benzo(b)fluoranthene	69,200	Pentachlorophenol	<25,000
Benzo(ghi)perylene	43,300	Perylene	<25,000
Benzo(k)fluoranthene	34,300	Phenanthrene	41,3000
Bis(2- chloroethoxy)methane	<25,000	Phenol	<25,000
Bis(2- chloroethyl)ether	<25,000	Pyrene	130,000
Bis(2- chloroisopropyl)ether	<25,000		

Table 37. Summary of the results of NAPL SVOC results from SUMP sample (ug/kg)

Results of the NAPL SVOC analysis show multiple concentrations of VOCs above the laboratory detection limit.

8.6 Groundwater Analysis – Coal Stockyard Area

A summary of the analytical results is presented below in Tables 38. The laboratory certificates are presented in Appendix F.

Determinand	Min	Max	GAC	No. > GAC
BTEX				
Benzene	<1	<1	10	0/4
Toluene	<1	<1	74	0/4
Ethylbenzene	<1	<1	300	0/4
m- & p- Xylenes	<1	<1	500	0/4
o-Xylenes	<1	<1	500	0/4
MTBE	<1	<1	-	0/4
Aliphatic				
Aliphatic C5-C6	<1	<1		0/4
Aliphatic >C6-C8	<1	<1	15000	0/4
Aliphatic >C8-C10	<5	<5	300	0/4
Aliphatic >C10-C12	<5	<5	300	0/4
Aliphatic >C12-C16	<5	<5	300	0/4
Aliphatic >C16-C21	<5	<5	NA	0/4
Aliphatic >C21-C35	<5	8	NA	0/4
Aromatics				
Aromatic C5-C7	<1	<1	1	0/4
Aromatic >C7-C8	<1	<1	70	0/4
Aromatic >C8-C10	<5	<5	300	0/4
Aromatic >C10-C12	<5	5	90	0/4
Aromatic >C12-C16	5	34	90	0/4
Aromatic >C16-C21	6	17	90	0/4
Aromatic >C21-C35	<10	<10	90	0/4

Table 38. Summary of the results of hydrocarbon analyses of water samples from the Coal Stockyard (µg/l)

Results of the TPH and BTEX analysis of groundwater from the Coal Stockyard area returned concentrations of TPH above the laboratory detection limit for Aliphatic C21-C5 and Aromatic C10-C21, however, all the concentrations are below the GAC for waters.

Determinand	Min	Max	GAC	No. > GAC
Arsenic (dissolved)	<1	1	50	0/2
Boron (dissolved)	119	200	1000	0/2
Cadmium (dissolved)	<0.2	<0.2	5	0/2
Copper (dissolved)	<1	1	20	0/2
Chromium (dissolved)	<1	<1	50	0/2
Lead (dissolved)	<1	7	0.05	1/2
Mercury (dissolved)	<0.1	<0.1	1	0/2
Nickel (dissolved)	3	11	50	0/2
Selenium (dissolved)	<1	<1	10	0/2
Zinc (dissolved)	5	8	500	0/2

Table 39. Summary of the results of Metal analyses of water samples from the Coal Stockyard (ug/l)

Metal analysis returned one sample, RBH2, with a concentration above the GAC for lead in waters. All other samples returned a concentration below each of the GAC for waters.

Contaminant	Min	Max	GAC	No. > GAC
Acenaphthene (w)	<0.01	7.32	-	-
Acenaphthylene (w)	0.02	0.22	0.1	2/3
Anthracene (w)	<0.01	0.04	-	-
Benzo(a)anthracene (w)	<0.01	0.03	-	-
Benzo(a)pyrene (w)	<0.01	<0.01	0.00017	0/3
Benzo(b)fluoranthene (w)	<0.01	<0.01	-	-
Benzo(ghi)perylene (w)	<0.01	<0.01	-	-
Benzo(k)fluoranthene (w)	<0.01	<0.01	-	-
Chrysene (w)	<0.01	0.03	-	-
Dibenzo(ah)anthracene (w)	<0.01	<0.01	-	-
Fluoranthene (w)	0.02	0.2	0.01	3/3
Fluorene (w)	<0.01	1.08	-	-
Indeno(123-cd)pyrene (w)	<0.01	<0.01	-	-
Naphthalene (w)	<0.01	0.08	10	0/2
Phenanthrene (w)	0.02	0.24	-	-
Pyrene (w)	0.02	0.17	-	-
Total PAH 16MS (w)	0.02	9.37	-	-
Total Phenols	<0.01	<0.01	0.0077	-

Table 40. Summary of the results of PAH and Phenol analyses of water sample ug/l

Concentrations of Acenaphthylene (BH201 and RBH1D) and Fluoranthene (BH201, RBH1D and RBH2) from groundwater samples from the Coal Stockyard were recorded above the GAC for waters. Total Phenol concentration was below the laboratory method detection limit in all samples.

Determinand	Units	Min	Max	GAC	No. > GAC
Cyanide (free)	mg/l	<0.005	<0.005	-	-
Cyanide (total)	mg/l	0.018	0.07	0.05	1/2
Thiocyanate	mg/l	0.3	1	0.05	2/2
Ammoniacal Nitrogen	mg/l	<50	15.3	-	-
Total Hardness	Mg/l CaCO ₃	507	845	-	-

Table 41. Summary of the results of Inorganic compounds

Two groundwater samples, BH203 and RBH1D, from the Coal Stockyard area recorded concentrations of Cyanide (total) (BH201) and Thiocyanate (BH201 and RBH1D) above the GAC for waters.

Ammoniacal Nitrogen and total hardness ranged from <50mg/l to 15.3mg/l and 507mg/cacO₃ to 845mg/CaCO₃.

8.7 Groundwater Analysis – Southern Area

A summary of the analytical results is presented below in Tables 42 to 45. The laboratory certificates are presented in Appendix F.

Determinand	Min	Max	GAC	No. > GAC
BTEX				
Benzene	<1	0	10	0/2
Toluene	<1	0	74	0/2
Ethylbenzene	<5	0	300	0/2
m- & p- Xylenes	<5	0	500	0/2
o-Xylenes	<5	0	500	0/2
MTBE	<5	0	-	0/2
Aliphatic				
Aliphatic C5-C6	<1	0		0/2
Aliphatic >C6-C8	<1	0	15000	0/2
Aliphatic >C8-C10	<5	0	300	0/2
Aliphatic >C10-C12	<5	0	300	0/2
Aliphatic >C12-C16	<5	0	300	0/2
Aliphatic >C16-C21	<5	0	NA	0/2
Aliphatic >C21-C35	<5	5	NA	0/2
Aromatics				
Aromatic C5-C7	<1	<1	1	0/2
Aromatic >C7-C8	<1	<1	70	0/2
Aromatic >C8-C10	<5	<5	300	0/2
Aromatic >C10-C12	<5	<5	90	0/2
Aromatic >C12-C16	<5	<5	90	0/2
Aromatic >C16-C21	<5	7	90	0/2
Aromatic >C21-C35	<10	<10	90	0/2

Table 42. Summary of the results of hydrocarbon analyses of water samples from the Southern Area (ug/l)

Two samples of groundwater from the Southern Area were collected for analysis. One sample, WS20-10, returned concentrations of Aliphatic C21-C35 and Aromatic C16-C21 above the laboratory detection limit, however, these concentrations are below the GAC for waters. All other analysis was below the laboratory detection limit.

Determinand	Min	Max	GAC	No. > GAC
Arsenic (dissolved)	<1	<1	50	0/2
Boron (dissolved)	95	233	1000	0/2
Cadmium (dissolved)	<0.2	0.3	5	0/2
Copper (dissolved)	4	7	20	0/2
Chromium (dissolved)	<1	4	50	0/2
Lead (dissolved)	<1	<1	0.05	0/2
Mercury (dissolved)	<0.1	<0.1	1	0/2
Nickel (dissolved)	4	15	50	0/2
Selenium (dissolved)	14	22	10	2/2
Zinc (dissolved)	5	36	500	0/2

Table 43. Summary of the results of Metal analyses of water samples (ug/l)

Metal analysis of groundwater from the Southern Area returned concentrations of Selenium in both groundwater samples above the GAC for waters. All other samples recorded concentrations below the GAC for waters.

Determinand	Min	Max	GAC	No. > GAC
Acenaphthene (w)	0.02	0.04	-	-
Acenaphthylene (w)	<0.01	0.02	0.1	0/2
Anthracene (w)	<0.01	0.03	-	-
Benzo(a)anthracene (w)	<0.01	0.06	-	-
Benzo(a)pyrene (w)	<0.01	0.04	0.00017	1/2
Benzo(b)fluoranthene (w)	<0.01	0.04	-	-
Benzo(ghi)perylene (w)	<0.01	0.01	-	-
Benzo(k)fluoranthene (w)	<0.01	0.02	-	-
Chrysene (w)	<0.01	0.06	-	-
Dibenzo(ah)anthracene (w)	<0.01	<0.1	-	-
Fluoranthene (w)	0.01	0.19	0.01	2/2
Fluorene (w)	<0.01	0.02	-	-
Indeno(123-cd)pyrene (w)	<0.01	0.02	-	-
Naphthalene (w)	<0.01	<0.01	10	0/2
Phenanthrene (w)	<0.01	0.1	-	-
Pyrene (w)	0.01	0.18	-	-
Total PAH 16MS (w)	0.04	0.83	-	-
Total Phenols	<0.01	<0.01	0.0077	0/2

Table 44. Summary of the results of PAH and Phenol analyses of water samples from the Southern Area ug/l

Concentrations of PAH analysis of groundwater samples from the Southern Area returned elevated concentrations of Benzo(a)pyrene (WS20-10) and Fluoranthene (WS9 and WS20-10) above the GAC for waters. Total Phenol concentration was below the laboratory method detection limit in all samples.

Determinand	Units	Min	Max	GAC	No. > GAC
Cyanide (free)	Mg/l	0.008	0.022	-	-
Cyanide (total)	Mg/l	0.376	0.896	0.05	2/2
Thiocyanate	Mg/l	0.9	1.3	0.05	2/2
Ammoniacal Nitrogen	Mg/l	0.31	0.46	-	-
Total Hardness	Mg/CaCO ₃	551	935	-	-

Table 45. Summary of the results of Inorganic compounds

Two groundwater samples, WS9 and WS20-10, from the Coal Stockyard area recorded concentrations of Cyanide (total) and Thiocyanate above the GAC for surface waters.

Ammoniacal Nitrogen and total hardness ranged from 0.31mg/l to 0.46mg/l and 551mg/caCO₃ to 935mg/CaCO₃.

8.8 Surface Water Analysis

The analysis, conducted by a Gas Chromatography / Flame Ionisation Detector (GC/FID) and Gas Chromatography / Mass Spectrometry (GC / MS) comprised fractionation and speciation of hydrocarbons including analysis for hydrocarbons, benzene, toluene, ethylbenzene and xylenes (BTEX) compounds and MTBE.

The analytical results were analysed for contaminants based on historic site investigation findings. The results of analyses of the water samples were compared to screening criteria sourced from the following legislation:

- Water Supply (Water Quality) Regulations 2000.
- Standards for Hazardous Substances (from the WFD, 2006/60/EC), 2013.
- Drinking Water Quality Standards England and Wales, 2000 (Amended 2004, DWS).
- Environmental Quality Standards (EQS) as presented in the River Basin Districts Typology, Standards and Groundwater Threshold Values (England and Wales) Directions 2010.
- WHO Guidelines for Drinking Water Quality. Third edition (2004)

A summary of the analytical results is presented below in Tables 46 - 48. The laboratory certificates are presented in Appendix F.

Five rounds of samples were collected from four locations:

- Lineside Dyke North – Approximately 50m west of the site
- Lineside Dyke South – Approximately 50m to the south-west of the site
- Wakefield Beck North – Located approximately 120m west of the site
- Wakefield Beck South – Located approximately 120m south-west of the site

Samples from Lineside Dyke were taken upstream and downstream of the site to assess the impact the site has on the stream.

Samples from Wakefield Beck were obtained from both upstream and downstream of the site to assess the impact from the site.

Two more samples labelled Lineside Dyke 3 and Lineside Dyke 4 were taken to assess the condition of the dyke at other locations, these samples were taken after the initial five rounds of surface water sampling rounds were completed from 28th April 2020 to 14th July 2020. The locations of the sampling points on Lineside Dyke are presented on Figure 12 in Appendix A.

It should also be noted that infrastructure was seen to be entering Lineside Dyke. The points where infrastructure was noted to enter the Dyke is presented on Figure 12 in Appendix A.

Determinand	Min	Max	EQS	No. > EQS
BTEX				
Benzene	8	12,548	10	12/18
Toluene	2	1,551	74	5/18
Ethylbenzene	3	41	300	0/18
m- & p- Xylenes	25	540	500	1/18
o-Xylenes	9	188	500	0/18
MTBE	<1	<1	-	-
Aliphatic				
Aliphatic C5-C6	1	3		-
Aliphatic >C6-C8	1	27	15000	0/18
Aliphatic >C8-C10	7	126	300	0/18
Aliphatic >C10-C12	6	100	300	0/18
Aliphatic >C12-C16	8	48	300	0/18
Aliphatic >C16-C21	7	14	NA	-
Aliphatic >C21-C35	7	293	NA	-
Aromatics				
Aromatic C5-C7	8	12548	1	13/18
Aromatic >C7-C8	2	1551	70	5/18
Aromatic >C8-C10	8	6022	300	10/18
Aromatic >C10-C12	283	15000	90	11/18
Aromatic >C12-C16	6	8900	90	11/18
Aromatic >C16-C21	8	785	90	11/18
Aromatic >C21-C35	20	175	90	3/18

Table 46. Summary of TPH and BTEX in Surface Waters (µg/l)

Concentrations of Benzene, Toluene, m and p Xylenes and aromatic hydrocarbons were recorded at concentrations above the EQS for waters. The exceedances were recorded in every sampling round at Lineside Dyke N and Lineside Dyke S. In addition, the extra samples taken at Lineside Dyke 3 and Lineside Dyke 4 also recorded concentrations of Benzene and aromatic hydrocarbons above the EQS for waters.

There was only one exceedance from a sample taken Wakefield Beck S which recorded an exceedance of the EQS for waters during a sampling round on 28th April 2020. The exceedance concerned Aromatic C21-C35. All other samples taken from Wakefield Beck were below the EQS for waters, however, limited water in Wakefield Beck prevented collecting multiple samples.

Determinand	Min	Max	EQS	No. > EQS
Acenaphthene (w)	0.05	1250	-	-
Acenaphthylene (w)	0.05	10	0.1	11/18
Anthracene (w)	0.06	29.1	-	-
Benzo(a)anthracene (w)	<0.01	0.68	-	-
Benzo(a)pyrene (w)	<0.01	0.26	0.00017	3/18
Benzo(b)fluoranthene (w)	<0.01	0.34	-	-
Benzo(ghi)perylene (w)	0.07	0.07	-	-
Benzo(k)fluoranthene (w)	<0.01	0.14	-	-
Chrysene (w)	0.02	0.73	-	-
Dibenzo(ah)anthracene (w)	0.02	0.02	-	-
Fluoranthene (w)	0.07	14.2	0.01	13/18
Fluorene (w)	0.02	596	-	-
Indeno(123-cd)pyrene (w)	<0.1	0.12	-	-
Naphthalene (w)	0.43	5930	10	10/18
Phenanthrene (w)	0.03	218	-	-
Pyrene (w)	0.02	8.08	-	-
Total PAH 16MS (w)	0.48	8050	-	-
Total Phenols	<0.01	<0.01	0.0077	10/18

Table 47. Summary of PAH and Phenols in Surface Waters (µg/l)

Multiple exceedances of the EQS for waters were recorded for PAH compounds. Of the PAH compounds only one was recorded from Wakefield Beck N on 28th April 2020 and concerned Fluoranthene. All other exceedances were recorded in both Lineside Dyke N, Lineside Dyke S, Lineside Dyke 3 and Lineside Dyke 4.

With regards to total phenols ten of the samples that were recorded above the EQS for waters all were collected from Lineside Dyke N, Lineside Dyke S, Lineside Dyke 3 and Lineside Dyke 4. All samples from Wakefield Beck were below the laboratory detection limit.

Determinand	Min	Max	EQS	No. > EQS
Arsenic (dissolved)	3	46	50	0/18
Boron (dissolved)	63	229	1000	0/18
Cadmium (dissolved)	0.3	2.3	5	0/18
Copper (dissolved)	2	78	20	5/18
Chromium (dissolved)	1	220	50	2/18
Lead (dissolved)	1	8	0.05	4/18
Mercury (dissolved)	0.3	0.3	1	0/18
Nickel (dissolved)	7	309	50	6/18
Selenium (dissolved)	1	10	10	0/18
Zinc (dissolved)	3	356	500	0/18
Total Hardness (mg/CaCO ₃)	176	1,208	-	-
Ammoniacal Nitrogen as N (mg/l)	0.35	75.7	-	-
Total Cyanide (mg/l)	0.034	0.45	0.05	14/18

Table 48. Summary of Metals and Inorganics in Surface Waters (µg/l)

Concentrations of metals (Copper, Chromium, Lead and Nickel) were detected above the GAC for waters in sample from Lineside Dyke N, on 28th April 2020, and Lineside Dyke S, on all five sampling rounds. In addition, samples from Wakefield Beck N also reported samples of water contained concentrations of Lead and Nickel were above the GAC for waters on two occasions (Lead – 28th April 2020 and Nickel – 08th June 2020).

Total cyanide was reported above the GAC for waters in all Lineside Dyke N and Lineside Dyke S samples, in one sample from Lineside Dyke 4 sample and in Wakefield Beck N (28th April 2020) and two samples from Wakefield Beck S (28th April 2020 and 08th July 2020)

9.0 Risk Estimation

9.1 Discussions of Results – Production Area

Investigation of the Production Area comprised forty-six trial pits, fifteen window samples and eight deep boreholes. The investigation found that the area was underlain predominately with hardstanding concrete of varying thickness and strength, underlain by made ground of predominately sandy gravels and gravelly sands up to a maximum of 3.6m bgl. This was further underlain by sandstone bedrock that was found to be weak at the top of the strata.

Visual and olfactory evidence of contamination and laboratory results indicating significantly elevated concentrations of contaminants were identified in multiple locations as presented on Figure 7. The distribution of contamination is focused on the processing area which extends from the centre of the Production Area to the western boundary. Areas to the south and east in the Production Area did not identify potentially significant contamination.

Key areas of soil contamination to be noted are TP9, TP10 and TP22 for cyanide contamination which are located in the west of the production area.

Numerous TPH exceedances of the human health GAC were identified within the Production Area with the exception of the CHP area in the southern part of the Production Area which recorded TPH below the human health GAC. Figure 7 presents the distribution of the TPH impact.

Coal tar impacts were identified within soils of the central area of the Production Area (east to west) and impacts were predominately found close to old structure with visible coal tar staining and around underground infrastructure such as pipes. The top of the sandstone bed rock appeared to be impacted with coal tars below infrastructure which indicates that any potential impacts may migrate through fractures in the bedrock.

In the location of BH19-07 and TP48 a solvent odour was noted during the trial pitting and drilling investigation. It is thought this solvent odour maybe associated with the historic Benzole plant located directly north of these two locations. Analysis from BH19-07 at 0.5m returned significantly elevated concentrations of SVOC compounds that may be responsible for the strong solvent odour.

Metals were also found to be above the human health GAC in the shallow soils within the central part of the production area and the CHP, however, it is considered that these impacts are localised and associated with made ground.

Combustible material was identified within the Production Area, associated with shallow breeze in subsoils in TP10 (CHP), TP23 and TP43 (both in the centre of the production area) with caloric value testing recording concentrations between 4.6MJ/kg and 16MJ/kg which are indicative of flammable material. However, given that the combustible material was not found to be widespread and is most likely from made ground deposits it is thought the risk from combustible coal breeze to be low in the Production Area.

Asbestos in the shallow soils was identified in three of five samples sent off for analysis. Of the three positive asbestos samples only one sample returned a quantifiable value of 0.017%w/w (BH19-03 1.0m) while the other two samples were below 0.01%w/w at TP23 1.0m and TP28 0.5m.

Ten groundwater samples were collected from newly installed monitoring wells and historical monitoring wells. TPH, total phenols and PAH's were identified in the all the samples analysed with the highest concentrations of TPH, total phenols and PAH recorded in BH19-02, BH19-05 and BH19-06 which are all located in the west area of the Production Area. In addition, these

boreholes range from 12-20m bgl suggesting that the deeper sandstone aquifer is impacted. Only two samples from RBH4 and RBH4a in the north of the production area returned concentrations of TPH below the GAC for waters.

BH19-07 was found to be grossly impacted and TPH concentrations are indicative of NAPL. This location is also a deep borehole that was installed to 20m bgl; during monitoring of this location it was noted that visual evidence of contamination was noted in the bottom 6.10m of the monitoring well, where the borehole enters the underlying low permeability mudstone.

A DNAPL sample collected from the sump at TP24 (near the former Quench Pond area) identified the NAPL to be within the TPH range of C12 – C21 which is consistent with soil samples and groundwater samples suggesting that the identified impacts within both soils and groundwater are associated with the historic works on site.

Total cyanide and thiocyanate were recorded above the GAC for waters in five of the six groundwater samples collected (RBH4A, BH19-02, BH19-03, BH19-05 and BH19-06). The highest concentration of cyanide and thiocyanate are recorded in BH19-03 and BH19-05 which are in close proximity to where visual impacts of cyanide were noted during the trial pitting exercise.

Metals have been recorded in the newly installed deep boreholes across the area with exceedances in arsenic, dissolved iron, lead, manganese and nickel. This impact is likely to be associated with historical activities in this area of the site.

Consideration must be taken when developing the site with respect to the large deposit of silica bricks.

During the trial pitting exercise notable underground infrastructure was identified. A summary of the infrastructure is provided below and presented in Figure 8 within Appendix A:

- Numerous underground pipes containing and surrounded by coal tar. It is thought substantially that more pipe infrastructure is still present beneath the site and widespread coal tar around the infrastructure is to be anticipated.
- Underground storage tanks have been encountered in the western area of the Production Area.
- A sump full of coal tar located directly south of TP24, close to the former Quench tanks.
- Two tunnels running in an east-west direction located to the north of TP24 and TP25.
- Multiple concrete obstructions with the thickest concrete (0.8m thick) located at TP92.

9.2 Discussion of Results – Coal Stockyard

Investigation of the Coal Stockyard involved forty-eight trial pits and six window sample boreholes. The findings of the investigation identified that the site was surfaced in a mix of hardstanding concrete of variable thickness and strength and a coal breeze cover.

In the east and north of the engineering yard is a bunded area with heavy vegetation. Made ground was found to a maximum depth of 4.0m bgl comprising predominately sandy gravels or gravelly sand which the occasional horizon of clay. Beneath the made ground natural clay was identified in some locations across the Coal Stockyard with mudstone and sandstone bedrock being noted beneath. Sandstone bedrock was located predominately to the south of the Coal Stockyard and Mudstone bedrock was mainly identified to the north of the Coal Stockyard.

Soil concentrations of TPH and SVOC were recorded above the human health GAC from one sample from TP61. TP61 is located in the south-west of the Coal Stockyard and contained infrastructure likely associated with the Production Area. One other sample from WS20-03 (0.8m) reported an exceedance of the human health GAC for Benzene of 0.14mg/kg, however, this exceedance is only considered marginal.

Concentrations of metals (beryllium, lead and mercury) were reported above the human health GAC, however, these impacts are considered localised and to be associated with made ground deposits.

Cyanide (free and total) was recorded as elevated in a soil sample from TP51 in the north-west part of the Coal Stockyard where blue staining was on some soils, however, this appears to be localised to this location.

Seven soils samples were taken from across the Coal Stockyard to be analysed for calorific value. The results ranged from 8MJ/kg to 25mg/kg which is indicative of combustible material, however, coal breeze had been scraped back and stockpiled in the northern part of the stockyard and thicknesses of breeze across the site was minimal with a maximum thickness of 0.4m located at TP55 in the west. Figure 9 in Appendix A shows the distribution of identified combustible material. The risk of the from the combustible coal material could be reduced if scraped back and removed from site.

Two trenches and fifteen dynamic probeholes were advanced in the area of a potential historic train tunnel. Trench 1, presented in Figure 6, identified the train tunnel beneath surface level, however, the Trench 2 did not identify the train tunnel. It is considered that in the area of Trench 2 the ground may have since been reworked or that the tunnel at this location may have been above ground level. The fifteen probeholes did identify softer ground in places of the where the suspected train tunnel may be located, however, nothing conclusive was made from the probehole investigation.

Eleven soil samples were analysed for asbestos and two returned positive results. The two positive results were then quantified and one returned a value of 0.127%w/w at TP69 (0.7m) while the other sample, TP53 0.5m, was below 0.001%w/w.

Four groundwater samples were collected from the Coal Stockyard Area which returned concentrations of slightly elevated TPH concentrations within deep and shallow groundwater, however, all samples returned concentrations below the GAC for waters.

Three groundwater samples, BH201, RBH1D and RBH2, were sent to the laboratory for PAH analysis which all returned concentrations of acenaphthylene, and Fluoranthene above GAC for waters. However, it is considered that these results to be slightly elevated and low risk.

In addition, Cyanide (total) and Thiocyanate were detected above the GAC for waters in BH201 and RBH1D (north-west Coal Stockyard). This could be associated with any made ground deposits as the soils in this area contained cyanides within the ground.

Dissolved metals were also detected at significantly elevated concentrations in BH201 and RBH2 (north Coal Stockyard).

Other notable features that were identified during the investigation were:

- In addition, three mine shafts were located at depths of between 2.9m and 3.5m bgl and are presented on Figure 8 in Appendix A.
- Multiple concrete obstructions as presented in Figure 8 in Appendix A.

- Potential train line in the bunded area to the east at TP77 at approximately 1.8m bgl This is approximately in the same location as historical railway lines as presented in the historical plan of the map in Appendix A.
- The historical clay pit was not identified during any trial pitting. Shallow natural bedrock and concrete obstructions were noted suggesting that the ground level has been lowered since the clay pit works. Gas sampling in this area also reports low ground gas concentrations.
- Multiple underground services such as sewers (northern part of the Coal Stockyard) are still present within the Coal Stockyard. It is unknown as to whether the sewers are active.

9.3 Discussion of Results – Southern Area

Investigation of the Southern Area involved five trial pits and one window sample borehole. The findings of the investigation found that the surface of the Southern Area was predominately grass cover with some concrete hardstanding in the east. Made ground was found to a maximum depth of 2.0m bgl comprising gravelly sands and clays. Beneath the made ground was sandy clay on top a mudstone bedrock. No evidence of coal measure was identified during the investigation.

It should be noted that during drilling and trial pitting exercises coal seams were not identified in any of the locations investigated which appear to be present on geological maps.

Slightly elevated soil concentrations of TPH and one SVOC were recorded, however, it is considered that the concentrations are low risk.

Soil concentrations of VOCs were not detected above the laboratory detection limit.

Metal concentrations in soils were considered above the laboratory detection limit but are considered to be slightly elevated.

Cyanide (free and total) was detected in one sample, TP73(1.8m) but was below the detection limit in all other samples from the Southern Area and is therefore considered localised.

No visual or olfactory evidence of contamination was noted during the investigation.

Two groundwater samples were collected from WS9 and WS20-10 in the Southern Area. Concentrations of TPH are below the GAC for waters.

The two samples returned concentrations of total cyanide and thiocyanate above the GAC for surface waters.

PAH concentrations in the two groundwater samples from the Southern Area were recorded above the GAc for waters. Benzo(a)pyrene (WS20-10) was recorded at 0.04µg/l and Fluoranthene was recorded at 0.01µg/l and 0.19 µg/l in WS9 and BH20-10 respectively.

Concentrations of selenium were recorded above the GAC for waters in WS9 and WS20-10. All other metals were below the GAC for waters.

However, groundwater appears to be localised in the southern area as groundwater is approximately 0.8m different in elevation which is suggestive of perched water. In addition, the groundwater is located in low permeability deposits, therefore, the risk from the groundwaters to controlled waters is considered low.

9.4 Discussion of Results – Hydrogeology

Groundwater monitoring was undertaken on all the newly installed monitoring wells and historic monitoring wells. It was found that within the deep aquifer the groundwater table is approximately 7 – 9m lower in the Coal Stockyard than the Production Area. This is considered to be due to the geology of the site. In the Production Area sandstone bedrock is recorded at a shallow depth and within the Coal Stockyard (southern half) sandstone is recorded much deeper suggesting the bedrock is dipping to the north. Geological maps also show that the sandstone bedrock is also dipping to the north.

In the northern half of the Coal Stockyard mudstone bedrock was identified. This could potentially be acting as a confining layer to the underlying sandstone and explain why the groundwater levels are significantly different across the site.

Discussion of Results – Ground Gas

Ground gas results found that the suitable monitoring wells on site identified the worst-case risk from ground gas as Characteristic Situation 2 which is described as low risk. This was identified in four monitoring across the site, three were located in the Coal Stockyard (WS20-01, WS20-03 and WS20-04) and the other was located in the Production Area (WS20-06).

All other results from the ground gas monitoring identified a Characteristic Situation 1 (very low risk).

Therefore, based on a worst-case scenario it is considered the site is considered to be a Characteristic Situation 2 which would require protective measures for any future residential dwellings.

However, the assessment conducted at the site is considered insufficient to suitably approve the risk to residential developments. This would require a greater programme of monitoring including twelve visits over a six-month period. However, the proposed change in land level at the site may influence the gas regime.

In addition, the site is located in an intermediated probability radon area (5 to 10% of homes are estimated to be at or above the action level). Therefore, basic radon protection measures are necessary in the construction of new dwellings or extensions.

9.6 Discussion of Results – Surface Waters

Five surface water sampling monitoring rounds were undertaken of Lineside Dyke and Wakefield Beck. However, due to Wakefield Beck being dry on some of the monitoring rounds a limited number of samples were collected from this location. In addition, further samples from Lineside Dyke (3 and 4) were collected to analyse the extent of any impact.

The nearest surface water course is a culverted stream known as Lineside Dyke, situated approximately 50m west of the closest potentially significant impact. Located adjacent to the northern part of the western boundary of the main coking works site, Lineside Dyke flows in a generally southerly direction joining Cudworth Dyke approximately 140m to the south of the site.

Lineside Dyke was noted to flow through an enclosed pipe buried at a shallow depth in the railway cutting adjacent to the base of the sandstone outcrop. Lineside Dyke was observed through series of access manholes or vents along its length. Flow was noted to be low to nil on all visits.

Analysis from Lineside Dyke, collected at locations shown on Figure 7, in Appendix A, indicates concentrations of contaminants to be present far in excess of surface waters Environmental Quality Standards (EQS) for hydrocarbons, phenols, cyanides, metals and PAH. These

concentrations have been reported both up (near the Stockyard- highest reading 9,180µg/l) and downstream (at the southwestern tip of the site) on all five sampling visits. The highest reported concentrations were consistently reported in the 'South' sample point (30,400µg/l TPH). This data strongly indicates that the Lineside Dyke is regionally impacted, however, there is clear evidence that the site is contributing to this impact. The most significantly elevated readings are all located at points immediately downstream of inlet connections with pipework which runs up the bank to the site.

Two other sample points Nos 3 and 4, samples on one occasion (and shown on Figure 7), reported readings of 2,460µg/l and 3,132µg/l, respectively. These locations fall between the northern and southern sample points and are located away from identified pipe connections to the main site.

Groundwater levelling indicates that the topographic high point of the site, in the south of the production area acts to divide the site into two watersheds, most of the site being covered by a watershed with a north easterly flow direction, with the remainder, comprising grossly impacted areas of the production area, flowing to the southwest, towards the Lineside Dyke.

Lineside Dyke is located topographically lower than the site, being situated in a railway cutting along the western boundary at a level of approximately 53m-56m AOD, and as such groundwater along the western site boundary at a level of 61m- 64m AOD is likely to flow through the sandstone aquifer and enter into the proximity of the Dyke.

The method by which migrating groundwater through the Sandstone enters the Dyke is unclear, however it is likely that migrating groundwater will enter a baseflow of water around the culvert, where it may enter at joints or cracks.

Evidence suggests that release of water to the Lineside Dyke still occurs through residual infrastructure, which may account for the highest reported values within this waterbody. Pipework is visible in the bank connecting the watercourse to the site near the Stockyard, suggesting derelict pumping or drainage connections (as inferred in historical reports) and also by the Biological Treatment Plant in the south of the site.

Geo² consider the principal pathway by which Lineside Dyke has or is becoming impacted is the relict or disused drainage pipework. Migration through the deeper sandstone is considered likely to be contribute to this as well as regional diffuse / point sources associated with the coal mining legacy of the wider area.

Groundwater migration to the north across much of the site appears to be governed by the underlying mudstone, which slopes in the same direction.

Groundwater in the wells in the south of the site appears to be perched within shallow cohesive deposits, overlying the low permeability mudstone, as shown in Figure 8, in Appendix A, which appears to act as an aquitard across the site (groundwater trends in the north appear to be governed by the slope of this low permeability horizon as detailed in the site investigation). These levels report a difference of 1m to water level within the wells, due to their close proximity and level topography of the southern area this provides further evidence of perched groundwater. As such, Geo² do not consider the groundwater in the Southern area to be significant waterbody or to be in connectivity with the underlying aquifer or Lineside Dyke.

Samples from the Wakefield Beck N and S record concentrations of cyanide, lead, nickel, PAHs, and TPH aromatic C21-35. However, the impact to this surface water is most likely affected by the parcel of land to the west of the site.

With respect to flooding, which is outside the scope of this assessment, at the site consideration will need to be undertaken during development.

With regards to geotechnical constraints and structural risks, consideration needs to be taken when redeveloping the site.

9.7 Qualitative Risk Assessment

Based on the findings from the site investigation in the three areas, Production Area, Coal Stockyard and Southern Area, a revised Qualitative Risk Assessment has been produced. Table 49 presents the revised source-pathway-receptor linkages.

Potential Source	Area	Potential Pathway	Potential Receptor	Likelihood	Severity	Risk
Combustible Shallow Soils	Coal Stockyard	Direct contact, exposure, plus instability risk in event of fire	Future residential site users.	Likely	Medium	Moderate risk
PAH, Metal and Asbestos Contamination within Made Ground	Production Area and Coal Stockyard	Direct contact, ingestion and inhalation.	Future residential site users	Low Likelihood	Medium	Moderate Risk
Hydrocarbon and Tar / Oil Contamination	Production Area	Direct contact, ingestion and inhalation.	Future residential site users	Low Likelihood	Severe	High Risk
		Groundwater Migration	Controlled Waters	Likely	Severe	High Risk
			Offsite Landusers	Low Likelihood	Mild	Low Risk
Ground Gases	Whole site	Accumulation of Vapours or Gases	Future residential site users	Likely	Mild	Low Risk
			Offsite Landusers	Low Likelihood	Mild	Very Low Risk

Table 49. Revised Qualitative Risk Assessment

10.0 Conclusion

An intrusive investigation was conducted of the site at the Former Monckton Coke Works Site, Lund Hill Lane, Royston adjacent to Monckton Coking Works facility at Lund Hill Lane, Royston, Barnsley, S71 4BD.

This report was designed to assess the potential for a risk to be posed to human health and sensitive environmental receptors (i.e. Controlled Waters) from a number of identified point and diffuse sources associated with historical use of the site as a colliery and coking works and also potential offsite sources.

The site investigation within the Production Area identified impacts in the production area identified impacts in both the soils and the groundwater. Coal tar was present within numerous underground infrastructures, such as pipes and a sump, located across the Production Area with increased impact noted to the west and central parts of the Production Area. Drilling within the area has also confirmed deeper impacts within the sandstone aquifer. In addition, infrastructure noted to be in connectivity with Lineside Dyke is mainly likely to be responsible for the observed contamination in the receptor.

The investigation on the Coal Stockyard area identified minimal contamination, however, cyanide contamination was noted in both soil and water in the north portion of the site. In addition, PAHs were also found within ground within three monitoring wells also in the northern part of the stockyard.

Coal breeze was found at a maximum thickness of 0.4m and was found across the Coal Stockyard at varying thicknesses and localised areas within the Production Area likely to be associated with made ground deposits. It is considered that material is classified as flammable, however, the risk from the flammable material could be reduced by removing the coal breeze.

Three capping pads for three of the mine shafts were identified in the centre of the coal stockyard.

The underground railway tunnel was found towards the west but not in the east. It is considered that the tunnel may have been previously removed and backfilled during the site operations. However, another potential historical railway tunnel was identified in TP77 in the bunded area to the east of the Coal Stockyard.

Evidence of the historic clay pit in the north east of the Coal Stockyard was not identified during any trial pitting works, however, it is considered that the ground level has decreased since the time of the mining works.

Numerous concrete obstructions and services were identified beneath ground level in the Production Area and Coal Stockyard.

Investigation of the Southern Area identified localised impacts of Nickel within the soils at TP75 0.4m and PAHs and cyanides within the groundwater. However, they are considered localised and low risk.

Asbestos was detected in soils from within all three areas.

Ground gas monitoring of the site classified the site as a Characteristic Situation 2.

Geo² recommend a detailed quantitative risk assessment to be undertaken to further assess the impact to controlled waters and that a remediation method statement be produced to remove any remaining risks to human health for a residential setting with plant uptake.

11.0 Limitations

Geo²s' conclusions, recommendations and opinions are based on information gathered at the time of the investigation from a variety of third party sources and from observations made during site reconnaissance and ground conditions encountered during the field work and on the results of laboratory and field tests performed during the investigation. However, there may be conditions at the site that have not been taken into account, such as unpredictable soil strata and water conditions between or below intrusive locations. It should also be noted that groundwater levels may vary due to seasonal or other effects and may at times differ to those measured during the investigation.

A portion of this report is based solely upon information provided by third parties. The information has not been independently verified by Geo². Whilst this report and the opinions given in it are accurate to the best knowledge of Geo², Geo² cannot guarantee the completeness or accuracy of any descriptions, opinions or conclusions based solely upon information that has not been independently verified.

The recommendations contained within this report represent our professional opinions. These opinions were arrived at in accordance with currently accepted industry practices and hydrological and engineering practices at this time. As such they are not a guarantee that the site is free of hazardous materials or conditions.

Geo² prepared this report for our Client; any third parties using this report do so entirely at their risk. Geo² makes no warranty or representation whatsoever, express or implied, with respect to the use by a third party of any information contained in this report or its suitability for any purpose. Geo² assumes no responsibility for any costs, claims, damages or expenses (including any consequential damages) resulting from the use of this report or any information contained in this report by a third party.

12.0 References

BGS

BGS Geology of Britain Viewer

British Standards Institute

BS10175:2011 "Investigation of potentially contaminated land sites – code of practice"

Ciria

C552 Contaminated Land Risk Assessment: A guide to good practice.

C665 Assessing risks posed by hazardous ground gases to buildings

CL:AIRE / EIC

Environment Industries Commission (EIC); The Association of Geotechnical and Geo-Environmental Services (AGS); and Contaminated Land Applications in Real Environments (CL:AIRE). The EIC/AGS/CL:AIRE Soil Generic Assessment Criteria for Human Health Risk Assessment. December 2009.

Department of the Environment

Industry Profile- Road vehicle fuelling, service and repair- Garages and Filling Station.1996

DEFRA SP1010 Category 4 Screening Levels (C4SL) for assessment of land affected by contamination 2014

Environment Agency

CLR 11- Model procedures for the management of contaminated land.

Science Report Final SC050021/SR2. Human Health Toxicological Assessment of Contaminants in Soil. Environment Agency. January 2009.

Science Report SC050021/SR3. Updated Technical Background to the CLEA Model. Environment Agency. January 2009.

Science Report SC050021/SR7. Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values. Environment Agency, November 2008.

SC050021/Final Technical review 1. A Review of Body Weight and Height Data used within the Contaminated Land Exposure Assessment Model (CLEA). Environment Agency. January 2009.

Science report: SC050021. Using Soil Guideline Values. / SGV Introduction. Environment Agency, March 2009.

Chemical Standards Database (accessed online) - Workplace exposure limits (WELs) are set under the Control of Substances Hazardous to Health (Amendment) Regulations 2004 (SI 2004/3386).

Geo²



Preliminary Site Investigation (Former Gas Purification Plant) Ref: 20/B0010.3.1, Geo², July 2020.
Gap Analysis and Data Review. 19.B0010.1.2, Geo² October 2019

LQM/ CIEH

LQM/CIEH Suitable 4 Use Levels Nathaniel, C.P; McCaffrey, C.; Gillett, A.G.; Ogden, R.C. & Nathaniel, J.F. Land Quality Press, Nottingham 2015

NHBC

Guidance for Safe Development of Housing on Land Affected by Contamination.
R+D Publication 66:2008

Appendix A

Figures

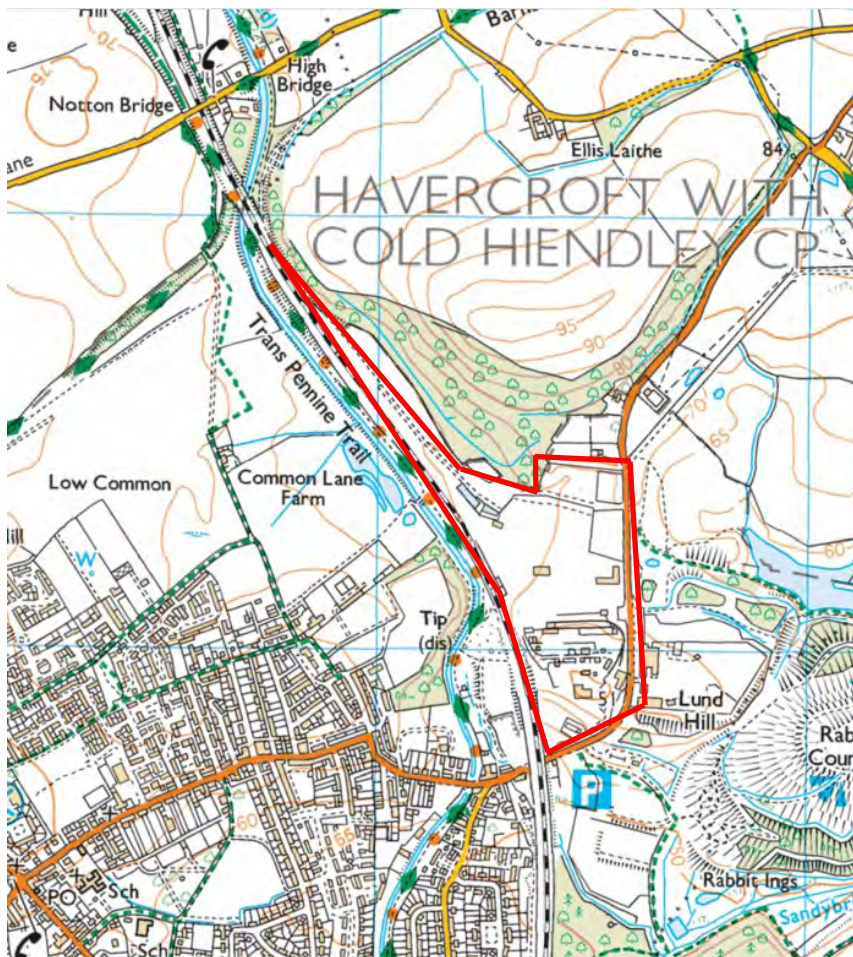


Figure 1 - Site Location

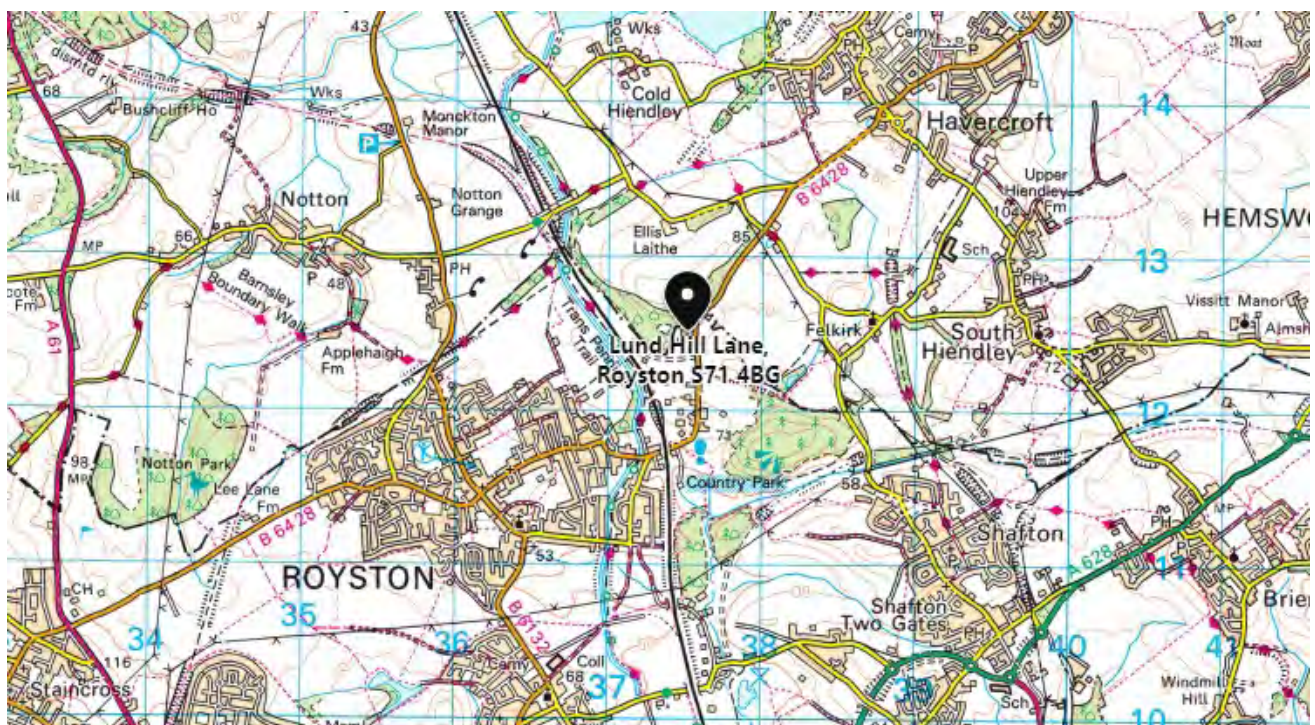


Figure 2 - Site Location

Ref: Ordnance Survey



Figures 1 & 2 Site Location -
Former Moncton Coke and Colliery Works, Lund Hill Lane, Royston,
Barnsley, South Yorkshire, S71 4BD.

Geo2 Remediation Limited, The Coniston, Louisa Street, Idle, West Yorkshire, BD10 8NE

Tel: (0113) 2575397

www.geo2.co.uk

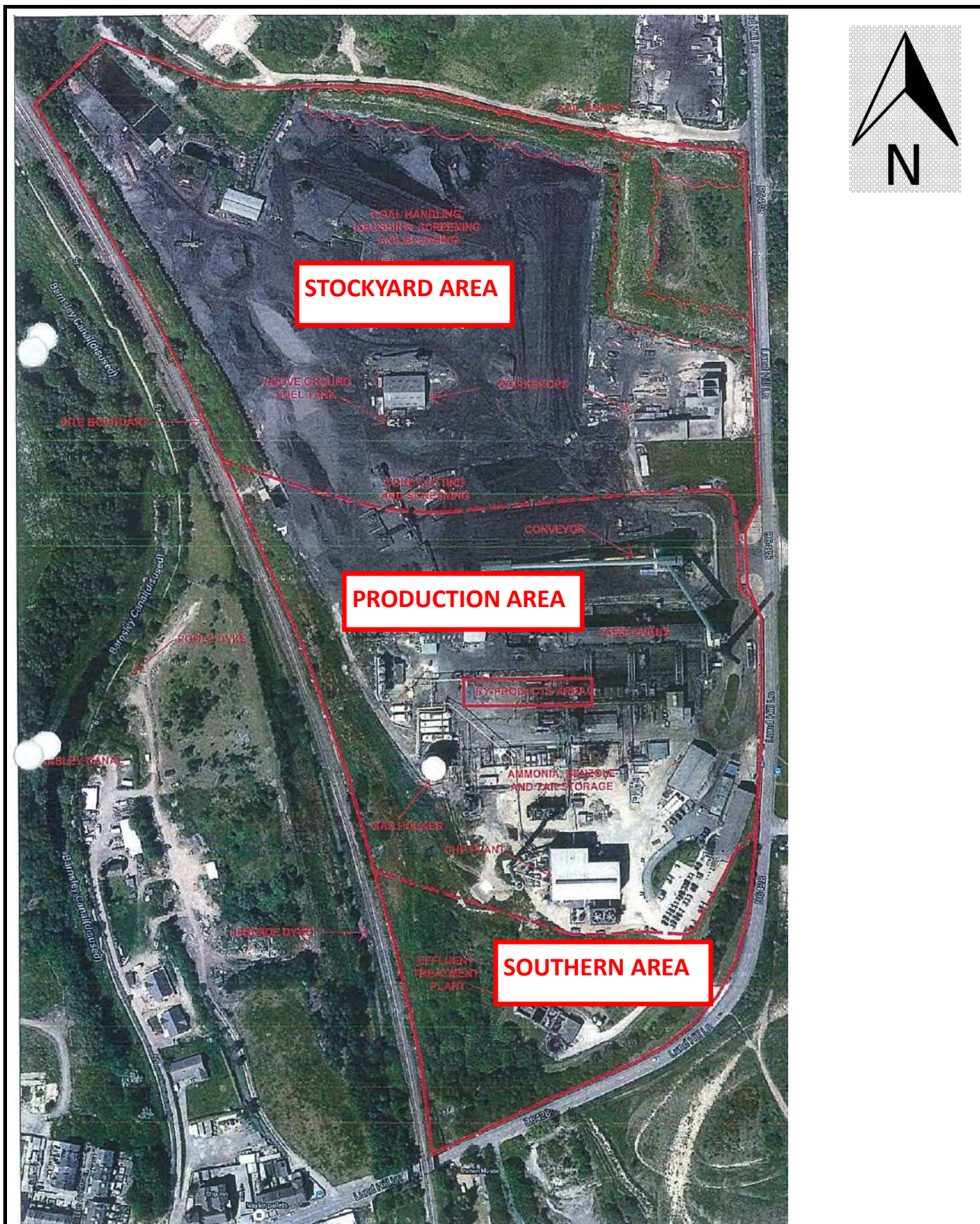


Figure 3— Aerial Photo and Site Layout

Drawn from Patrick Parsons 2015

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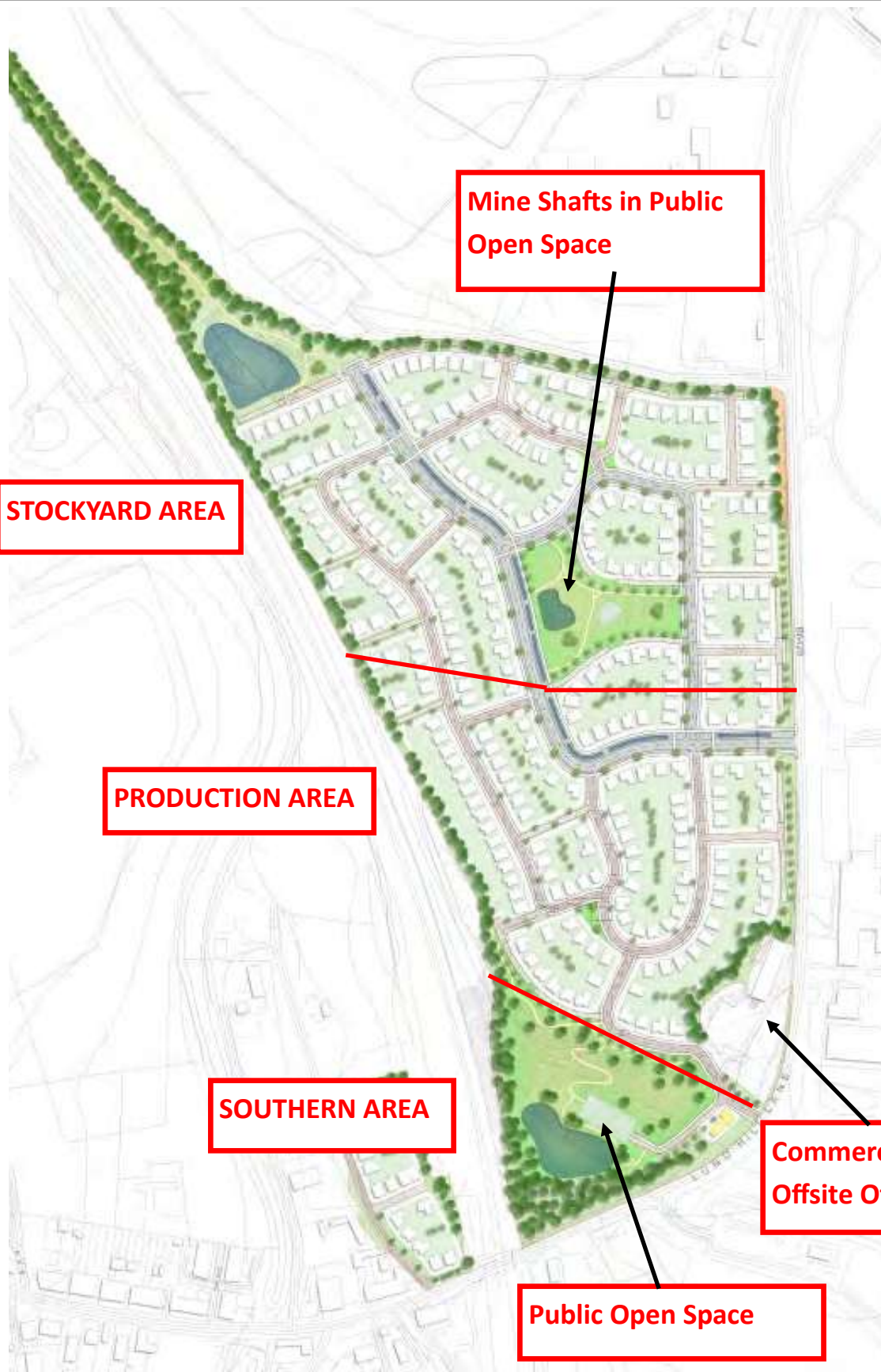
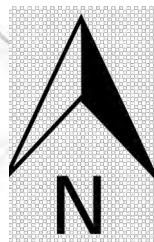


Figure 4 — Proposed Site Development Plan

Provided by Pegasus Group

Geo² Remediation Limited, The Coniston, Louisa Street, Idle, West Yorkshire, BD10 8NE

Tel: (0113) 2575397

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LEGEND

-  Exploration Hole
-  Trial Pit

Figure 6a

Sheet Layout:



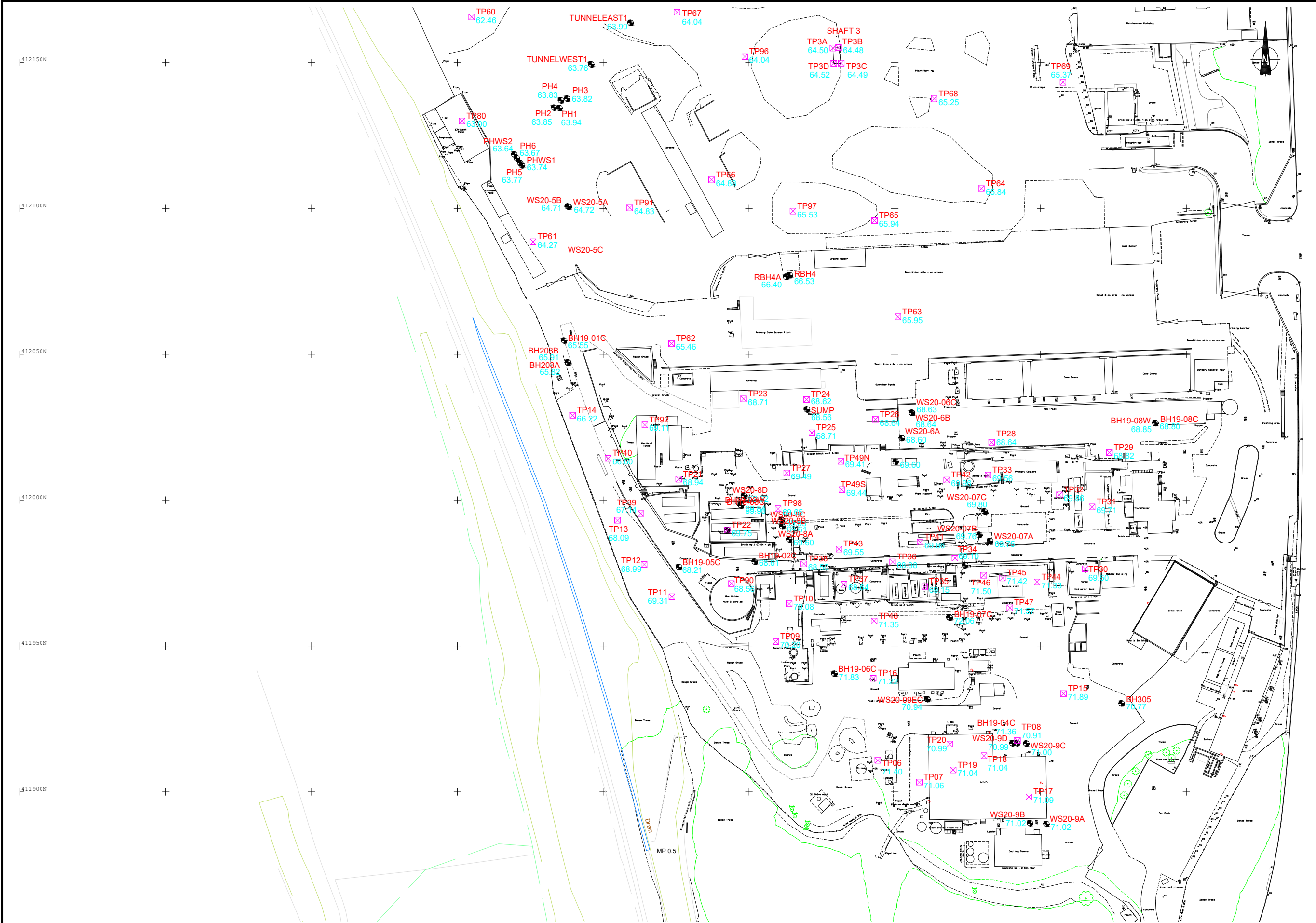
Geo2 Remediation Limited
11 The Mending Rooms, Sunny Bank Mills, Town St,
Farsley, Leeds, LS28 5UJ.

Client -

Site Location

Monkton Coke Site

Surveyed by -	Drawn by A.B.	Approved by -
Drawing No. 0720-GEO2-7955	Revision -	
Scale 1:1250@ A3	Date 15-07-20	Sheet No. 1 of 3



LEGEND

- Exploration Hole
- Trial Pit

Figure 6b

Sheet Layout:



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Site Location:
Monckton Coke Site

Surveyed by	Drawn by A.B.	Approved by
Drawing No. 0720-GEO2-7955		Revision
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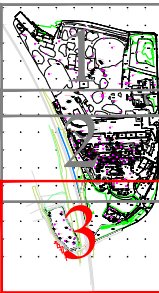


LEGEND

-  Exploration Hole
-  Trial Pit

Figure 6c

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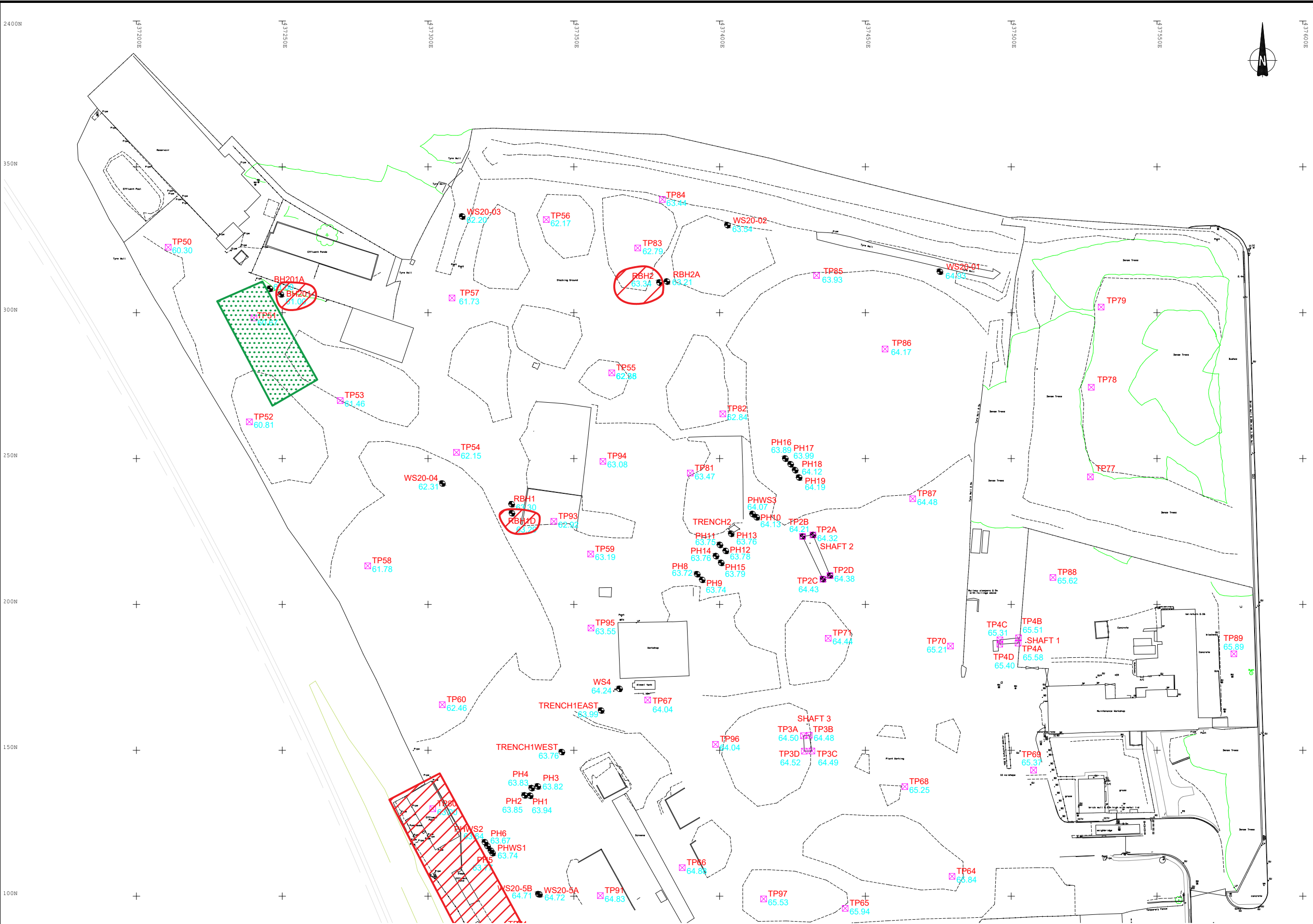


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LEGEND

- Exploration Hole
- Trial Pit
- Cyanide within the ground or/and groundwater
- Evidence of Hydrocarbon/coal tar Contamination within the ground or/and groundwater
- Evidence of Hydrocarbon/coal tar Contamination within the infrastructure
- VOC impact in benzole area

Figure 7a

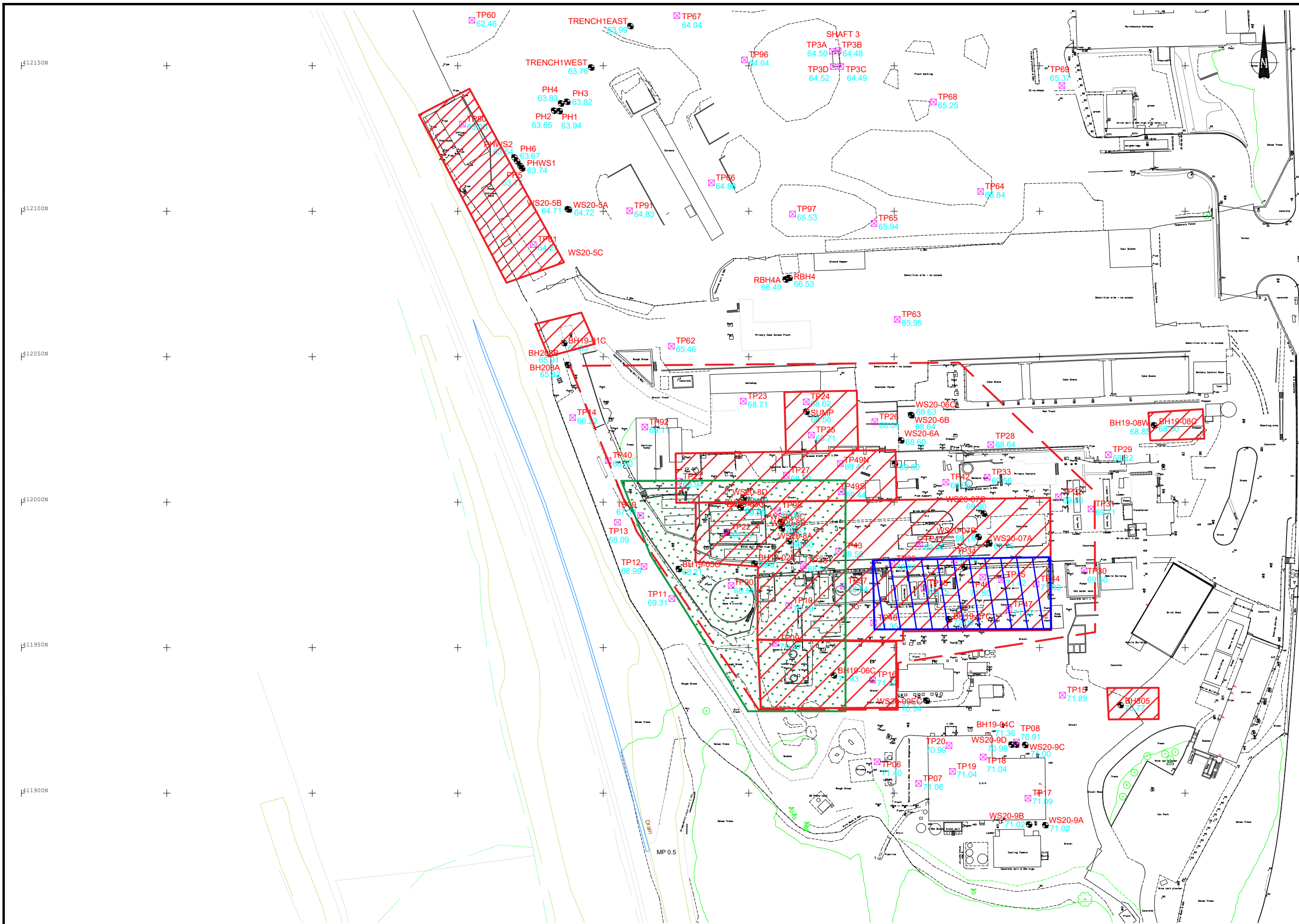
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11 The Mending Rooms, Sunny Bank Mills, Town St, Farsley, Leeds, LS28 5UJ.

Client: -

Site Location:
Monckton Coke Site

Surveyed by: -	Drawn by: A.B.	Approved by: -
Drawing No. 0720-GEO2-7955	Revision: -	
Scale 1:1250@ A3	Date 15-07-20	Sheet No. 1 of 3



LEGEND

- Exploration Hole
- Trial Pit
- Cyanide within the ground or/and groundwater
- Evidence of Hydrocarbon/coal tar Contamination within the ground or/and groundwater
- Evidence of Hydrocarbon/coal tar Contamination within the infrastructure
- VOC impact in benzene area

Figure 7b

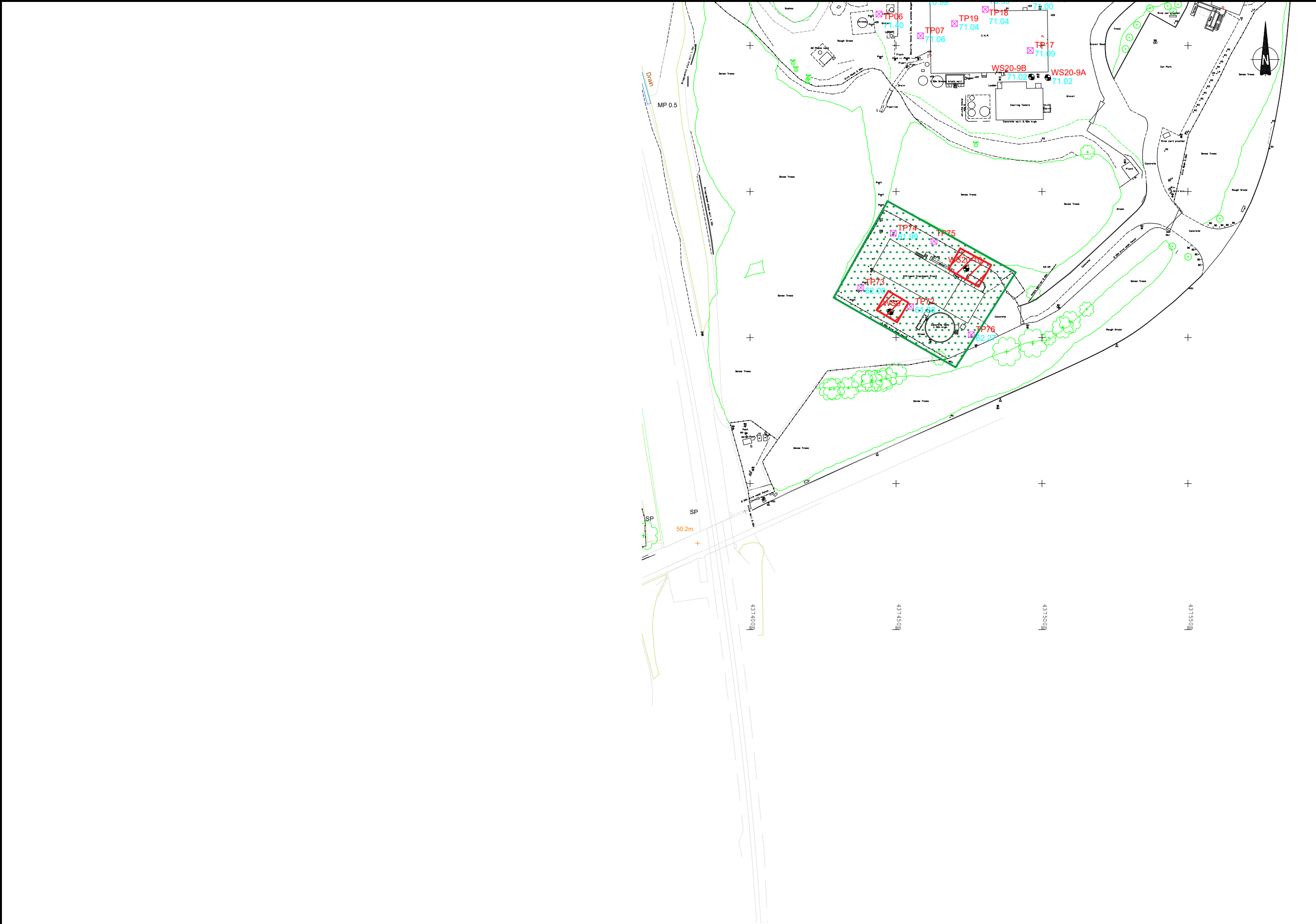
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Farsley, Leeds, LS28 5UJ.

Client: -

Site Location: **Monckton Coke Site**

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Drawing No. 0720-GEO2-7955	Revision: -	
Scale 1:1250@ A3	Date 15-07-20	Sheet No. 2 of 3



LEGEND

 Exploration Hole

 Trial Pit

 Cyanide within the ground or/and groundwater

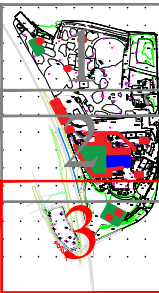
 Evidence of Hydrocarbon/coal tar Contamination within the ground or/and groundwater

 Evidence of Hydrocarbon/coal tar Contamination within the infrastructure

 VOC impact in benzole area

Figure 7c

Sheet Layout:





Geo2 Remediation Limited
11 The Mending Rooms, Sunny Bank Mills, Town St,
Farsley, Leeds, LS28 5UJ.

Client

-

Site Location

Monckton Coke Site

-

-

Surveyed by

Drawn by

Approved by

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A.B.

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Drawing No.

0720-GEO2-7955

Revision

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Scale

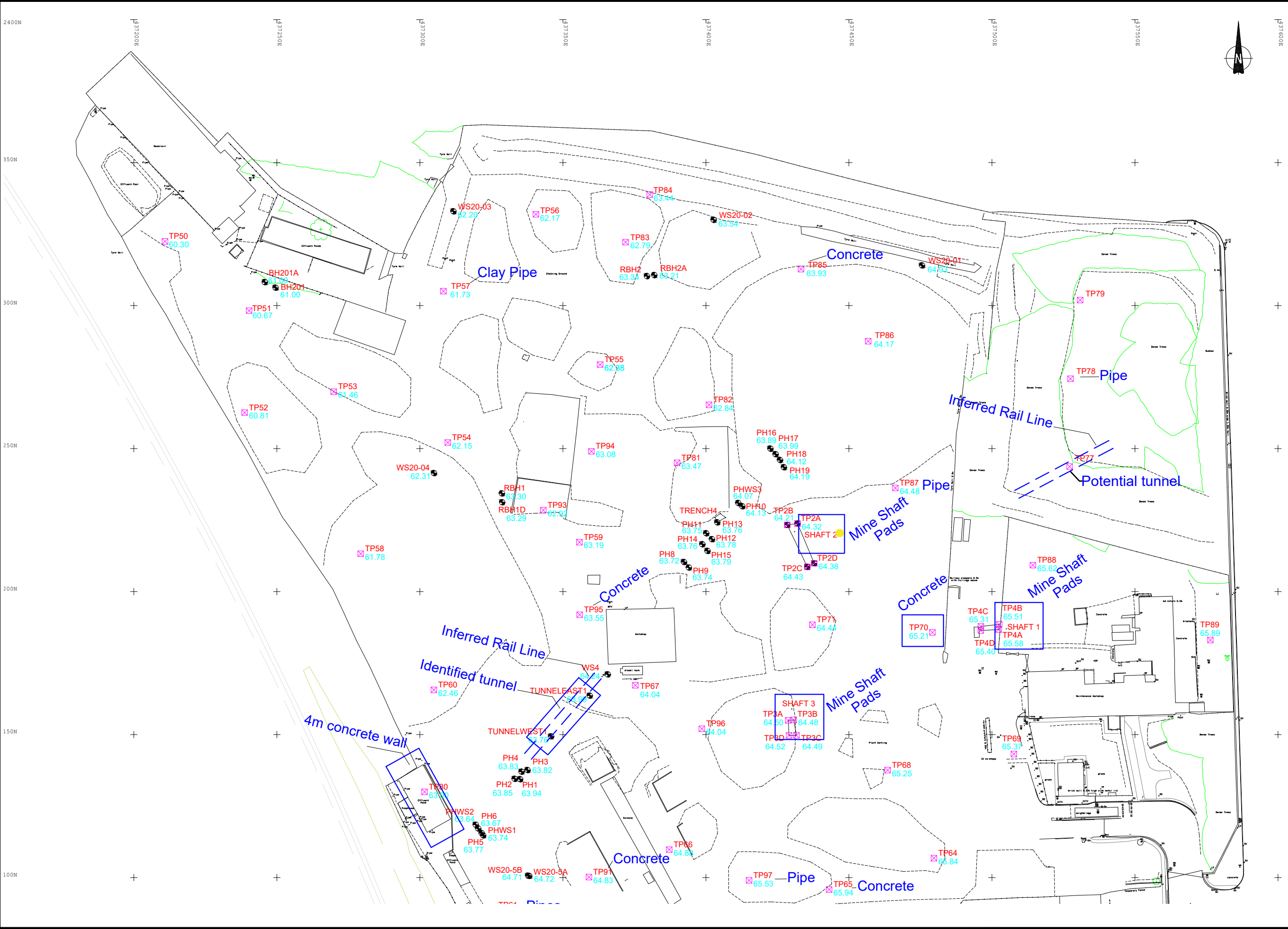
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Date

15-07-20

Sheet No.

3 of 3

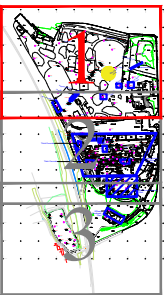


LEGEND

- Exploration Hole
- Trial Pit
- Obstruction

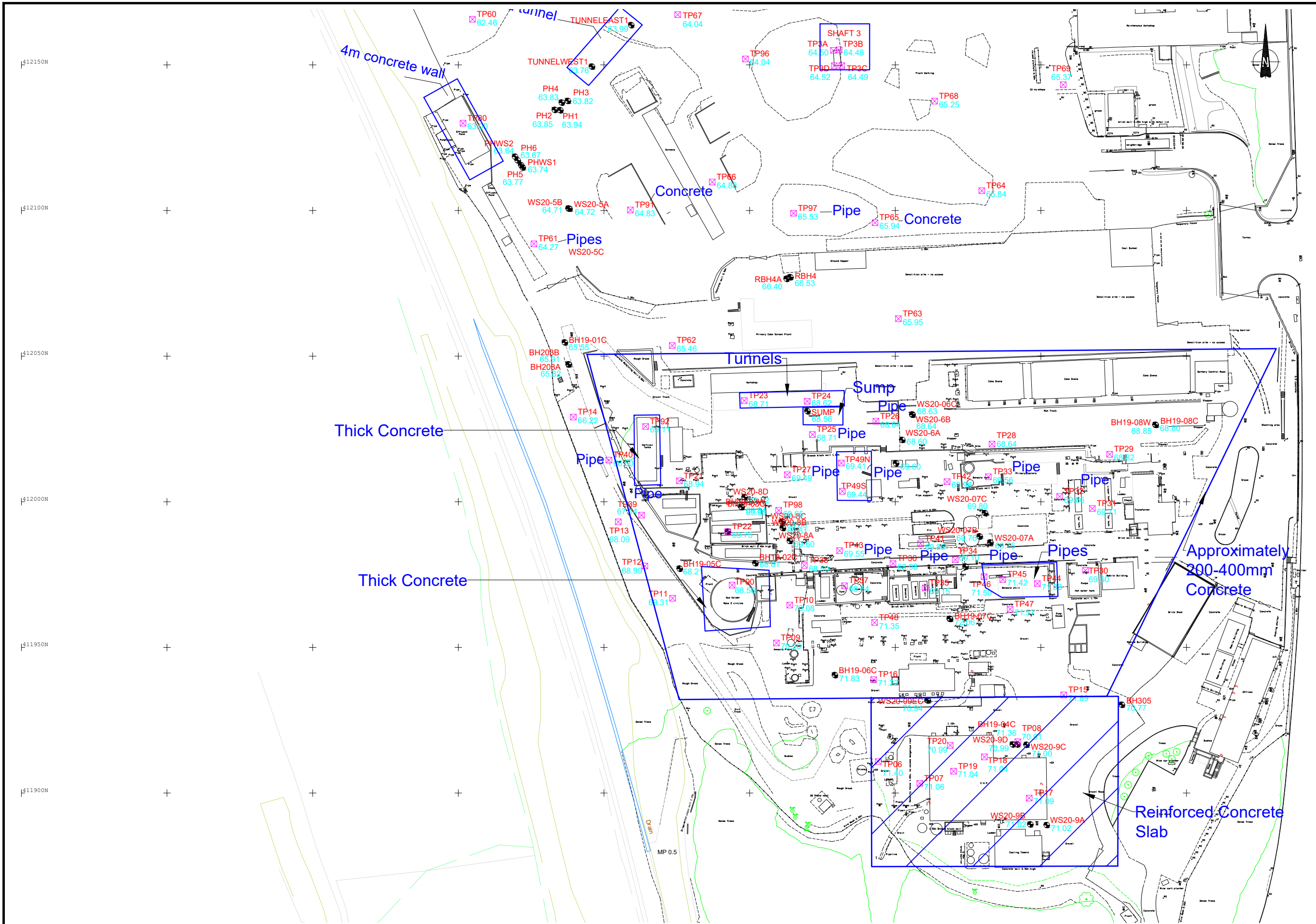
Figure 8a
Obstructions

Sheet Layout:



Geo2 Remediation Limited
11 The Mending Rooms, Sunny Bank Mills, Town St,
Farsley, Leeds, LS28 5UJ.

Client		
-		
Site Location		
Monckton Coke Site		
-		
Surveyed by	Drawn by	Approved by
-	A.B.	-
Drawing No.	0720-GEO2-7955	Revision
-	-	-
Scale	1:1250@ A3	Date
-	-	15-07-20
Sheet No.	1	of 3



LEGEND

- Exploration Hole
- Trial Pit
- Obstruction

Figure 8b
Obstructions

Sheet Layout:

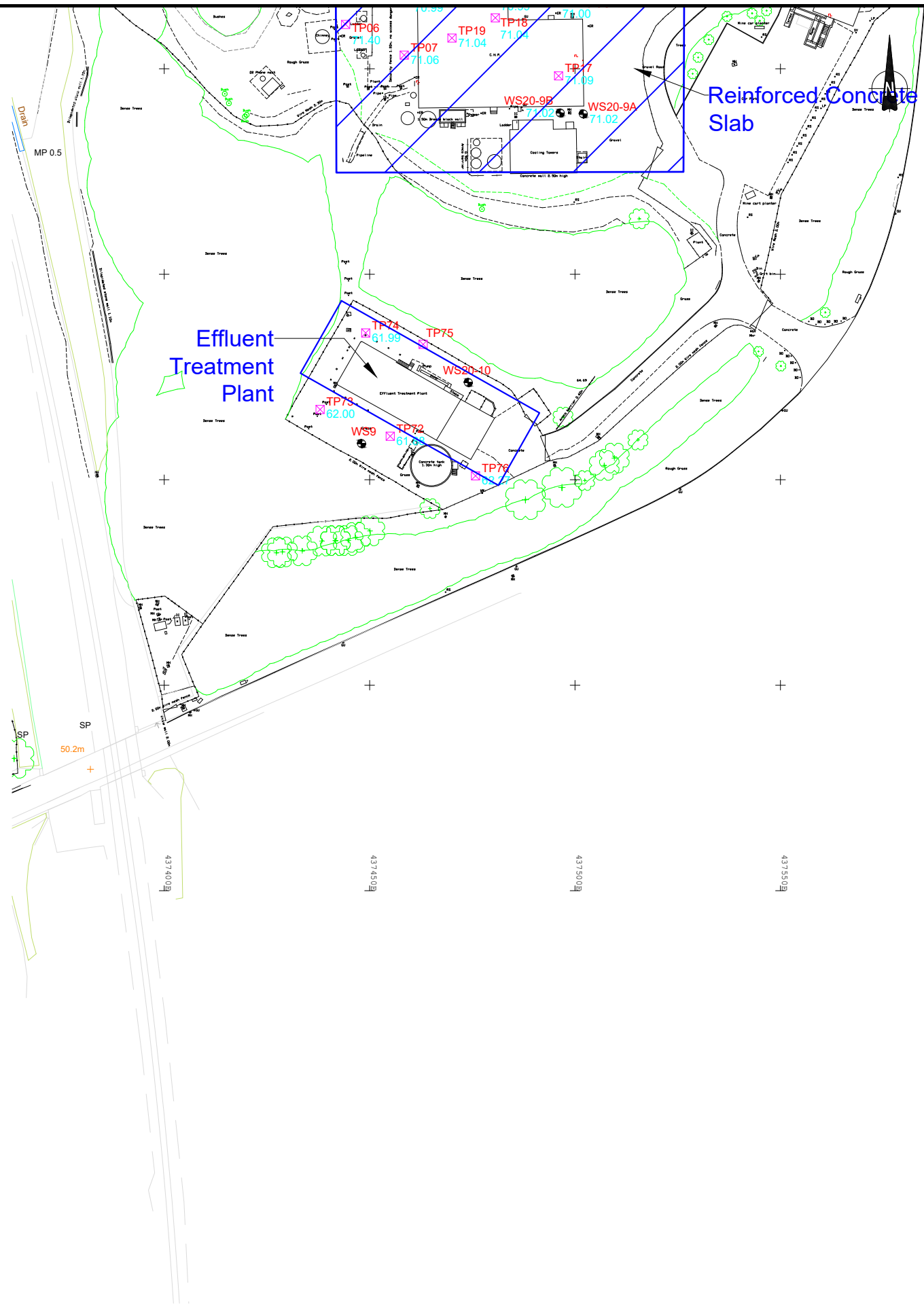
Geo2

Geo2 Remediation Limited
11 The Mending Rooms, Sunny Bank Mills, Town St,
Farsley, Leeds, LS28 5UJ.

Client: -

Site Location: **Monckton Coke Site**

Surveyed by: -	Drawn by: A.B.	Approved by: -
Drawing No. 0720-GEO2-7955	Revision: -	
Scale 1:1250@ A3	Date 15-07-20	Sheet No. 2 of 3



LEGEND

- Exploration Hole
- Trial Pit
- Obstruction

Figure 8c
Obstructions

Sheet Layout:

Geo2

Geo2 Remediation Limited
11 The Mending Rooms, Sunny Bank Mills, Town St,
Farsley, Leeds, LS28 5UJ.

Client -

Site Location
Monckton Coke Site

Surveyed by -	Drawn by A.B.	Approved by -
Drawing No. 0720-GEO2-7955	Revision -	
Scale 1:1250@ A3	Date 15-07-20	Sheet No. 3 of 3



LEGEND

- Exploration Hole
- Trial Pit
- Approximate Location of Coal Breeze > 0.1m

Figure 9a

Sheet Layout:

Geo2

Geo2 Remediation Limited
11 The Mending Rooms, Sunny Bank Mills, Town St,
Farsley, Leeds, LS28 5UJ.

Client: -

Site Location:
Monckton Coke Site

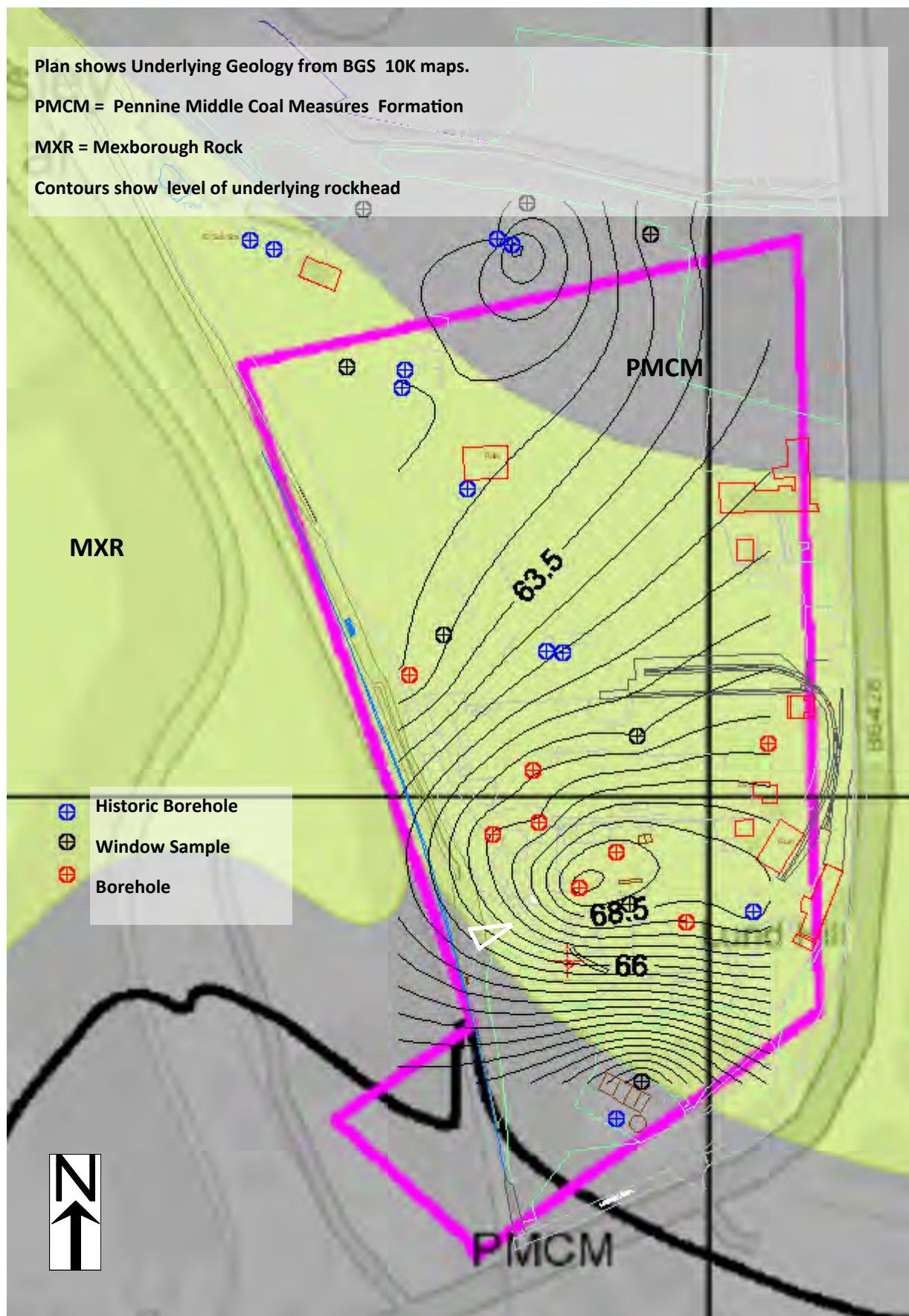
Surveyed by: -	Drawn by: A.B.	Approved by: -
Drawing No. 0720-GEO2-7955	Revision: -	
Scale 1:1250@ A3	Date 15-07-20	Sheet No. 1 of 3

Plan shows Underlying Geology from BGS 10K maps.

PMCM = Pennine Middle Coal Measures Formation

MXR = Mexborough Rock

Contours show level of underlying rockhead



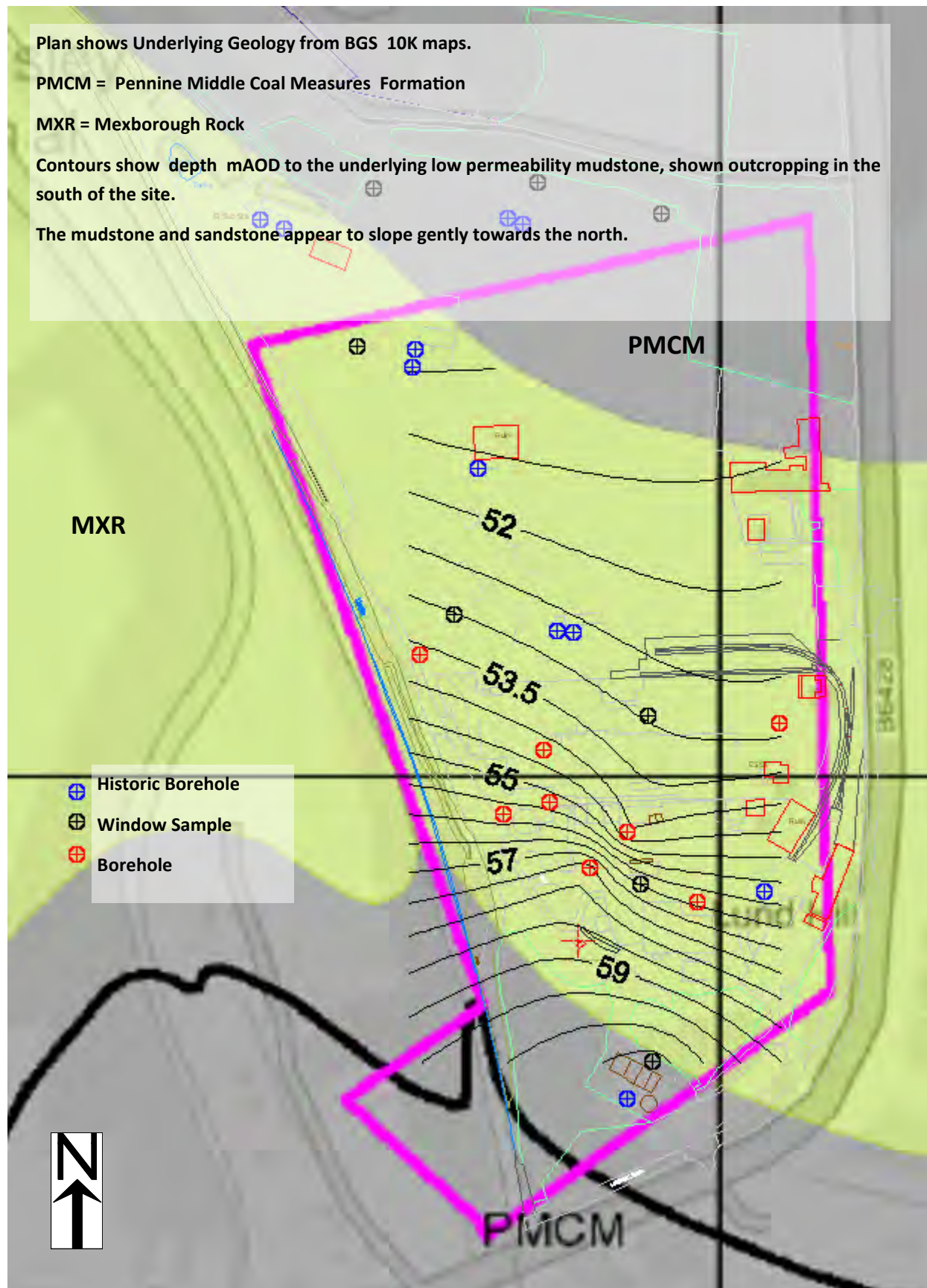
Plan shows Underlying Geology from BGS 10K maps.

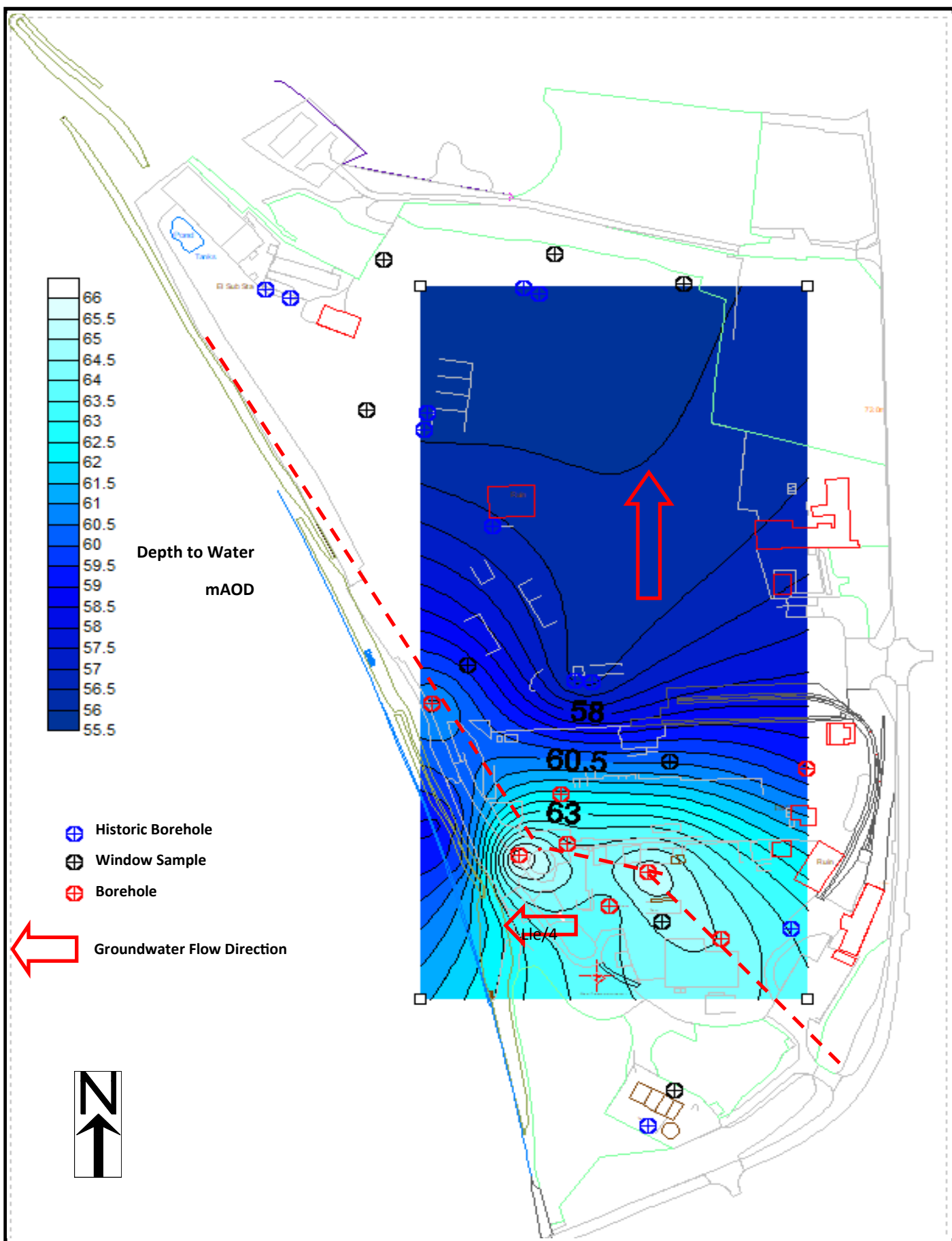
PMCM = Pennine Middle Coal Measures Formation

MXR = Mexborough Rock

Contours show depth mAOOD to the underlying low permeability mudstone, shown outcropping in the south of the site.

The mudstone and sandstone appear to slope gently towards the north.





Figures 1 & 2 Groundwater contour and direction of flow

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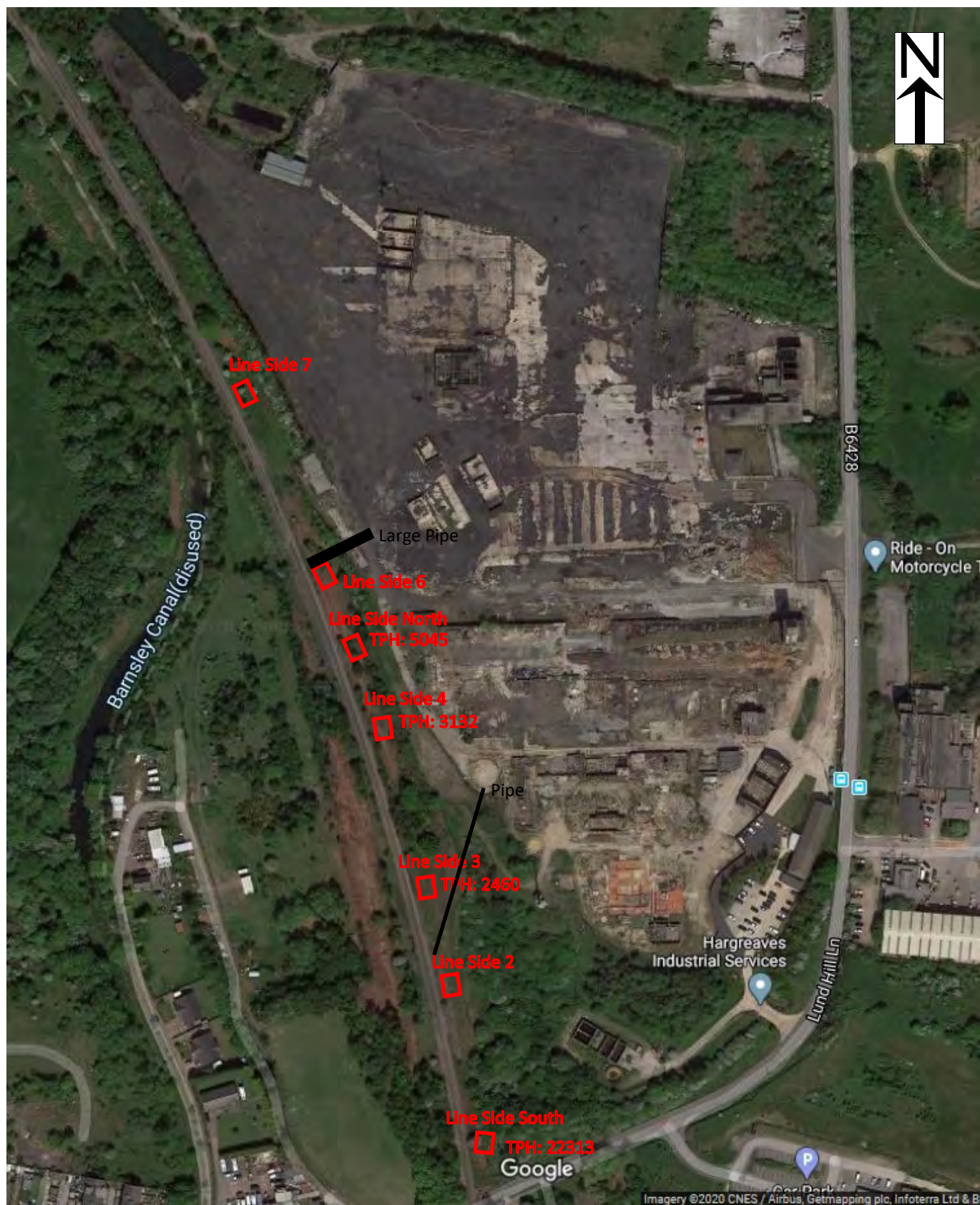


**Figure 12: Lineside Dyke Transect
Annotated with average TPH concentrations**

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Appendix B

Photographs

Photographic Survey

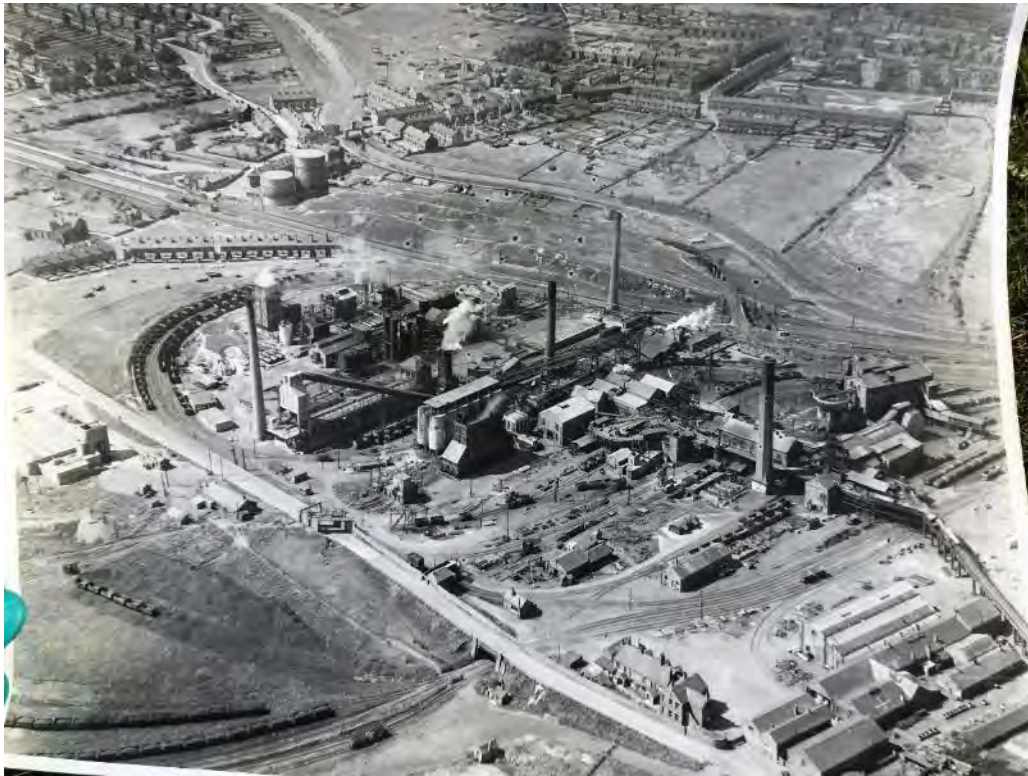


Photo 1: Historic Aerial Photograph of Monckton Coking Works when operational



Photo 2: Remaining tower associated with the coking ovens.



Photo 3: Small stack in the production area with coal tar staining.



Photo 4: Former Combined Heat and Power (CHP) area