

Eccleston Homes

REMEDIATION STRATEGY

for

Mondi Site, Ramsbottom

June 2023

REPORT No: 19ECH016/RS

- *Desk Studies and Site Walkovers*
- *Intrusive Contaminated Land Investigations*
- *Geotechnical Appraisals and Ground Investigations*
- *Landfill Gas Assessments and Remedial Design*
- *Remediation Design and Implementation*
- *Remediation Project Management and Supervision*
- *Site Abnormal Assessments (Foundations and contaminated land)*
- *Ecological Surveys (Bats, Badgers, Newts, Japanese Knotweed etc)*

GEOTECHNICAL - CONTAMINATED LAND - FLOOD RISK

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APPENDICES

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1. INTRODUCTION

The Commission and Brief

Betts Geo Environmental (Betts) has been commissioned by Eccleston Homes to prepare a Remediation Strategy for the remediation and preparatory works for former Mondi Mill site, Ramsbottom. The plan below shows the site boundary;



Site Boundary – March 2012

This Remediation Strategy has been prepared for the purpose of demonstrating to the Local Planning Authority the remediation methodology going throughout the duration of the development.

Regulatory approval is advised prior to site commencement.

Betts reserves the right to amend this remedial strategy in the light of further information, such as site observations and unforeseen conditions.

1.2 Proposed Development

The proposed development at time of issue comprises the construction of residential dwellings with associated gardens, public open space and other infrastructure.



1.3 Previous Reporting

Betts Geo have undertaken two phases of work, as detailed below;

- Desk Study and Ground Investigation Report for Mondri Site, Ramsbottom, Report ref. 19ECH016/DSGI/REV 3 dated Jun 23 on behalf of Eccleston Homes.

Where necessary the above report has been used throughout this report and referenced accordingly. The following 'Site History Summary', 'Geology' and 'Environmental Data' has been summarised from the report.

2 BACKGROUND

2.1 Site Description

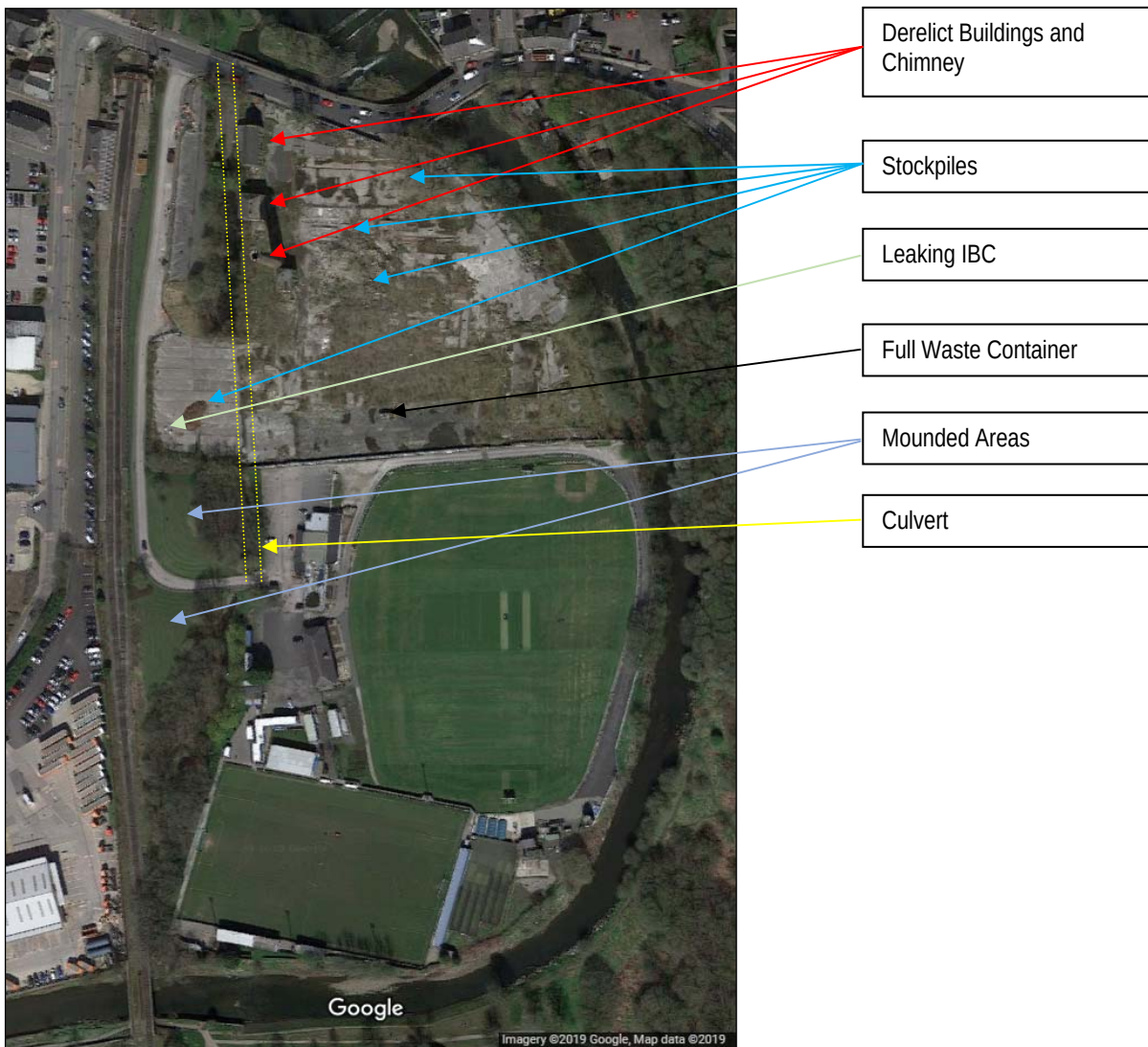
The site is located to the south of Bridge Street and north of Ramsbottom Cricket Club in Ramsbottom. The site has an approximate postcode of BL0 9AL, with coordinates on the British National Grid of 379433,416756. The proposed site is approximately 4.61 hectares in total.

The site is currently an unused parcel of land with several derelict structures in the west. The structures comprise two very dilapidated buildings and a large chimney.

The site is predominantly flat and almost entirely covered in hardstanding formed by concrete slabs, with several large and small stockpiles located throughout the site area. Large areas of the centre of the site area heavily vegetated. A full waste container was also noted in the south adjacent to the Cricket Club. A culverted stream / race was noted in the western site area.

A leaking IBC was noted adjacent to the entrance off the lane leading to the sports clubs. The leaking substance was found to be brown and 'rubbery' in nature but was no longer migrating.

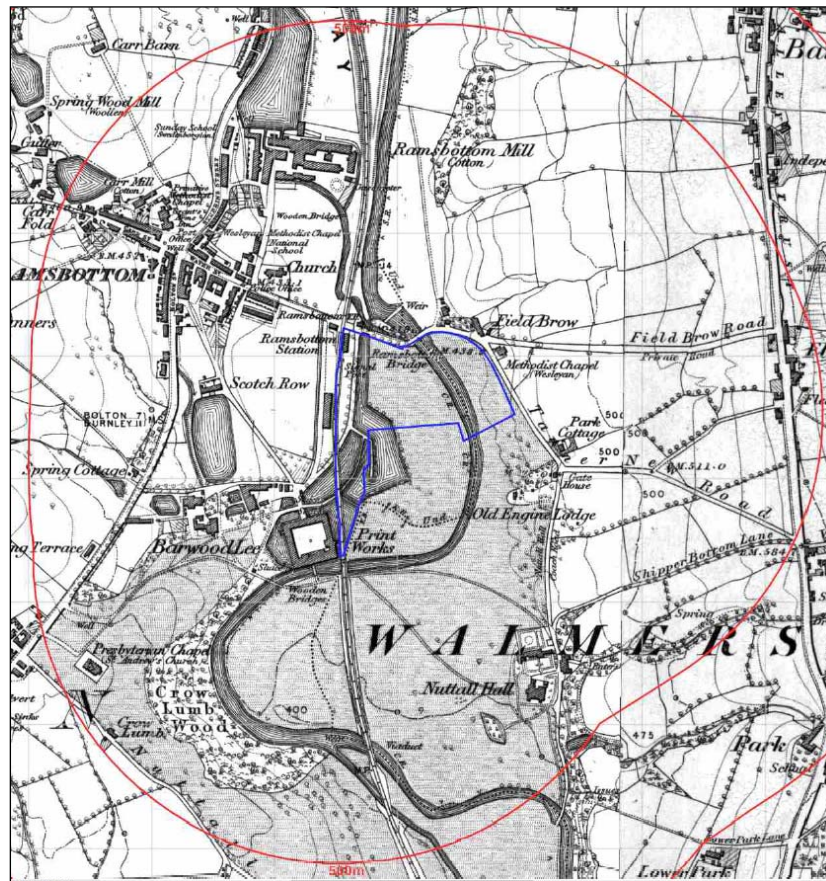
There are two 'mounded' areas of soft standing in southern spur with trees on their eastern boundary.



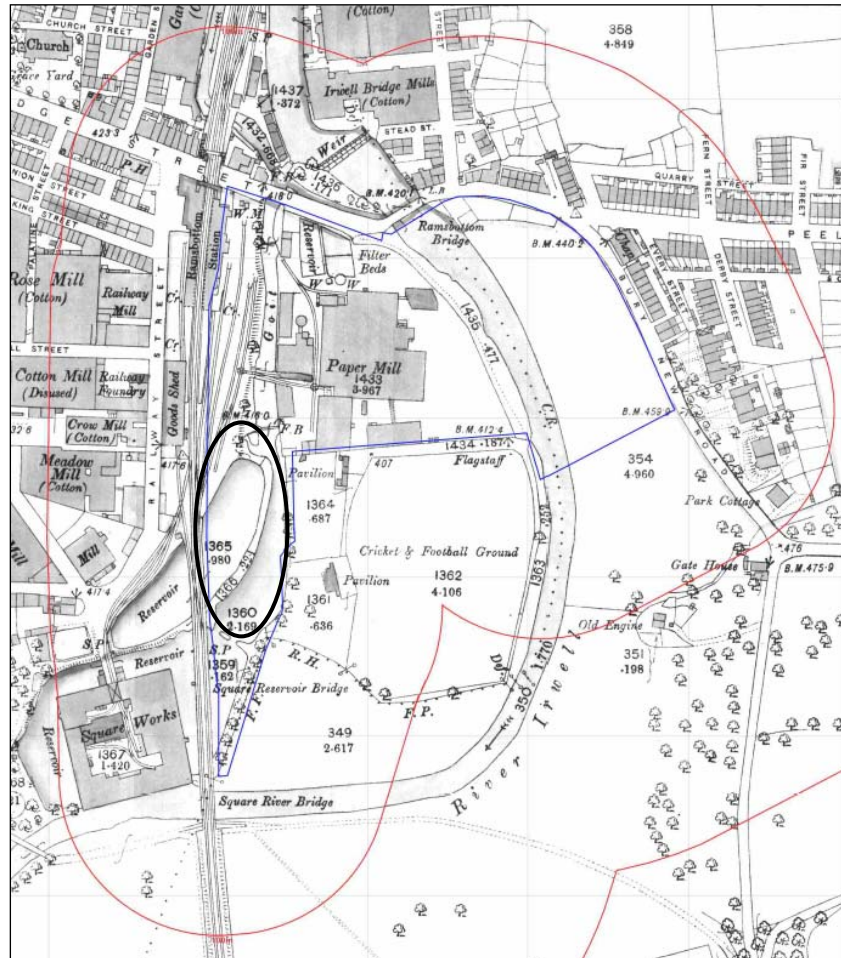
2.2 Site History

The earliest map, from 1850-1851, shows the site to be split between undeveloped land and the River Irwell in the east and reservoirs in the west. A small strip of land adjacent to the railway line is shown as a treelined road. An extract of the map is shown below;

1850-1851 1:10,560 map

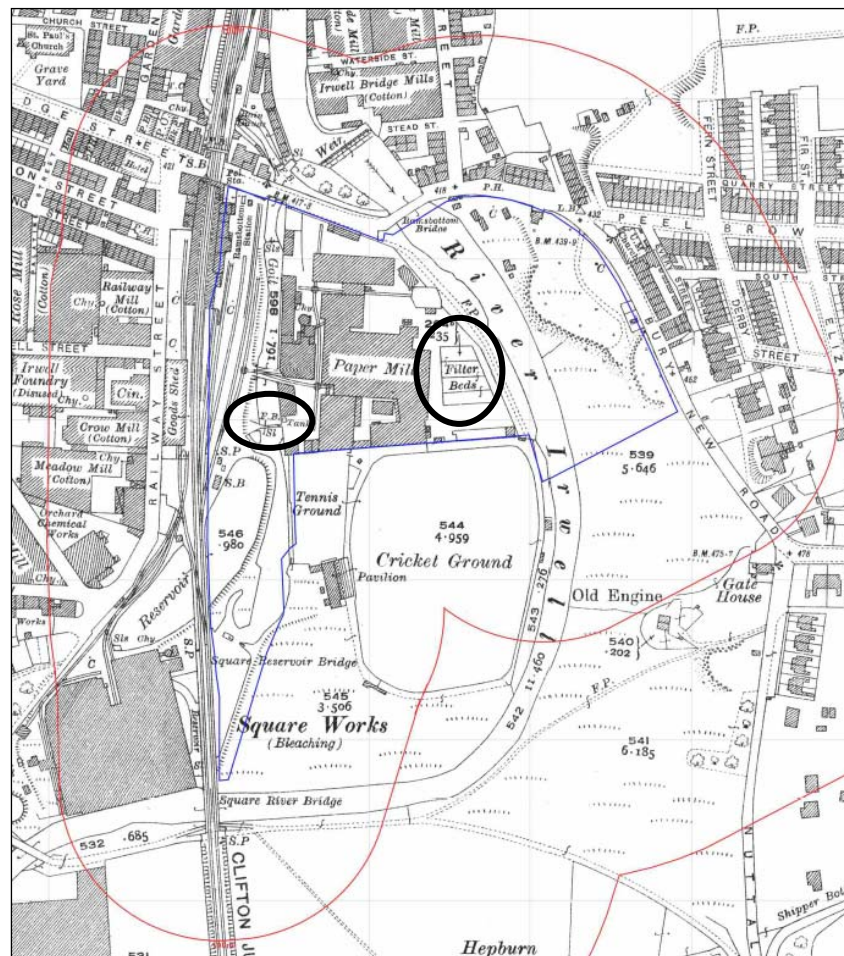


1891 1:2,500 map



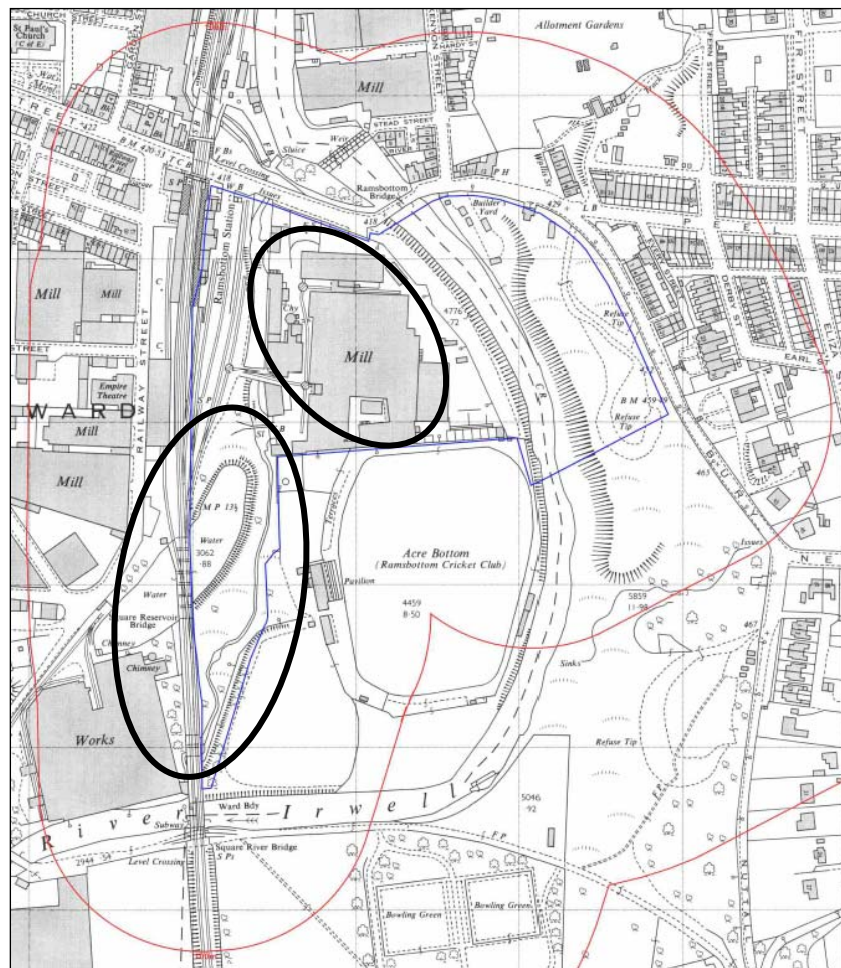
Mapping from 1929 shows a tank in the western area of the site and filter beds in the east of the site. There were also some minor configuration changes to the paper mill. An extract of the map is given below;

1929 1:2,500 map



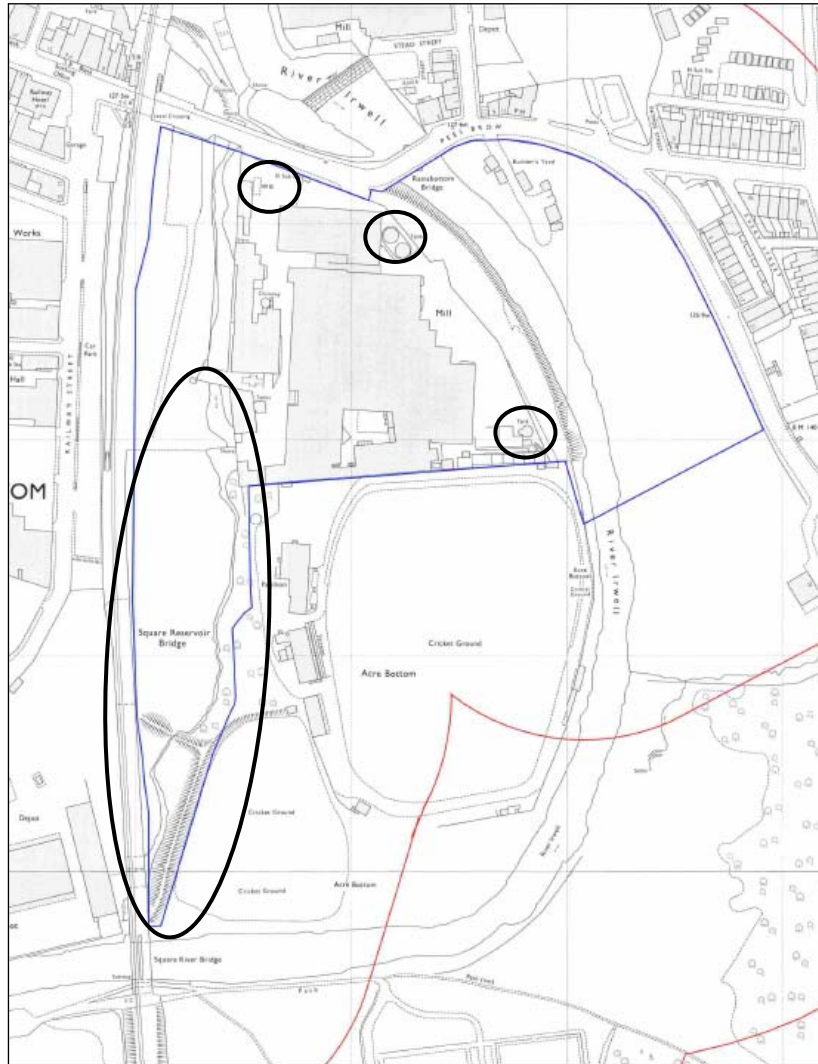
By 1962 the mill has been significantly extended, and a reservoir in the southern spur has been backfilled and a small stream has been created.

1962 1:2,500 map



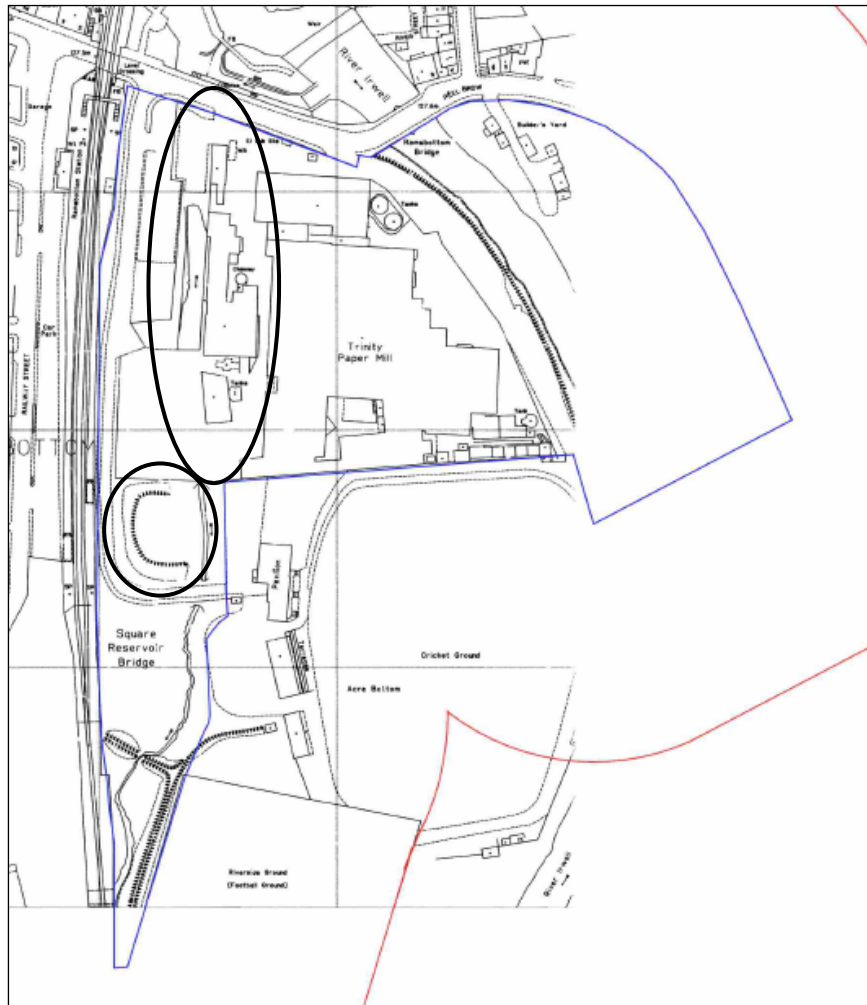
By 1978 the reservoirs in the west of the site have been backfilled. There are two new tank areas shown, the northern area shows two large tank, with one smaller tank in the southeast, and an electricity substation has been constructed on the northern boundary. An extract of the map is given below;

1978 1:1,250 map



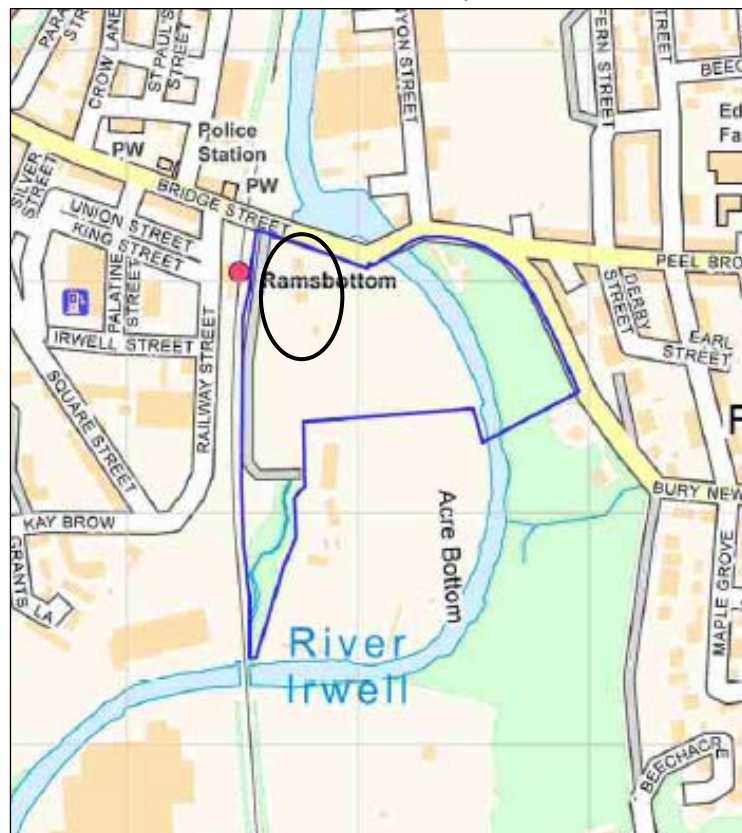
Mapping from 1994 shows a large area of hardstanding in the west has been constructed. The mill has also been extended slightly to the west. The first of the mounds in the southern spur has also been constructed.

1994 1:1,250 map



Historical mapping is inconsistent and often blank between 1994 and 2002. Between 2010 and 2014 the majority of the structures on site are demolished. However, some remain in the northwest of the site, it is assumed these are the structures remaining onsite currently. An extract of the map is shown below;

2014 1:10,000 map



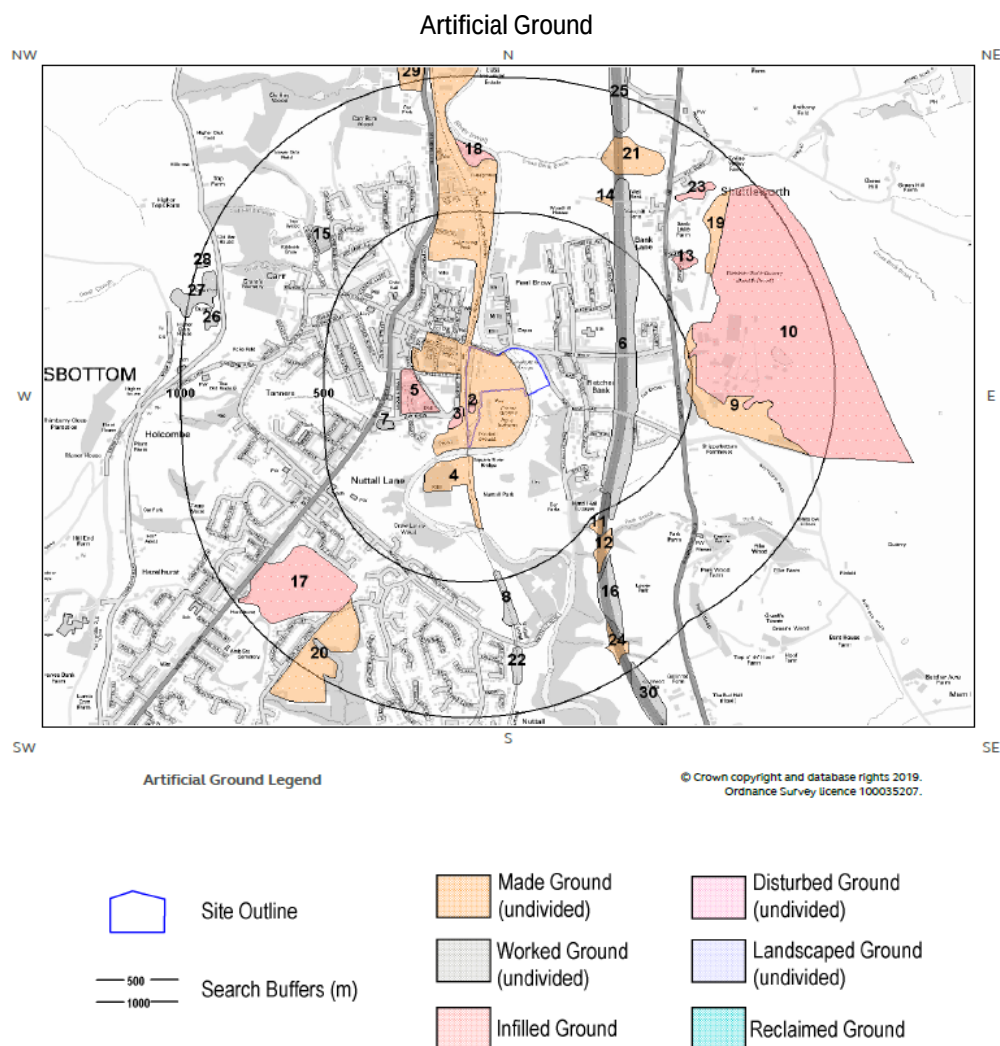
2.3 Hydrogeology and Hydrology

- The superficial deposits of the Alluvium are designated as Secondary A Aquifer (Moderate Permeability).
- The bedrock deposits of the Sandstone are designated as Secondary A aquifer (Moderate Permeability).
- The site does not lie within Groundwater Source Protection as defined by the Environment Agency.
- There are no potable water abstractions within 500m of site.
- Two groundwater abstractions located onsite on the western boundary.
- There are two (7 no.) recorded surface water features on site and seven (9 no.) within 250m.
- The site is record by the BGS as being at high risk of groundwater flooding.
- Flooding – Zones 2 and 3 noted as onsite. Risk is noted as Very Low to High (RoFRaS).

2.4 Geology

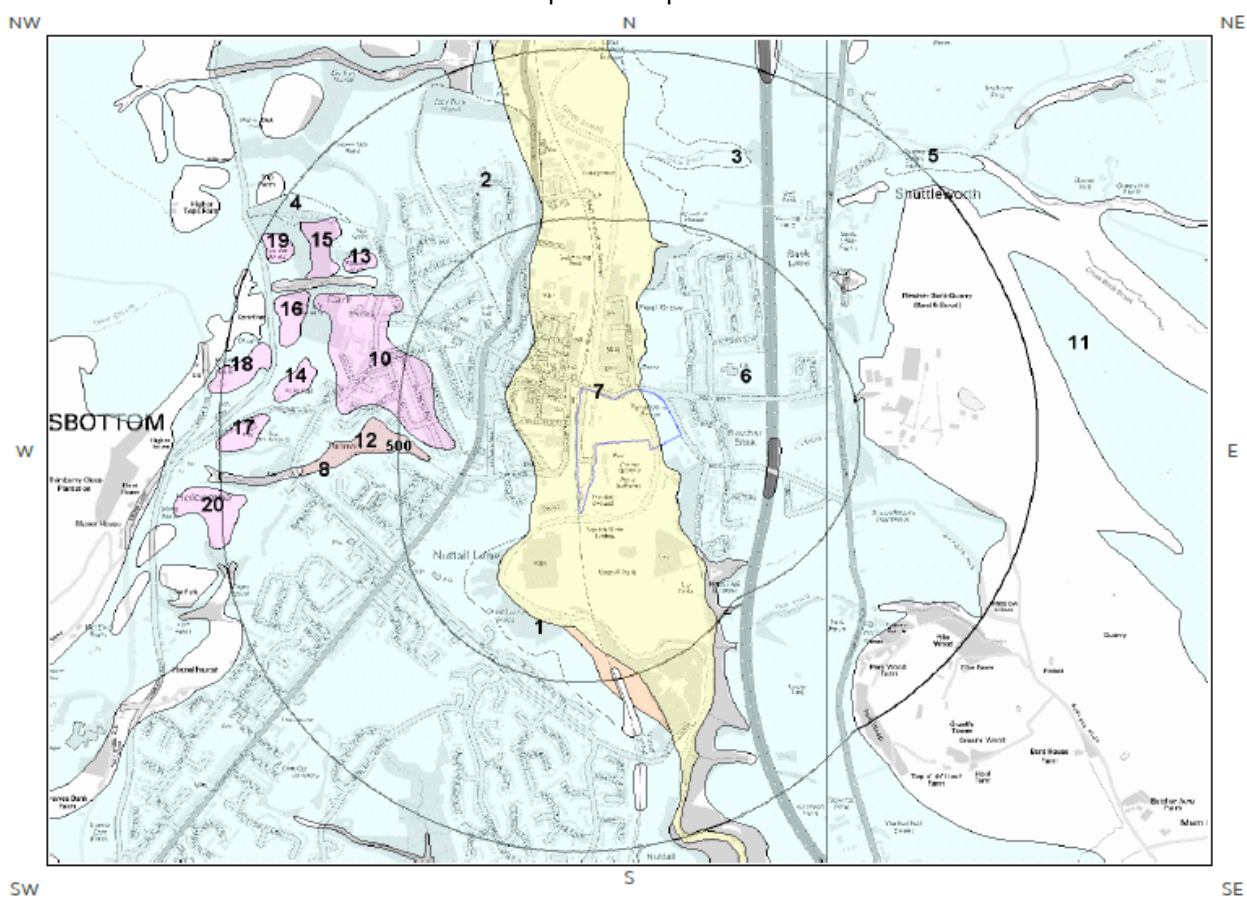
The documented geology of the site is summarised on the British Geological Survey map principally, with further site-specific details detailed below.

Geology	Artificial Ground and Land Slip	Drift	Solid
1:10,000	Made Ground & Infilled Land	Alluvium – Clay, Sand & Silt	Millstone Grit Group - Mudstone & Siltstone Hazel Greave Grit - Sandstone



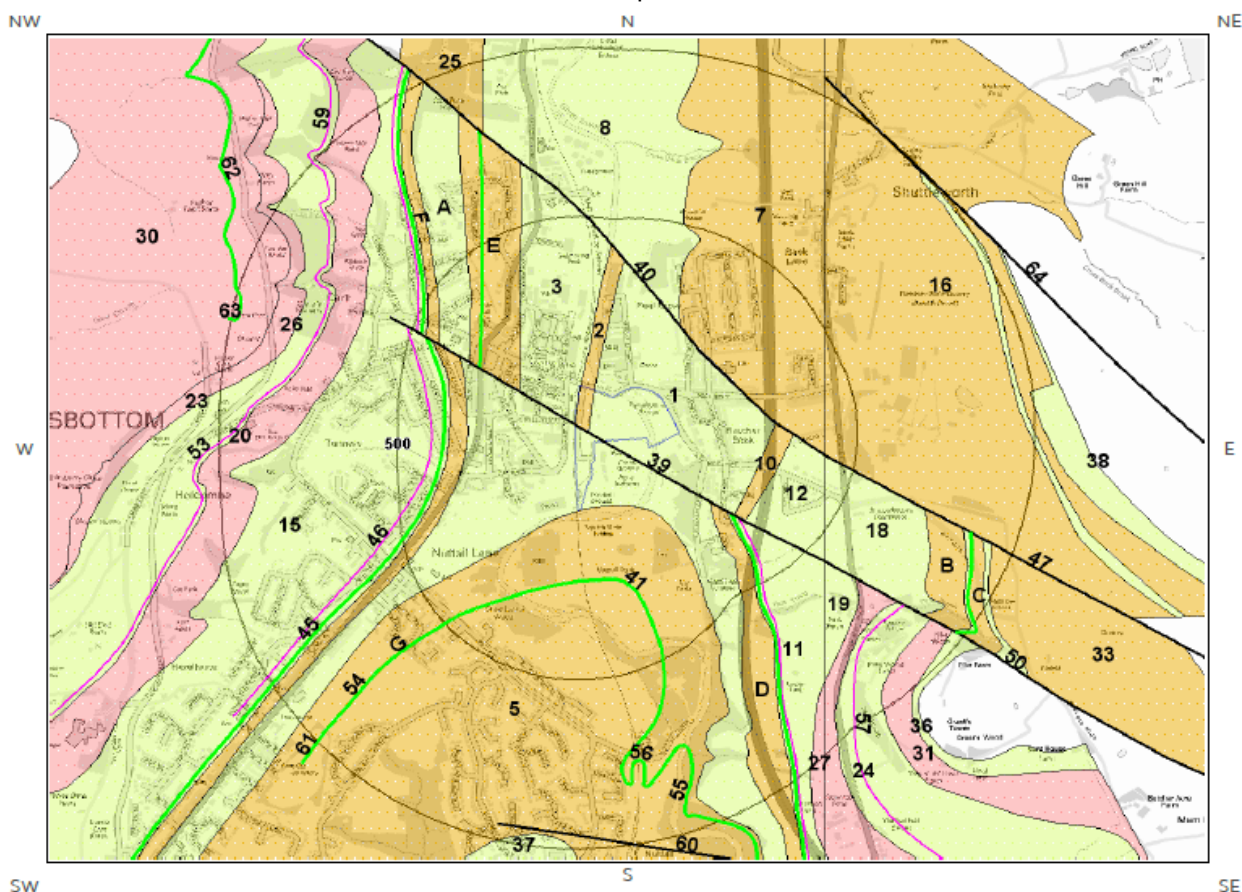
ID	Distance	Direction	LEX Code	Description	Rock Description
1	0.0	On Site	MGR-ARTDP	Made Ground (Undivided)	Artificial Deposit
2	0.0	On Site	WMGR-ARTDP	Infilled Ground	Artificial Deposit
3	11.0	W	WMGR-ARTDP	Infilled Ground	Artificial Deposit
4	33.0	S	MGR-ARTDP	Made Ground (Undivided)	Artificial Deposit
5	95.0	W	WMGR-ARTDP	Infilled Ground	Artificial Deposit
6	226.0	E	WGR-VOID	Worked Ground (Undivided)	Void
7	257.0	W	WGR-VOID	Worked Ground (Undivided)	Void
8	467.0	S	WGR-VOID	Worked Ground (Undivided)	Void
9	478.0	E	MGR-ARTDP	Made Ground (Undivided)	Artificial Deposit
10	495.0	E	WMGR-ARTDP	Infilled Ground	Artificial Deposit

Superficial Deposits

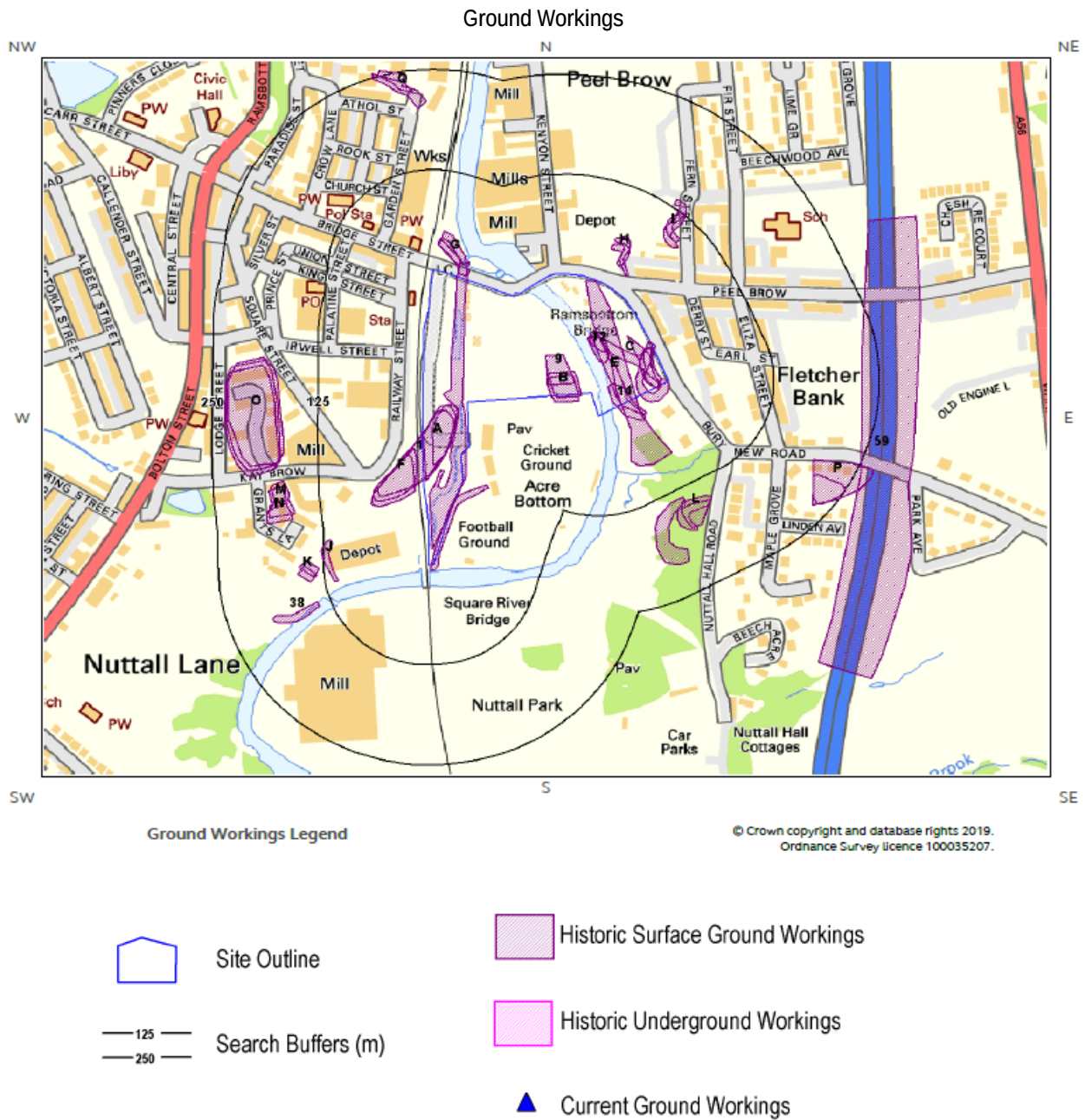


ID	Distance (m)	Direction	LEX Code	Description	Rock Description
6	0.0	On Site	TILLD-DMTN	TILL, Devensian - Diamicton	Diamicton
7	0.0	On Site	ALV-XCZSV	Alluvium - Clay, Silt, Sand And Gravel	Clay, Silt, Sand And Gravel
8	118.0	W	TILLD-DMTN	TILL, Devensian - Diamicton	Diamicton
9	334.0	S	RTD1-XSV	River Terrace Deposits, 1 - Sand And Gravel	Sand And Gravel
10	342.0	W	GFDUD-XSV	Glaciofluvial Deposits, Devensian - Sand And Gravel	Sand And Gravel
11	409.0	E	TILLD-DMTN	TILL, Devensian - Diamicton	Diamicton
12	413.0	W	HEAD-DMTN	Head - Diamicton	Diamicton

Solid Deposits



ID	Distance (m)	Direction	LEX Code	Description	Rock Age
1	0.0	On Site	MG-MDSI	Millstone Grit Group [see Also Migr] - Mudstone And Siltstone	Namurian Age
2	0.0	On Site	HZG-SDST	Hazel Grieve Grit - Sandstone	Marsdenian Sub-age
3	0.0	On Site	MG-MDSI	Millstone Grit Group [see Also Migr] - Mudstone And Siltstone	Namurian Age
4	0.0	On Site	MG-MDSI	Millstone Grit Group [see Also Migr] - Mudstone And Siltstone	Namurian Age
5	0.0	S	BBS-SDST	Brooksbottoms Grit - Sandstone	Marsdenian Sub-age



The features recorded onsite are split between ponds, reservoirs, refuse heaps, filter beds and 'unspecified workings', as listed below;

ID	Distance (m)	Direction	NGR	Use	Date
1	0.0	On Site	379290 416615	Reservoir	1955
2	0.0	On Site	379339 416694	Ponds	1955
3A	0.0	On Site	379318 416624	Reservoir	1948
4A	0.0	On Site	379318 416624	Reservoirs	1891
5A	0.0	On Site	379318 416624	Pond	1908
6A	0.0	On Site	379318 416624	Reservoir	1927
7A	0.0	On Site	379326 416638	Pond	1968
8	0.0	On Site	379327 416522	Unspecified Ground Workings	1908
9	0.0	On Site	379463 416719	Filter Beds	1927
10B	0.0	On Site	379466 416696	Filter Beds	1948
11B	0.0	On Site	379468 416701	Filter Beds	1955
12	0.0	On Site	379507 416745	Refuse Heap	1948
13C	0.0	On Site	379559 416729	Refuse Heap	1927
14	0.0	On Site	379542 416679	Refuse Heap	1948
15D	0.0	On Site	379561 416721	Refuse Heap	1968
16C	0.0	On Site	379568 416722	Refuse Heap	1948
17D	0.0	On Site	379572 416729	Refuse Heap	1955
18E	0.0	On Site	379531 416715	Refuse Heap	1955
19E	0.0	On Site	379544 416715	Unspecified Ground Workings	1968

2.5 Radon

The site lies within a low-risk area of radon where less than 1% of homes are estimated to be above the action level, therefore no radon protection measures are required for new dwellings or extensions.

3 SUMMARY OF SITE INVESTIGATION

3.1 Scope of Works

The fieldwork was carried out between the 25th June – 2nd July 2019 and included the following:

- Eighteen (18 no.) machine excavated trial holes to between 0.60mbgl (TP16) and 3.50mbgl (TP10).
- Eleven (11no.) window sample boreholes to depths between 0.35mbgl (WS18) and 5.00mbgl.
 - A further three (3no.) locations were attempted but the concrete slabs were too robust to be cored.
- Four (4no.) rotary boreholes drilled to depths between 30mbgl (RO1) and 38mbgl (RO4).
- Six (6no.) ground gas monitoring visits over a period of at least three months with varying barometric pressures.
- Chemical analysis of forty-seven (47no.) samples.
- Analysis of forty-seven (47no.) samples for asbestos screening, with fifteen (15no.) samples for quantification.
- Analysis of three (3no.) water samples taken from WS1, WS8 and WS16.
- Analysis of four (4no.) surface water samples from the River Irwell and the onsite culverted stream.
- Collection and analysis of three (3no.) soil samples for geotechnical analysis.

A further site investigation was carried out on 12th and 13th May 2022 and consisted of the following:

- 9 No. trial pits (TP101 – TP109) to 4.0 m bgl
- 1 No. trial trench (TT101) to 1.4 m bgl
- Chemical analysis of 2 No. samples (TP102 @ 1 m bgl and TP105 @ 1.5 m bgl)
- Asbestos analysis of 2 No. samples (TP102 @ 1 m bgl and TP105 @ 1.5 m bgl)
- Collection and analysis of two soil samples for Atterberg testing (TT101 @ 0.8 m bgl and TP102 @ 2.0 m bgl)
- Collection of 3 No. bulk samples for Particle Size Distribution (PSD) testing

The purpose of this investigation was to determine the materials that were below the concrete slabs and how thick the concrete slabs are.

3.2 Ground Conditions

Ground conditions typically consisted of a CONCRETE slab with reinforcement and a damp-proof course over either a very sandy GRAVEL of LIMESTONE or SANDSTONE, overlying a further CONCRETE slab and subbase. Some locations exhibited areas of possible reworked SAND and / or SILT.

The main site area was almost entirely covered by concrete slabs, and a number of locations showed secondary slabs at depth.

Natural strata consisted of both granular and cohesive strata, as well as shale bedrock at depth.

Excavation in TP16 showed significant amounts of water and potential contamination. Materials excavated were similar to those expected from the buildings strip and demolition (SAND to BOULDER graded materials).

The full logs should be consulted in conjunction with this summary.

Strata	Description	Thickness (m)	
		Top	Base
TOPSOIL	Maintained grass over brown clayey gravelly occasionally cobbly fine to coarse SAND. Gravel and cobbles are fine to coarse angular to subangular of rootlets, brick, concrete, metal, timber, paper and textiles.	0.00	0.20
CONCRETE	Reinforced concrete slab with DPC. Often noted as 200mm thick at varying depths across the site. Possibly up to 6.00m thick.	0.00	1.80
MADE GROUND -Granular	Made ground granular materials consisted largely of either a subbase such as limestone or sandstone gravel or a demolition type waste. Demolition wastes comprised mixed brick, concrete and sandstone, as well as metals, textile, plastic, papers, ash and glass. Granular made ground was prevalent across the site from shallow depth.	0.00	2.85
MADE GROUND -Cohesive	Cohesive made ground as identified as either reworked CLAY or SILT and was occasionally noted as having hydrocarbon or organic odours.	0.90	4.50
NATURAL - Cohesive	Cohesive strata were recorded as either CLAY and SILT and were often sandy. CLAY was noted as often having a significant granular content which became coarse with depth.	0.60	23.00
NATURAL - Granular	Natural granular deposits were noted to be SAND, GRAVEL and SANDS & GRAVELS. Coarse grained granular materials were usually recorded at a greater depth when compared to SAND.	1.35	9.50
Bedrock	Dark grey shale with occasional sandstone bands	23.00	38.00

3.2.1 Visual and Olfactory Contamination

Other than the MADE GROUND identified above, visual and olfactory contamination has been observed in the locations detailed below;

Exploratory Hole	Depth (mbgl)	Strata	Remark
TP1	1.00	MADE GROUND	Hydrocarbon odour
TP2	1.00		
TP5	2.25	Possible MADE GROUND	Slight organic odour
TP8	1.20	MADE GROUND	Black water with sheen and strong hydrocarbon odour.
TP16	0.60		Strong hydrocarbon and 'waste' type odour
WS1	2.75		Slight hydrocarbon odour
WS16	1.95		Hydrocarbon odour
	2.20		Slight organic odour
TP101	0.30	MADE GROUND	Hydrocarbon odour
TP102	0.25	MADE GROUND	
TP105	1.20	MADE GROUND	Hydrocarbon staining and odour on base of concrete

3.2.2 Obstructions

Concrete slabs were noted at surface and also at depth, some of these slabs were recorded in excess of 600mm thick.

A number of the slabs could not be cored and could not be broken out using a 13tonne machine, it is thought that these may be machine bases from the former paper mill.

The large hard slabs were noted around TP11, TP18, WS4, WS5 and WS19. It is likely that more of these slabs will be present at the site.

The slabs were broken through during the investigation in May 2022.

3.2.3 Groundwater – Fieldwork

Exploratory Hole	Depth (mbgl)	Strata	Remark
TP2	1.70	MADE GROUND:	Seepage
TP4	2.65	GRAVEL	Water Strike
TP5	2.25	MADE GROUND	
TP8	2.10		
TP10	1.75	MG / SILT	
	3.50		Water Strike
TP11	1.35 – 3.00	SAND	Slightly Damp
TP13	1.80	SILT	Damp
TP16	0.60	MADE GROUND	Standing Water – with sheen and hydrocarbon odour
TP18	1.30	SILT	Slightly Damp
WS1	2.75	MADE GROUND	Wet from 2.75mbgl
WS7	3.70 – 3.85	SAND	Water Strike
WS8	4.00	SAND	Water Strike
WS9	2.60	MADE GROUND	Water Strike
WS15	0.90	MADE GROUND	Standing Water
WS16	3.00	SILT	Water Strike
TP103	1.15	MADE GROUND	Water entering pit from broken pipe, movement across top of silt.
TP104	0.9	MADE GROUND	700mm culvert noted, standing water, no flow noted
TP106	2.2	SILT	Clay pipe at 2.20mbgl - medium inflow reducing.
TP107	2.05	SILT	Clay pipe noted at 2.05mbgl, medium inflow reducing.
TP108	1.85 and 2.05	MADE GROUND & SILT	Water seepage at 1.85mbgl, likely linked to broken pipe.
TP109	2.3	SILT	Clay pipe noted at 2.30mbgl with low-medium inflow, reducing.
TT101	1.20	MADE GROUND	Unrecorded water supply pipe struck at around 1.20mbgl. Fast inflow, not slowing. Dark brown to light brown to clear flow.

3.2.4 Groundwater – Post-Fieldwork Monitoring

The table below indicates groundwater encountered during the monitoring post fieldwork (6/6 visits have been undertaken);

Exploratory Hole	Depth to Water (mbgl)	Depth to Base of Well (mbgl)
WS1	2.73 - 3.13	4.05 - 4.15
WS7	2.9 - 3.38	4.10 - 4.15
WS8	1.75 - 1.93	3.30 - 3.50
WS16	0.8 - 1.15	2.80 - 2.85

3.3 Coal Mining Investigation

The site lies at the base of the Rossendale Coalfield, part of the Carboniferous Pennine Lower Coal Measures of Namurian age. The Geological Survey shows a possible outcrop of the thin Holcombe Brook Coal across the southern part of the site dipping north and overlain by the thick drift deposits of an infilled glacial meltwater channel.

There are no relevant collieries and shaft sections in Ramsbottom and evidence of the presence of the Holcombe Brook Mine is derived from hillside exposures on the valley sides east and west of the site. Evidence for shales possibly lying above the seam was encountered in water wells bored for the former paper works which occupied the site.

The Holcombe Brook Coal is a variable and impersistent coal seam of poor quality and interbedded with black shales. The seam was occasionally mined on the hills above Rossendale where it was occasionally worked at outcrop, and has a thickness thought to be up to 300mm. There are no shaft sections showing the seam and no deeper coal seams of workable thickness in this part of Lancashire. The Coal Authority have no records of any mineshafts on or within 20m of the site. Coal mining in Rossendale is first recorded in 1612 at Gambleside on the eastern slope of the valley 3km north of the site where the Upper and Lower Mountain Mines outcrop. Four (4no.) rotary holes were sunk to depths between 30mbgl (RO1) and 38mbgl (RO4) and was undertaken with a Coal Authority Permit.

Rockhead is weathered and comprised of dark grey shales and sandstones at depths greater than 20m. Drilling did not show any workings or seams of coal. It is therefore deemed that the site is at Low Risk from Coal Mining.

3.4 Soil Contamination Summary and Risk

Made Ground Strata

Location	Depth (mbgl)	Determinant	Soil Organic Matter Content (SOM) (%)	Observed Concentration (mg/kg)	Threshold Concentration (mg/kg)
TP1	0.10	Lead	7	290	200
		Benzo(a)anthracene		16	8.54
		Benzo(a)pyrene		15	2.05
		Benzo(b)fluoranthene		17	9.86
		Dibenzo(ah)anthracene		2.4	1

	1.00	Lead Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Dibenzo(ah)anthracene Naphthalene Chrysotile & Amosite	5.3	280 12 10 13 1.4 1.3 <0.001 %	200 4.52 1.5 7.72 0.838 0.829 <0.001 %
TP2	0.50	Lead Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Dibenzo(ah)anthracene Naphthalene Chrysotile & Amosite	5.2	260 9.6 9.3 13 1.5 1 <0.001 %	200 4.52 1.5 7.72 0.838 0.829 <0.001 %
TP3	0.15	Lead Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Dibenzo(ah)anthracene Naphthalene Chrysotile & Amosite	5.9	250 25 23 28 3 9.7 <0.001 %	200 4.52 1.51 7.72 0.838 0.829 <0.001 %
	1.50	Lead TPH C16-C21 Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Dibenzo(ah)anthracene Indeno(123-cd pyrene) Naphthalene Chrysotile & Amosite	4.4	220 400 25 23 28 3 9.7 3.5 <0.001 %	200 319 4.52 1.5 7.72 0.838 7.31 0.829 <0.001 %
TP4	0.50	Chrysotile	0.8	<0.001 %	<0.001 %
TP5	1.70	Arsenic Chrysotile	6.2	46 <0.001 %	37 <0.001 %
TP6	0.50	Lead	7.8	970	200
TP9	0.20	Lead Chrysotile	4.4	430 0.001 %	200 <0.001 %
TP10	0.50	Chrysotile	2.7	<0.001 %	<0.001 %
TP11	0.50	Chrysotile	1.1	<0.001 %	<0.001 %
TP12	0.45	Chrysotile	2.6	0.095	<0.001 %
TP14	0.50	Chrysotile & Amosite	2.9	<0.001 %	<0.001 %
TP15	1.00	Chrysotile	3.7	<0.001 %	<0.001 %
TP16	0.60	Chrysotile	4.5	0.002 %	<0.001 %
TP17	0.60	Amosite	4.9	<0.001 %	<0.001 %
TP18	1.00	Lead	4.1	240	200
WS1	0.55	Arsenic Lead Chrysotile	6.3	67 670 0.002	37 200 <0.001 %
WS7	0.95	Arsenic Lead Benzo(a)pyrene Naphthalene	2.4	43 1100 2.8 0.94	37 200 1.51 0.829

WS8	0.50	Benzo(a)anthracene Benzo(a)pyrene Naphthalene	4.6	6.5 4.9 0.89	4.52 1.51 0.826
WS11	0.50	Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene	8.2	8.1 7.2 8.3	8.54 2.05 9.86
WS12	0.35	Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Dibenzo(ah)anthracene Naphthalene	2.9	8.5 7.2 7.8 0.88 13	4.52 1.5 7.72 0.838 0.829
WS16	0.75	Arsenic Lead	2.2	140 470	37 200
	2.00	Arsenic Lead	5	160 1100	37 200

Possible Made Ground / Natural Strata

Location	Depth (mbgl)	Determinant	Soil Organic Matter Content (%)	Observed Concentration (mg/kg)	Threshold Concentration (mg/kg)
TP5	2.25	Arsenic Benzo(a)pyrene	5.1	53 1.8	37 1.51
WS1	2.75	Lead	7.1	200	200

Naphthalene and VOCs / SVOCs

Naphthalene was recorded above the most stringent 1% SOM thresholds in a number of locations and may pose a risk to end users through volatilisation and ingress into the new structures. The list below highlights areas potentially at risk;

Location	Depth (mbgl)	Observed Concentration (mg/kg)	1% SOM Threshold Concentration (mg/kg)
TP1	0.10	1.1	0.829
	1.00	1.3	
TP2	0.50	1	
TP3	0.15	3.5	
	1.50	8.6	
TP5	1.00	0.84	
WS1	2.75	5.3	
WS7	0.95	0.94	
WS8	0.50	0.89	
WS11	0.50	7.7	
WS12	0.35	13	

Further to the above, positive detections of VOCs / SVOCs have also been observed in the locations detailed below;

Location	Depth (mbgl)	Determinant	Observed Concentration (mg/kg)	1% SOM AtRisk Threshold Concentration (mg/kg)
VOCs				
WS1	2.75	Ethylbenzene	0.001	-
		p & m-Xylene	0.015	-
		o-Xylene	0.011	-
		1,3,5-Trimethylbenzene	0.001	-
		1,2,4-Trimethylbenzene	0.037	-
SVOCs				
TP1	1.00	2-Methylnaphthalene	1.20	-
		Dibenzofuran	1.60	-
		Carbazole	1.50	-
		Anthraquinone	0.80	-
TP3	1.50	2-Methylnaphthalene	6.30	-
		Dibenzofuran	6.50	-
		Carbazole	6.00	-
		Anthraquinone	1.50	-
TP5	1.70	2-Methylnaphthalene	0.80	-
		Dibenzofuran	1.10	-
		Carbazole	0.80	-
		Anthraquinone	0.80	-
WS1	2.75	2-Methylnaphthalene	3.30	-
		Dibenzofuran	1.60	-
		Carbazole	1.00	-
		Anthraquinone	0.50	-
WS7	0.95	4-Chloroaniline	0.40	-
		2-Methylnaphthalene	0.70	-
		Dibenzofuran	0.80	-
		Carbazole	0.80	-
		Anthraquinone	0.60	-

- No current guidance using AtRisk Thresholds

Natural Strata

Location	Depth (mbgl)	Determinant	Soil Organic Matter Content (%)	Observed Concentration (mg/kg)	Threshold Concentration (mg/kg)
WS10	1.00	Benzo(a)anthracene	4.2	20	4.52
		Benzo(a)pyrene		14	1.5
		Benzo(b)fluoranthene		12	7.72
		Dibenzo(ah)anthracene		1.5	0.838

Asbestos

Asbestos, of varying types, was detected in a number of locations as detailed in section 13.2.1, with quantification only showing four locations with concentrations above detection limits (0.001%), as shown below;

Location	Depth (mbgl)	Asbestos Type	Observed Concentration (%)
TP9	0.20	Chrysotile	0.001
TP12	0.45		0.095
TP16	0.60		0.002
WS1	0.55		0.002

3.5 Controlled Waters Contamination

Water samples were collected from boreholes onsite, the culvert and the River Irwell, as stated below;

- Samples of groundwater were collected from WS1, WS8 and WS16.
- Samples from the River Irwell were labelled as US1 (Upstream) and DS1 (Downstream).
- Samples from the Culvert were labelled as MS1, MS2 and MS3 (Midstream).

Analysis of the water results has shown that the majority of determinants were below detection. However, there were several exceedances, as detailed in the table below;

Location	Determinant	Observed Concentration (µg/l)	Threshold Freshwater Surface (FS) & General Quality of Groundwater (GQGW) (µg/l)
WS1	Cyanide Arsenic	14 9.35	5 (FS: short-term value) 7.5 (GQGW)
MS1b	Zinc	14	5 (FS: short-term value)
DS1	Zinc	12 (visit 1) 11 (visit 2)	10.9 (FS: long-term value)
US1 MS1 MS1b MS2 MS3	Copper	6.2 – 12 5.6 – 6.8 10 3.4 – 6.1 1	1* (FS: long-term value)
Location	Determinant	Observed Concentration (µg/l)	Threshold Freshwater Surface (FS) & General Quality of Groundwater (GQGW) (µg/l)
DS1	Copper	6 - 11	1* (FS: long-term value)

* Dependant on bioavailability

3.6 Assessment

Soils

A number of exceedances have been observed across the site within Made Ground strata, these are associated with various PAHs, TPH C16-C21, Lead, Arsenic and asbestos. PAHs include the SVOC, Naphthalene. Further to these, a number of VOCs / SVOCs have also been observed above detection limits.

The Made Ground exceedances have been recorded at varying depths between 0.10mbgl and 2.00mbgl. With deeper exceedances at 2.25mbgl (TP5) and 2.75mbgl (WS1), within potential Made Ground strata.

Based on the locations of TP5 and WS1, in relation to the formerly existing reservoirs, it is now considered likely that these are Made Ground samples from backfill / basal reservoir materials. As shown in the sketch below;



Occurrences of Dibenzo(ah)anthracene and Naphthalene are hotspots and statistically significant, and will therefore require further works, such as delineation, to mitigate the risk they pose to human health.

Double Ratio Plot analysis identified the source of the elevated benzo(a)pyrene in TP7 and TP8 to be coal derived. As the source is coal derived, the values may be compared against the DEFRA C4SL 2017 value of 4.95mg/kg due to a reduced bioavailability. Given that the results are below this threshold, minimal risk is anticipated from this source and it is deemed below residential thresholds in TP7 and TP8. The remaining benzo(a)pyrene exceedances are shown to likely sourced from Coal Tar / Creosote and cannot be discounted on this basis.

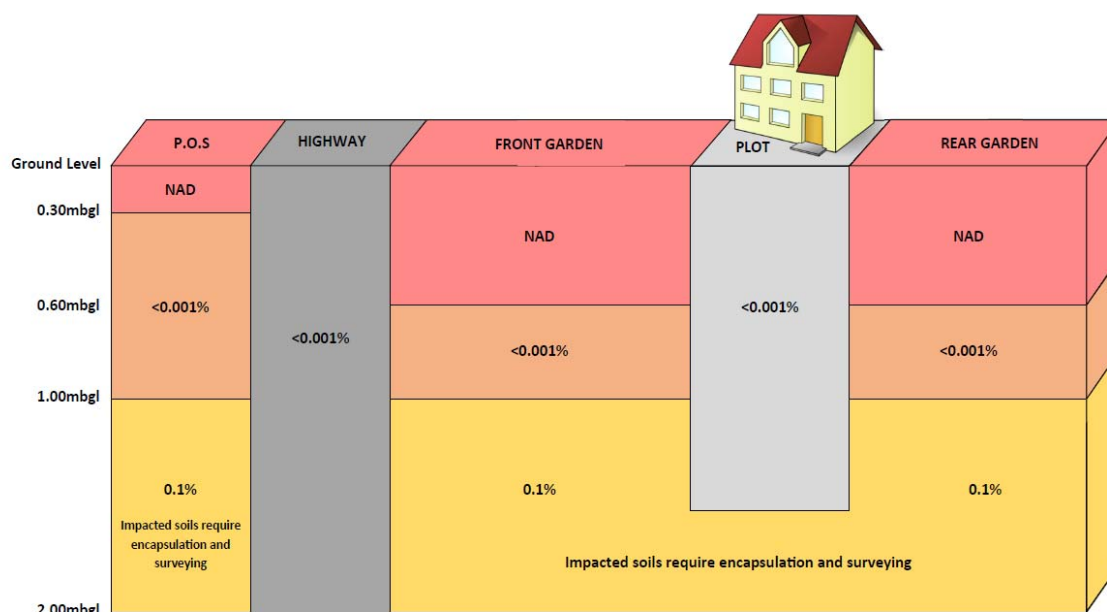
Statistical analysis of the Arsenic exceedances has shown that they are statistically significant and should be treated as hotspots, where they exceed the threshold value of 37mg/kg. Similarly, the occurrences of Lead are also considered significant and will require further works or mitigation in locations where they exceed 200mg/kg.

Asbestos (Amosite and Chrysotile) was identified in a number of locations with quantification testing recording concentrations within soils ranging from 0.001% (TP9) to 0.095% (TP12).

The presence of asbestos within the Made Ground is likely due to poorly managed historical demolition which the fill is largely comprised of and the practice of incineration of waste materials without prior screening. ICRCL Guidance Note 64/85 "Asbestos on Contaminated Sites" (1990) is still the most current guidance for asbestos in soil and suggests asbestos fibres should be <0.001% w/w within soil. Dutch and Australian Guidance also suggest the use of a threshold of 0.001% as a threshold for asbestos in soil. The Dutch Guidelines consider the risk from Chrysotile to be ten times less than Amphibole asbestos but the HSE, WHO, the Australian DoH and the USEPA have chosen not to distinguish between different asbestos fibre types.

The concentration (0.095%) of Chrysotile asbestos within the ash fill in TP12 at 0.45m potentially poses a significant risk to end users and construction workers, if the material is exposed and soil and asbestos fibres allowed to become airborne. Groundworks should follow CAR-SOIL™ Guidance. Given that the material used to back fill comprises a high percentage of demolition waste, the presence of further asbestos is likely. Detections of asbestos are also likely to occur the demolition waste stockpiles that exist onsite.

Below is a sketch showing levels of asbestos concentrations and locations where they are commonly accepted / unacceptable. This should be confirmed with the Local Authority prior to implementation, and should therefore only be used as a guide;



Notes:

P.O.S - Public Open Space

NAD - No Asbestos Detected

0.001% - Soils may contain $\leq 0.001\%$ using composite testing to ensure there is no potential risk to human health. Value is present where there may be short-term low level exposure of soils containing trace asbestos fibres by construction workers where an appropriate level of asbestos management is employed (e.g. dust suppression).

0.1% - Soils at depth of $>1.00\text{mbgl}$ may contain $<0.1\%$ asbestos using composite testing where they will be not likely not be disturbed in the future and will therefore be in an area of Low Sensitivity. Risk assessment completed in accordance with the Asbestos JIWG Risk Assessment Tools.

Undefined - Dependant upon soils encountered during earthworks, which may be placed at depths to ensure no potential risk to human health.

Burial and encapsulation of asbestos should be agreed with regulators and consultant prior to the works being undertaken. Consideration should also be made to CAR-SOIL™.

In general, widespread contamination was observed across the site, in conjunction with several hotspots.

Further investigation into the stockpiles is advised. Movement of these materials should also be carried out using correct dampening down methods.

A minimum thickness of 600mm of debris-free soil is required within garden areas and landscaped areas as a capping system to mitigate residual risk to site end users from the asbestos and remaining determinants. It is also anticipated that the secondary slabs will be containing further contamination not observed during the investigation due to plant access limitations within the exclusion zone. The capping is to be made up of imported subsoil and topsoil.

Several areas of hydrocarbon odours were noted across the site during investigation; however, these were not substantiated in testing. As a result, a hydrocarbon vapour resistant membrane may be required across the site to mitigate nuisance risk – this is to be reviewed following the site strip.

Groundwater Contamination and Risk

Various exceedances have been noted within surface and groundwater samples. As summarised below;

Location	Determinant	Observed Concentration (µg/l)	Threshold Freshwater Surface (FS) & General Quality of Groundwater (GQGW) (µg/l)
WS1	Cyanide Arsenic	14 9.35	5 (FS: short-term value) 7.5 (GQGW)
MS1b	Zinc	14	5 (FS: short-term value)
DS1	Zinc	12 (visit 1) 11 (visit 2)	10.9 (FS: long-term value)
US1 MS1 MS1b MS2 MS3	Copper	6.2 – 12 5.6 – 6.8 10 3.4 – 6.1 1	1* (FS: long-term value)
DS1	Copper	6 - 11	1* (FS: long-term value)

* Dependant on bioavailability

Exceedances for Copper have been noted in all holes. There is little to no variation between upstream and downstream samples, so the source is likely located upstream of the site. No elevated levels of copper were identified on site within the soils suggesting the source is not on site.

The water sampled in WS1 are thought to be perched waters within the made ground strata it is therefore not considered representative of true groundwater at the site. Based on site history, the types of contamination and levels observed are considered typical of a site such as this. Downstream and midstream sampling has not showed correlating results, so the onsite perched waters are not considered to be in significant continuity with the River Irwell.

The downstream and midstream samples show a minor Zinc exceedance against the long-term mean threshold. On the basis, that this is a short sampling period with a minor exceedance, continued monitoring is likely to show mean concentrations below the threshold. No elevated levels of zinc were identified on site within the soils suggesting the source is not on site.

No significant risks to sensitive water abstractions/controlled waters are anticipated due to the following: no groundwater abstractions within 500m of site, no significant link between onsite and River Irwell chemical concentrations.

The risk to groundwaters / aquifers is therefore deemed as Low.

3.7 Gas Monitoring and Assessment

Radon

The EnviroCheck data states that the site is within a low probability radon area (1-3% of properties above the action level).

3.8 Ground Gas Assessment and Recommendations

The four (4 No.) boreholes were all installed up to 5.00 mbgl with 1.00 m of plain pipe and between 4.0 m of slotted pipe. A typical installation is shown below;

Location	Peak Gas Flow (l/h)	Atmospheric Pressure Range (mb)		Peak CH ₄ (%)	Peak CO ₂ (%)	Minimum O ₂ (%)	Gas Screening Value (GSV) (l/h)	
		Min	Max				CH ₄	CO ₂
WS1	<0.1	985	1006	0.10	4.30	16.70	0.0001	0.0043
WS7	0.1	985	1006	0.10	3.60	14.10	0.0001	0.0036
WS8	0.1	985	1006	0.10	9.70	14.10	0.0001	0.0097
WS16	0.1	985	1006	0.10	0.60	18.80	0.0001	0.0006

Elevated CO₂ has been observed in one location, WS8, which showed a maximum concentration of 9.70%. Whilst this is close to the suggested Amber 1 / Amber 2 threshold, it does not exceed it. Further to this, when taking gas flow into account, the calculated gas screening value (GSV) is significantly lower than the Amber 1 / 2 - threshold, showing there is little driving force to mobilise the ground gas.

From a review of the strata identified, the majority of made ground was granular in nature with no significant organic matter noted to suggest significant ground gas production or migration. Small pockets of organic material may be present within the alluvial material or other made ground on site. When alluvium or peat was deposited it contained organic material. Initially this would have degraded to produce methane gas. However, only the labile (easily degradable material) would have been used up. Old recalcitrant peat such as deep peat layers in alluvium generates very little new methane. As was generated it would have been emitted from the surface of the alluvium before being encased beneath made ground. Therefore, the ongoing risk from ground gas from this source is low.

On the basis of the above, the site can be classed as Amber 1 / CS2. The site will require low level gas protection measures to be installed.

A number of volatile odours and VOCs/SVOCs were noted within the Made Ground during the site investigation however were not substantiated in testing. A hydrocarbon vapour resistant membrane may be required across the site to mitigate nuisance risk – this is to be reviewed following the site strip and localised remediation.

3.9 Geotechnical Constraints

The following may have an impact on further remedial works;

- Possible existing and redundant services across site
- Potential tree heave as cohesive stratum anticipated (anticipated)
- Shallow groundwater / perched water
- Depth of Made Ground / former foundations within the vicinity of former buildings
- Possible large, buried structures / machine bases
- Culvert crosses site in the west
- Erosion of the riverbanks
- Potential for deep saturated SILT deposits
- Former extraction wells onsite

4 ESTIMATED DEPTHS AND VOLUMES OF MADE GROUND

4.1 Depths of MADE GROUND

MADE GROUND depths have been estimated from the locations where trial pits and boreholes were able to breakthrough to natural strata. No allowance can be made for areas outside of these locations or where made ground depth could not be proven, as such these are considered estimates.

It should be noted that few locations within the exclusion zone have been reached natural.

Hole	Depth to BASE of MG
TP101	2.60+
TP102	2.00
TP103	1.15
TP104	1.00+
TP105	1.20
TP106	1.80
TP107	2.60
TP108	2.00
TP109	1.80
TT101	1.40
TP1	1.85+
TP2	3.00+
TP3	2.45+
TP4	1.75
TP5	3.30+
TP6	3.40+
TP7	1.90+
TP8	2.40+
TP9	1.20+

TP10	3.50+
TP11	1.35
TP12	2.45
TP13	1.80
TP14	1.85+
TP15	1.90+
TP16	0.60
TP17	1.50
TP18	1.30
WS1	4.50
WS2	1.45+
WS6	0.60+
WS7	1.80
WS8	1.70
WS9	0.40
WS10	0.95
WS11	0.60
WS12	0.60+
WS13	0.60+
WS14	0.60+
WS15	1.20+
WS16	2.80
WS17	0.45+
WS18	0.35
RO1	2.00

RO2	1.20
RO3	5.50
RO4	5.00
TP101	2.6+
TP102	2.00
TP103	1.15
TP104	1.0+
TP105	1.20
TP106	1.60
TP107	2.60
TP108	2.00
TP109	1.80
TT101	1.4+

5 REMEDIAL ACTIONS

All remedial works are to be completed under the supervision of an independent and suitably qualified consultant.

A watching brief is recommended for the remediation and earthworks phases to identify and deal with unexpected contamination.

5.1 Ground Gas Protection Measures

Elevated CO₂ has been observed in one location, WS8, which showed a maximum concentration of 9.70%.

Whilst this is close to the suggested Amber 1 / Amber 2 threshold, it does not exceed it. Further to this, when taking gas flow into account, the calculated gas screening value (GSV) is significantly lower than the Amber 1 / 2 - threshold, showing there is little driving force to mobilise the ground gas.

Considering the above, the site can be classed as Amber 1 / CS2. The site will require low level gas protection measures to be installed.

VOC / SVOC testing has revealed a number of locations with exceedances and / or elevated concentrations.

As this affects the majority of the site and earth works will rearrange materials, all new structures will require hydrocarbon resistant membranes.

Considering the above, the site can be classed as Amber 1 / CS2. The site will require low level gas protection measures to be installed with hydrocarbon vapour resistant membranes.

The requirement for membranes may be reassessed and validated during the earthworks phase via PID and lab testing. Validation of the membranes will take place during the construction phase.

5.2 Installation of Clean and Inert Capping

Due to the spread and depths of contamination and MADE GROUND, the whole site will require the installation of a clean and inert capping system with a geotextile no dig layer, as per the below;

Within Garden Areas

150mm topsoil
450mm subsoil (free of construction debris)
Geotextile membrane

Within Soft Landscaped Areas

150mm topsoil
150mm subsoil (free of construction debris)
<i>Proven to a depth of 450mm, in line with NHBC guidance.</i>

The above is proposed to comply with NHBC regulations regarding physical composition of cover as below:

- Section 10.2.9 states – Garden Areas:
 - o *old foundations, concrete bases and similar obstructions removed from within 450mm of the finished ground surface. – this has been completed during the remediation and enabling works.*
 - o *Subsoil should not be placed over topsoil. Construction rubbish and debris should be removed from the garden and other areas around the home before topsoiling, and before or after planting, turfing or seeding.*
- Section 10.2.7 states – Materials:
 - o *Topsoil and subsoil should be of a quality that will not present a hazard to users of the garden area.*

The risk to construction workers is mitigated by the proper use of PPE and welfare facilities.

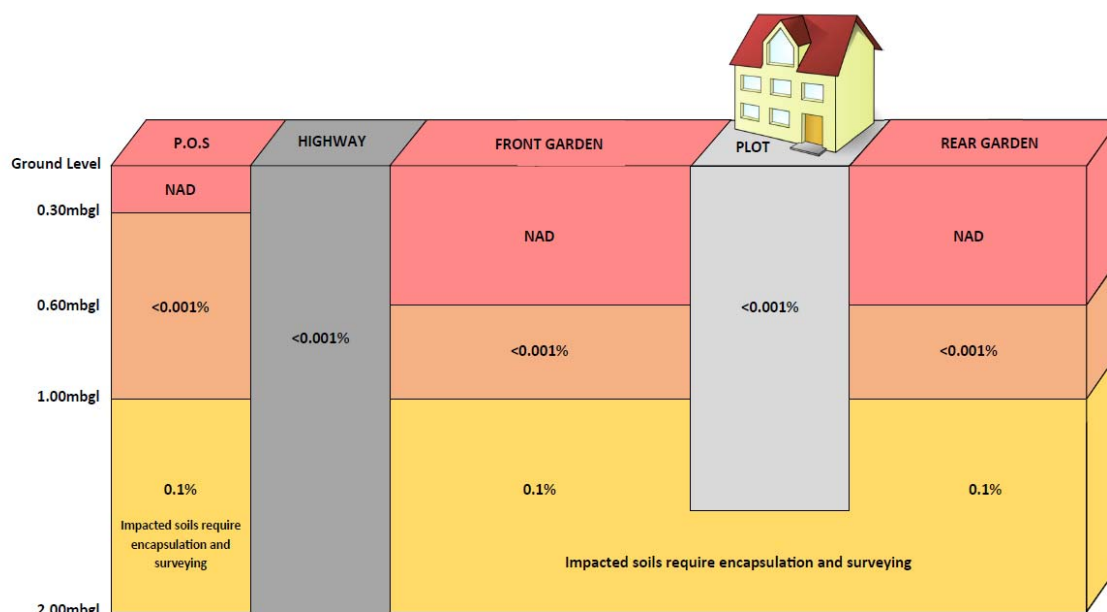
5.3 Asbestos

Asbestos (Amosite and Chrysotile) was identified in a number of locations with quantification testing recording concentrations within soils ranging from 0.001% (TP9) to 0.095% (TP12).

The presence of asbestos within the Made Ground is likely due to poorly managed historical demolition which the fill is largely comprised of and the practice of incineration of waste materials without prior screening. ICRCCL Guidance Note 64/85 “Asbestos on Contaminated Sites” (1990) is still the most current guidance for asbestos in soil and suggest asbestos fibres should be <0.001% w/w within soil.

The concentration (0.095%) of Chrysotile asbestos within the ash fill in TP12 at 0.45mbgl potentially poses a significant risk to end users and construction workers, if the material is exposed and soil and asbestos fibres allowed to become airborne. Groundworks should follow CAR-SOILTM Guidance. Given that the material used to back fill comprises a high percentage of demolition waste, the presence of further asbestos is likely. Detections of asbestos are also likely to occur the demolition waste stockpiles that exist onsite.

Below is a sketch showing levels of asbestos concentrations and locations where they are commonly accepted / unacceptable. This should be confirmed with the Local Authority prior to implementation, and should therefore only be used as a guide;



Notes:

P.O.S - Public Open Space

NAD - No Asbestos Detected

0.001% - Soils may contain ≤0.001% using composite testing to ensure there is no potential risk to human health. Value is present where there may be short-term low level exposure of soils containing trace asbestos fibres by construction workers where an appropriate level of asbestos management is employed (e.g. dust suppression).

0.1% - Soils at depth of >1.00mbgl may contain <0.1% asbestos using composite testing where they will be not likely not be disturbed in the future and will therefore be in an area of Low Sensitivity. Risk assessment completed in accordance with the Asbestos JIWG Risk Assessment Tools.

Undefined - Dependant upon soils encountered during earthworks, which may be placed at depths to ensure no potential risk to human health.

Burial and encapsulation of asbestos should be agreed with regulators and consultant prior to the works being undertaken. Consideration should also be made to CAR-SOIL™.

It is proposed that a geotextile no dig layer is placed at the base of the 600mm clean cover in garden areas instead of 1m cover without no dig geotextile.

Dampening down using a mist spray should be considered when moving dry materials. Run off will also need to be controlled to protect sensitive controlled water receptors.

5.4 Protection of Controlled Waters

Shallow groundwater and perched water have been observed across the site. The river Irwell is also adjacent to the site and is below the existing site level. Further to this, due to site history, there will be considerable amount of existing drainage with unknown outfalls.

Unknown or significant drains should be traced to ensure they don't outfall to the river, or into the underlying aquifers (Secondary A Aquifer).

Sediment traps and interceptors should also be considered to stop both chemical and sedimentary pollution entering the water course.

Pumping and tankering equipment should be held onsite, to ensure that if contaminated perched waters are found, it can be removed from the ground before it can spread further.

5.5 Invasive Species

The invasive species remediation is being led by Ascerta; their report should be read in conjunction with this report to ensure all salient points are understood. It is currently anticipated that impacted materials will be moved the public open space for treatment.

5.6 Site Won Soils

Use of site won topsoil is not anticipated given the sites history and contamination identified.

Significant site won recycled aggregate from process of arisings is anticipated to provide at least a 6f2 material for reuse.

The use of Natural site won subsoil may be possible, however, it is, in general, located at depth it is not deemed possible.

The area in the south west corner identified very different ground in the form of organics / textile / paper waste within a predominantly granular matrix with boulders of concrete. Processing of this material under a mobile plant licence is anticipated with control of groundwater and groundwater treatment potentially required. Piling / vibro in this area will need reviewing post remediation to ensure a pathway to groundwater is created. The use of binders and soil modification to mitigate movement of determinants may be viable subject to regulatory approval to 'lock up' mobile determinants.

The use of site won material will be subject to suitability testing as per the Local Authority's guidance. Confirmation of the testing will be required, as per the schedule below;

Intended End Use	Source / Origin of Material		
	Greenfield	Remediated	Brownfield / Unknown
Gardens	1:200m ³	1:100m ³	1:50m ³
Soft Landscaping	1:200m ³	1:150m ³	1:150m ³
Other	1:200m ³	1:200m ³	1:200m ³

Copies of all waste transfer documentation for material removed from site will need to be provided.

5.7 Imported Soils

Imported soil being brought to site should be tested for contamination to ensure it is suitable for the proposed use, and it is generally advisable to test a minimum of three samples per source, and to be in line the Local Authority's testing specification, as show below;

Intended End Use	Source / Origin of Material		
	Greenfield	Remediated	Brownfield / Unknown
Gardens	1:200m ³	1:100m ³	1:50m ³
Soft Landscaping	1:200m ³	1:150m ³	1:150m ³
Other	1:200m ³	1:200m ³	1:200m ³

Imported subsoil being brought to site should be tested for contamination to ensure that it is suitable for the proposed use, and it is generally advisable to test a minimum of three samples, or one sample per 250m³ so that a representative mean value can be calculated.

5.8 Construction / Maintenance Workers

In order to reduce potential risks associated with the determinants encountered on site, the following recommendations should be adhered to during site works:

- Any proposed imported soils should be tested for contamination to ensure that they are suitable for the proposed end use as per Section 3.2 and 3.4.
- Site workers should wear gloves, boots and overalls and wash their hands before eating, drinking and smoking. Excessive dust generation should be avoided. The site manager will inspect the risk assessments of the contractors on site/inspect on a regular basis to make sure this is upheld as per HSE / CDM guidance.
- Asbestos was encountered on site therefore vigilance should be adhered, and any suspected asbestos should be notified and a suitably qualified.
 - Careful dampening down off impacted materials should be considered.
- It is recommended that during all excavations adequate ventilation should be maintained. If man entry is required, gas monitoring should be carried out as a precaution.
- Given the existence of Made Ground on the site it would be prudent to maintain vigilance during site clearance and construction, in case any areas of suspected contamination are encountered.
- If areas of suspected contamination are found then a suitably qualified person should undertake appropriate sampling, testing and further risk assessment.

5.9 Drinking Water Supplies

Use of Protect-A-line is anticipated based on existing results – UURA to be undertaken post-demolition and post remediation as it highly probable that a clean service corridor is possible.

5.10 Review of Conceptual Site Model

Target (Receptor)	Potential Source-Pathway Linkage	Remedial Action Required (where appropriate)	Estimated Degree of Risk to Target Following Remedial Action Where Necessary
Site End Users	Inhalation of soil gases, odours or dust.	Amber 1 / CS2 with hydrocarbon membranes due to presence of VOCs. Remediation and site verification may allow removal of this requirement subject to further assessment and regulatory approval	Low
Site End Users	Ingestion of, and skin contact with, contaminated soil.	600mm clean cover system (150mm debris free topsoil/450mm subsoil) geotextile required for all plots. Public open space requires 300mm growing medium.	Low
Site End Users	Ingestion of contaminants in vegetables etc. or in soils adhering to vegetables, etc	600mm clean cover system (150mm debris free topsoil/450mm subsoil) geotextile required for all plots in east of the site. Public open space requires 300mm growing medium.	Low
Construction/ Maintenance Workers.	Inhalation of soil gases, odours or dust.	PPE	Low **
Construction/ Maintenance Workers.	Ingestion of, and skin contact with, contaminated soil	PPE	Low **
Plants	Adverse effects on growth caused by presence of contaminants in soil	600mm clean cover system (150mm debris free topsoil/450mm subsoil) geotextile required for all plots in east of the site. Public open space requires 300mm growing medium.	Low
Buildings and Structures	Flow of ground gas into buildings. Asphyxiation, toxicity, explosion and fire hazards	Amber 1 / CS2 with hydrocarbon membranes due to presence of VOCs. Remediation and site verification may allow removal of this requirement subject to further assessment and regulatory approval	Low
Foundations	Sulphate attack of foundations	Foundations to be designed as per the ground investigation report.	Low
Water Supplies	Hydrocarbons penetrating plastic water supply pipes.	UU Risk Assessment Required. Protect-A-line possible.	Low
Groundwater	Migration of soluble contaminants into groundwater on or off site	Some pumping may be required for contaminated perched water.	Low
Surface Water	Migration of soluble contaminants and/or direct run-off of contaminants	Use of interceptors and sediment traps is advised.	Low

** assumes basic PPE is used

6 REMEDIATION STRATEGY

6.1 Aims

Remediation aims are:

- Remove / relocate ground contamination issues in order to protect human health and potential environmental receptors, and render the site suitable for the proposed development
- Satisfy planning requirements of the Local Planning Authority.
- Satisfy Environmental Protection Act 1990 Part IIa requirements of the Environment Agency.

6.2 Remediation Scope

The following remedial works are required:

- Treatment of invasive species
- General site clearance of surface materials and vegetation.
- Protection of controlled waters
- Installation of ground gas protection measures.
- Break-up of areas of hard standing.
- Crushing of all suitable uncontaminated artificial hard material (i.e. concrete / brick etc) for re-use on site / disposal.
- Backfill of all resultant excavations, with demonstrably clean materials to engineered specification.
- Excavation and process of fill material in the south west corner with textiles / organics and plastics disposed off of site – remaining granular processed and reused on site. Stabilization of the material is anticipated – methodology and targets to be provided by remediation contractor for regulatory approval.
- Re-grade of site to specified levels.
- Provision of a required capping layers of 'clean' soils with geotextile membrane in garden areas. This cover layer should comply with NHBC guidance.

A watching brief is recommended for the earthworks phase to identify and deal with unexpected contamination and allow sign off of the works.

6.3 Remediation Methodology

6.3.1 Site Set-up, Organisation and Safety

Site works will be supervised throughout by a suitably qualified Engineer, who will report to the Project Manager. Consultancy supervision may be part-time for certain activities but must be full-time during the removal of any grossly contaminated soil/fill and any placement of fill to an engineering specification.

Site cabins and welfare facilities are to be established at a location to be agreed with the Engineer. All welfare facilities must be established in accordance with the relevant health & safety statutory requirements. Provision shall be provided on site for car parking for all site employees.

All site personnel will undergo a site-specific health and safety induction prior to commencement of work on site.

The Engineer will be informed prior to any proposed entry of a confined space or deep excavation. Entry must be restricted to suitably qualified and equipped personnel.

Works will be carried out with proper regard to current statutory requirements.

During the remediation works, all personnel on site will comply with guidance provided in the Health and Safety Executive (HSE) document "Protection of Workers and the General Public during the Redevelopment of Contaminated Land". In summary, the following shall be provided:

- Protective clothing, footwear and gloves (Personnel should be instructed in why and how they are to be used).
- Hand-washing and boot-washing facilities.
- Smoking shall be limited to designated areas.

If at any time during the works, personnel begin to feel unwell, they are to inform the Engineer or Site Manager, who will determine appropriate action.

All visitors to site must enter and register at the main Site Office.

6.3.2 Responsibilities

Prior to the commencement of any works, in agreement with the Engineer, The Client will:

- Establish the boundaries of the site and the working areas.
- Undertake a dilapidation survey of site boundaries, adjacent properties and highways, via dated photographs or video footage.
- Liaise with the Local Authority regarding working hours, noise\dust\odour control, and protected trees.
- Liaise with the Local Water Company regarding any proposed discharge to sewer.
- Complete a full services search and liaise with all relevant utility companies regarding work in close proximity to their apparatus
- Inform the Engineer of any risk, identified and assessed, which could impact upon the Engineer's activities.
- Prepare the necessary COSHH statements and Health & Safety Plan in accordance with CDM regulations.

The contractor will ensure that:

- Secure the full site boundary (if necessary, provide and erect herras-type fence to protect members of the public from the works).
- Personnel, plant, materials and other equipment related to the contract are confined within the boundaries of the site.
- Any live services lying within the site boundary are marked and protected, or appropriate arrangements made to truncate them.
- Invasive species are fenced off to ensure no spreading can occur.

- Good practices relating to personal hygiene are adopted.
- Suitable precautions are implemented at all times to prevent off-site migration of pollutants via airborne dust and vapours.
 - Suitable precautions are taken to prevent the spread of mud and debris on public highways.
- Refuelling of mobile plant is undertaken in a designated area. Above ground oil storage tanks shall comply with the requirements of Pollution Prevention Guideline PPG2. A spill kit shall be kept on site, adjacent to the designated refuelling area.

6.3.3 Engineering Supervision and Validation

Betts understand that the Engineer will ensure that the requirements of this RS are complied with in a safe and orderly manner.

The responsibilities of the Engineer shall include, but not be limited to, the following:

- Ensuring that all site personnel are suitably qualified and given an appropriate induction at the beginning of their first day.
- Supervision of the remedial and ground preparatory works by a competent and independent consultancy.
- Advice on the correct handling of materials and conditions encountered.
- Guidance on the appropriate protective clothing and safety equipment that is to be made available and used.
- Ensuring that personal hygiene arrangements are adequate.
- Retrieval of soil and water samples and the subsequent scheduling of appropriate laboratory analysis to enable validation of various aspects of the works, and to advise the Project Manager of progress
- Liaison with statutory authorities as required.

The Engineer will maintain records of the works to include the following:

- Daily record sheets to include a summary of the day's activities.
- Date and weather conditions.
- Plant, personnel and visitors present.
- Aspects relating to Health and Safety, Environmental Control, or non-compliance with this RS.
- Site surveys as necessary to record the locations of demolition, excavation and filling activity.
- Test results.

On satisfactory completion of all the works the Engineer will prepare a Validation Report. Copies of the Validation Report will be issued to the Client and the Local Authority.

The Validation Report will stand as certification that the remedial and ground preparatory works have been carried out in accordance with this RS.

The Validation Report will include:

- A summary of the preparatory & remedial works undertaken, including any works associated with

unforeseen ground conditions.

- Geotechnical test results associated with ground improvement or re-engineering beneath proposed highways and buildings.
- Copies of any correspondence with Regulators relating to specific aspects of the remedial works.
- Waste transfer notes are to be provided as part of the validation report to show an audit trail of where soil has been deposited.

For reasons of practicality, detailed daily records prepared by the Engineer during the works will not be appended to the Validation Report, but copies can be viewed at Betts offices if required.

The above recommendations will take account of the actual remedial works undertaken and may differ significantly from recommendations originally presented in the site investigation report and remedial strategy.

7 REMEDIAL WORKS (CONSTRUCTION OBJECTIVES)

7.1 Site Clearance

Site clearance will be required, as areas of hard standing are present on site. Hardstanding areas will need to be excavated and placed within less sensitive areas, such as areas of public open space and roadways. Any trees, bushes and shrubs that are required to be removed as part of the redevelopment of the site will be undertaken.

7.2 Ground Gas Protection

Radon - 'Unaffected – No special mitigation measures required'

'The GSV has been compared to the criteria outlined with CIRIA C665 to determine the level of risk to the proposed development and to ensure the appropriate remedial options are incorporated into any future building design in this area.

Ground gas monitoring shows that the site will fall under Characteristic Situation 2 / Amber 1, and specialist gas protection measures will be required with regards to ground gas concentrations.

7.3 Excavation of Hardstanding and Foundations

Tarmac hardstanding (and tarmac containing Made Ground) contains hydrocarbon compounds which are potentially contaminating. Tarmac should be lifted and placed in a stockpile separate from other arisings in order to avoid contamination. It is anticipated that tarmac arisings are suitable for re-use below proposed car parking areas or highways once they have been crushed.

Foundation arisings will need to be carefully managed to not contaminate natural soils with the overlying made ground, arisings should be segregated as they are dug out of foundation trenches/roadways etc. Arisings are physically different and as such should be able to be segregated accordingly. Subsoils will be physically assessed upon placement within garden areas, should any suspected made ground be encountered within the subsoil material placed then additional chemical validation will be required to confirm the suitability of the material placed.

The area in the south west corner identified very different composition of made ground in the form of organics / textile / paper waste / plastics within a predominantly granular matrix with boulders of concrete. Processing of this material under a mobile plant licence is anticipated with control of groundwater and groundwater treatment potentially required. It is proposed to reuse aggregate out of this area with disposal of unsuitable materials off site.

Due to proximity of railway and possibly interconnected bodies of fill / water care must be taken when considering remedial work / foundations in this locality.

[illegible]

A Materials Management Plan is to be put in place by both the contractor and developer to ensure soils are not deemed as waste / landfill and subject to HMRC taxes or fines.

7.4 Excavations

Site vigilance for unforeseen hotspots will be undertaken with the method of dealing with unforeseen contamination briefed to site management. Deep and unstable excavation should be anticipated.

7.5 Arisings

It is proposed that post removal / grubbing up / crushing and reclaiming concrete and masonry obstructions / coarse granular fill the processed material is to be reused on site as part of the earthworks and foundation strategy. It is proposed that Vibro Ground Improvement of residential dwellings is used and compaction of arisings to form hardstanding and road construction. (Detailed design awaited)

Site space is likely to be limited, however wherever possible, retention of arisings for reuse on site will be made. Foundation arisings of natural strata may be deemed chemically suitable for clean cover system and may be feasible to use in the lower capping layers. Chemical testing will be required.

Any material that is deemed to be unsuitable for re-use will be removed from the site to licensed landfill.

7.6 Dust, Vapour & Odour Control

The excavation of fill should not present a significant problem with regard to emission of dust during excavation. Nonetheless, the monitoring and mitigation measures outlined below may be required if dust, vapour or odour are noticeable.

7.7 Odour Monitoring

If necessary, olfactory monitoring for odour nuisance will be undertaken at the site boundary down-wind of the excavation area during all excavation works. Odour monitoring will be carried out at these locations no less than three times a day during active site works.

At each monitoring event, the odour level will be subjectively classified as none, slight, moderate, or high, where:

- a slight odour level is detectable but not particularly noticeable,
- a moderate odour level is noticeable but not offensive, and
- a high odour level is offensive.

If high odour levels are detected in the same location on more than two occasions during any three-day period, then one or more of the actions outlined Sections 5.7.3 below will be undertaken in order to reduce the odour levels.

7.8 Mitigation

At all times during the excavation works, Best Practicable Means shall be employed to minimise dust, odour and VOC generation and their emission off site.

If dust or VOC concentrations in air exceed the long-term trigger levels in the vicinity of the excavation area, but are below the long-term trigger levels at the site boundary, then respirator protection will be required for all site personnel working in the excavation area.

Respiratory protection that conforms to the European Product Directive (CE) shall be readily available for personnel exposed to odours. Twin cartridge respirators, that conform to EN140, fitted with class A1 filters cartridges, which conform to EN141 (organic gases and vapours), shall be used. If highly odorous material is encountered on site then masks with Class A2 filters shall be used.

In addition, one or more of the following corrective actions to mitigate against the generation of air-borne dust or volatile organic contamination will immediately commence:

- Mist and water spraying to eliminate dust and/or reduce generation of volatile compounds.
- Reduction of the exposed active excavation area by backfilling or covering to reduce the generation of volatile compounds.

If dust or VOC concentrations in air exceed the long-term trigger levels at the site boundary then excavation activities will be stopped immediately and one or more of the above corrective actions will commence. Work will not begin again until the air quality at the site boundary has returned to an acceptable level and only after all reasonable actions have been taken to prevent the air quality at the site boundary from again declining to an unacceptable level.

7.9 Export to Landfill

Any material exported from site to landfill will be hauled by a registered waste carrier in accordance with the requirements of the Duty of Care Regulations, 1991 and the Landfill (England & Wales) Regulations 2002.

A transfer note shall be completed, signed and retained by the parties involved. The transfer note shall include the volume of waste, the nature of the material and a statement of its chemical composition, details of the source and destination sites, and details of the haulier.

In order to protect the general public from dust, wagons that are to be used for the haulage of the contaminated material from the site will be sheeted. In addition, the Contractor must ensure that no fluids seep from the wagons.

In order to provide the landfill facility with information regarding chemical composition of the waste, analysis results from the ground investigation and the desk study will be supplied to the site prior to removal for classification.

As of 16th July 2005 the Waste Acceptance Criteria of the Landfill Regulations 2002 were fully implemented, which will result in the enforcement of a more stringent approach to waste assessment and its disposal to landfill.

All hazardous waste going for disposal at landfills must be classified according to the new European Waste Catalogue (EWC).

Contaminated soils are “Mirror entries” in the EWC. Waste contaminated soils may be classified as either *hazardous* or non-hazardous depending on the concentrations of “dangerous substances” in the waste soil. An assessment of the composition of the waste soil will therefore be undertaken to determine if it is hazardous waste.

The WAC set threshold concentrations for leachable components of the waste stream and landfill operators will have waste acceptance procedures in place to ensure that only compliant waste is landfilled. Most waste will need to be treated before it can be landfilled to reduce its quantity and the hazard it presents. Leaching compliance testing will be required in accordance with BS EN 12457-3:2002.

In addition, the site will be operating under a Site Waste Management Plan recording both import and export of materials.

7.10 Backfill of Excavations

Excavations and regrading (to remove relict structures, contamination etc) are to be “surveyed in” and backfilled as necessary to achieve the desired levels, with suitable materials and subjected to compaction specification, to be agreed with the Engineer. Specification to be agreed prior to remediation – dependant upon foundation strategy.

However, where an excavation conflicts with the footprint of a proposed adopted highway, compaction in accordance with the Specification for Highway Works Table 6/1 will be undertaken.

7.11 Boundary Issues

The Client's Designer should ensure that proposed levels tie in with the surrounding infrastructure, and ground levels of adjacent properties.

7.12 Highways

The contractor will agree acceptable performance criteria, and an appropriate Specification for any necessary ground improvement, with the Client and the adopting authority where necessary.

The Contractor will arrange for the necessary compliance testing to be undertaken at formation level on road alignments, as required by the adopting authority and Engineer.

7.13 Protection of Buried Concrete

It is considered for concrete design purposes that a brownfield site and mobile groundwater conditions are applicable, and the results are summarised below:

AREA AROUND TP1, TP3 and TP5 - Concrete Classification	
Design Sulphate Class	DS-2
ACEC Class	AC-2
Design Concrete Class	DC-2

Rest of Site - Concrete Classification	
Design Sulphate Class	DS-1
ACEC Class	AC-1
Design Concrete Class	DC-1

8 METHODOLOGY / PROGRAMME

8.1 Imported Soil

- Desk study undertaken to establish source
- Source used to determine sampling frequency / chemical analysis scheduling.
- Engineer to attend source site and collect representative samples for assessment.
- Samples analysed and screened for end use suitability for residential with root uptake.
- Validation from Local Authority for suitability.
- Import soil to site and place in garden areas to the agreed cover thickness.
- Engineer to attend site and undertake photographic cover thickness validation via hand dug exposure pits on the basis of 1:3 gardens. Report to be produced and submitted to the local Authority for approval.

Capping could be made of existing natural strata once proven to be clean and if commercially viable to retrieve.

Within Garden Areas

150mm topsoil
450mm subsoil (free of construction debris)
Geotextile membrane

Within Soft Landscaped Areas

150mm topsoil
150mm subsoil (free of construction debris)
<i>Proven to a depth of 450mm, in line with NHBC guidance.</i>

The above is proposed to comply with NHBC regulations regarding physical composition of cover as below:

- Section 10.2.9 states – Garden Areas:
 - o *old foundations, concrete bases and similar obstructions removed from within 450mm of the finished ground surface. – this has been completed during the remediation and enabling works.*
 - o *Subsoil should not be placed over topsoil. Construction rubbish and debris should be removed from the garden and other areas around the home before topsoiling, and before or after planting, turfing or seeding.*
- Section 10.2.7 states – Materials:
 - o *Topsoil and subsoil should be of a quality that will not present a hazard to users of the garden area.*

The significant risk to construction workers is mitigated by the proper use of PPE and welfare facilities.

Any soils intended for use as part of the clean cover (including site won material) will be tested at source or stockpiled on site until approved for use by the Supervising Engineer. Topsoil testing will be carried out at the frequencies below;

Intended End Use	Source / Origin of Material		
	Greenfield	Remediated	Brownfield / Unknown
Gardens	1:200m ³	1:100m ³	1:50m ³
Soft Landscaping	1:200m ³	1:150m ³	1:150m ³
Other	1:200m ³	1:200m ³	1:200m ³

Chemical analysis should be assessed using a desk study/details of historic use of the site where the imported soil originated. Chemical analysis is likely to include (but is not limited to); CLEA Metals (Arsenic, cadmium, chromium (Vi), lead, mercury, selenium, copper, nickel and zinc), pH values, Sulphate - soluble 2:1 extract, speciated polycyclic aromatic hydrocarbons (PAH), extractable petroleum hydrocarbons (EPH), TPH CWG, Asbestos screening and Organic matter.

This work may be undertaken as part of the contract for the preparatory & remedial works, in which case imported soils should be stockpiled in a location agreed with the Engineer. Alternatively, the Developer may choose to import soil at a later stage in the development.

In order to demonstrate that the required depth of 'clean' cover material has been placed across the required areas (i.e. within garden areas and areas of landscaping) a post-fill survey will be undertaken by hand-dug pits and provision of photographic evidence of the cover system within rear gardens. This will be provided to the contractor for their records.

It is suggested that given the garden size proposed, the simplest way to validate the soil is to sample 1 garden in 3 for imported topsoil and subsoil, along with a depth test in each plot to prove depth of cover is sufficient in garden areas.

8.2 Contingency for Unknown

There is at this stage a potential risk of localised, unidentified contaminated Made Ground being present at the site.

Should any suspicious material be encountered during the remediation works, the area will be investigated further by a Betts Geo Environmental engineer and sampled as necessary. The Contaminated Land Officer at the Local Authority will also be notified if the material is deemed to represent a risk to environmental receptors or public health. Samples will be forwarded to a UKAS accredited laboratory for a suite of analytical testing deemed appropriate based upon a visual and olfactory appraisal of the material identified.

Once the results of any analysis are known, the required remedial action (if any) will be determined.

8.3 Construction Workers

Due to the presence of contaminated Made Ground soils, a risk exists (in the short term) to any ground/construction workers involved in the redevelopment of the site.

A full discussion of the results of existing chemical analysis and the levels of contamination within these soils is included within the Pre-Tender Health and Safety File. The Contractor is aware of the presence of such soils and has therefore allowed for adequate Personal Protective Equipment to be provided on site.

It is recommended that full reference should be made to current guidance documents such as the HSE document "Protection of Workers and the General Public during the Redevelopment of Potentially Contaminated Land" HS (G) 66, HSE.

The results of all relevant chemical analysis will be provided to the relevant service providers in order to confirm any special precautions that may be required in respect of the installation of services and the protection of their workers.

8.4 Site Certification

Once the remediation works have been undertaken, a 'completion' report (as described in Section 4.3.3 of this report) will be prepared. This will comprise relevant site records and stand as certification that the appropriate remediation works have been carried out in accordance with the agreed redevelopment strategy. Reports will be submitted to the Local Authority for their approval, thereby enabling the release of the site for subsequent development.

9 Remediation Hold points

Demo Phase	Treatment of invasive species General site clearance Protection of controlled waters measures
Post-Demo Phase	Break and processing of hardstanding Regrade to site levels Replacement of 600mm pipe and clearing of goyt lodge Backfill of excavations
Construction Phase	Installation of ground gas protection measures Installation of clean and inert capping

Notes on Limitations

This report does not consider ecological impacts (e.g. bats) or botanical risks (e.g. Japanese knotweed). It is recommended that these are considered as part of the assessment of development constraints for the site.

The assessment and judgements given in this report are directed by both the finite data on which they are based and the proposed works to which they are addressed. The data essentially comprised a study of available documented information from various sources (including Client Furnished reports) together with discussions with relevant authorities and other interested parties. There may also be circumstances at the site that are not documented. The information reviewed is not exhaustive and has been accepted in good faith as providing representative and true data pertaining to site conditions. If additional information becomes available which might impact our environmental conclusions, we request the opportunity to review the information, reassess the potential concerns and modify our opinion if warranted.

It should be noted that any risks identified in this report are perceived risks based on the available information. Actual risks can only be assessed following a physical investigation of the site.

The site investigation has been carried out to provide information concerning the type and degree of contamination, and ground and groundwater conditions to allow a reasonable risk assessment to be made. Betts Geo Environmental Ltd undertake to exercise all reasonable skill, care and due diligence in the exercise of the investigation with respect to sampling techniques, sample storage and report interpretation.

The assessments and judgement given in this report are directed by both the finite data on which they are based and the proposed works to which they are addressed. Data acquisition is subject to the limitations of the methods of investigation used. Exploratory holes undertaken during fieldwork investigate small a small volume of ground in relation to the size of the site and as such can only provide an indication of site conditions. There may be conditions pertaining to the site and the proposed development i.e. localised "hotspots" of contamination, which have not been disclosed by the investigations.

The findings and opinions are relevant to the dates of our site works and should not be relied upon to represent conditions at substantially later dates. Conditions at the site will change over time due to natural variations and anthropogenic activities. Groundwater, surface water and soil gas conditions should be anticipated to change with diurnal, seasonal and meteorological variations.

The opinions expressed in this report regarding any contamination are based on simple statistical analysis and comparison with available guidance values. No liability can be accepted for the retrospective effects of any changes or amendments to these values.

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