

5. CONSULTATIONS

5.1. LANDFILL SITES AND WASTE TREATMENT SITES

There are no active or historical landfill sites within 500 m of the site.

A licensed waste site 181 m NW of the site surrendered its license on 06/06/2010. No other active or historical waste sites are within 250 m of the site.

5.2. REGULATORY DATABASE

The information summarised in Table 5.1 has been obtained from a commercially available environmental database. The summary table only includes records from within 250 m of the subject site and not otherwise detailed in the report.

TABLE 5.1 SUMMARY OF ENVIRONMENTAL DATA

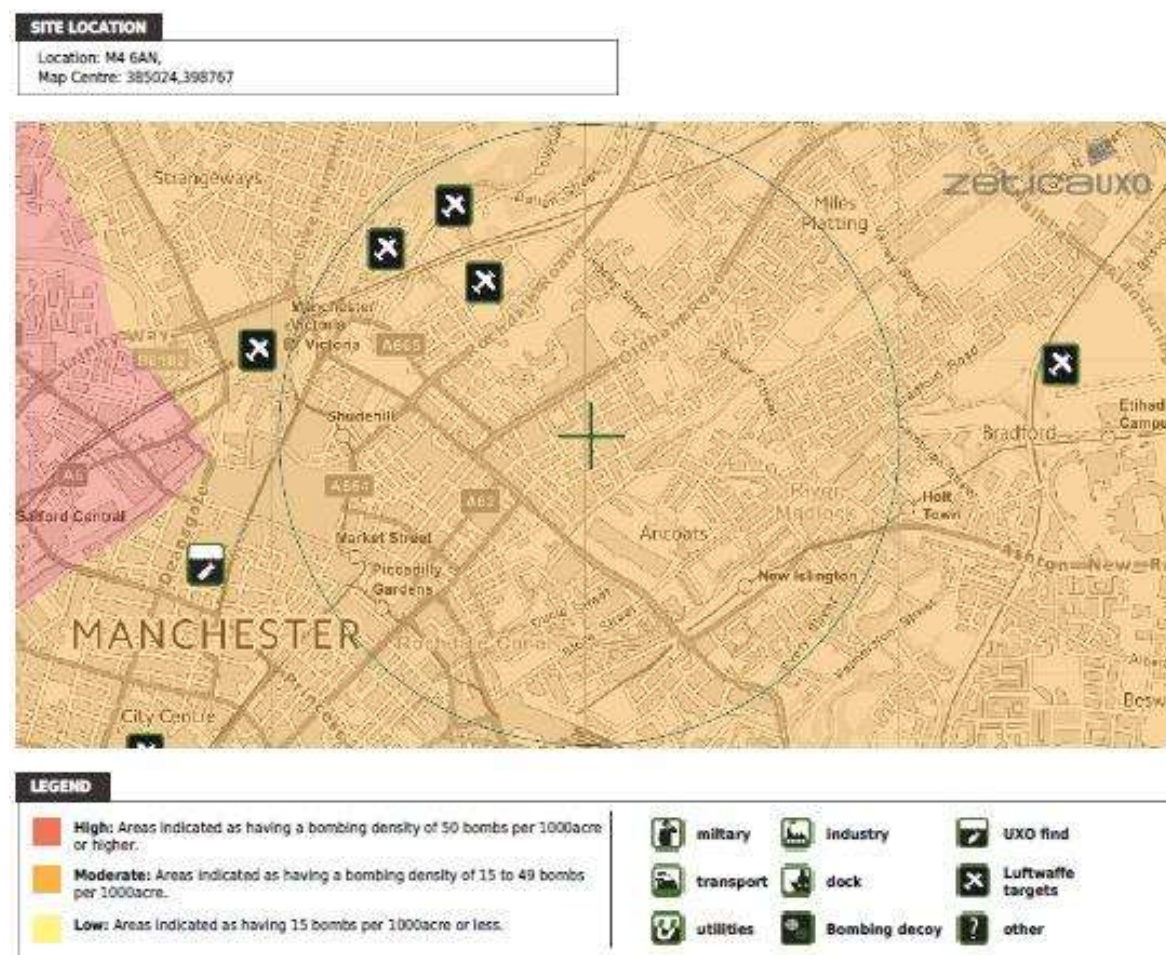
RECORD	ENTRIES WITHIN 250 m	DETAILS
Contaminated Land Register Entries and Notices	0	None Identified
Authorised Industrial Processes (IPC/IPPC/LAPPC)	1	202 m SW - Express Printers Manchester Ltd, Henry Street, M60 4HB - Coating Process, Historical Permit Part B - No Date
Fuel Stations Entries	2	64 m SW - Obsolete - 27 Gun Street, Ancoats, M4 5DN - Status: Obsolete 250 m NW - Unbranded - 12 Rochdale Road/Bendix Street, M24 6DP - Status: Obsolete
Licensed Radioactive Substances	0	None Identified
Enforcements, Prohibitions or Prosecutions	0	None Identified
Discharge Consents	0	None Identified
Pollution Incidents	2	17/05/2001 - 218 m SE - Pollutant: Contaminated Water - Water Impact: Cat 3 (Minor) 22/05/2001 - 227 m SE - Pollutant: Contaminated Water - Water Impact: Cat 3 (Minor)
Consents Issued Under the Planning (Hazardous Substances) Act 1990	0	None Identified
Control of Major Accident Hazard (COMAH) Sites	0	None Identified



5.3. UNEXPLODED ORDNANCE

The regional unexploded bomb risk map from Zetica (2014) indicates that the site is in an area at moderate risk from possible unexploded ordnance (UXO) resulting from the Second World War. The Zetica UXO Risk Map is presented as Figure 5.1.

FIGURE 5.1 ZETICA UXO RISK MAP



Source - <https://zeticauxo.com/downloads-and-resources/risk-maps/>



6. INITIAL CONCEPTUAL SITE MODEL

In accordance with EA LCRM (2019) and BSI 10175 (Code of Practice for Investigation of Potentially Contaminated Land), E3P has developed an initial conceptual site model (CSM) to identify potential contamination sources, migration pathways and receptors within the study area. This is summarised within Table 6.1.

ON-SITE SOURCES OF CONTAMINATION

The following potential on-site sources of contamination have been identified:

- ✚ Made Ground fill deposits – Heavy metals and inorganic compounds, PAHs, hydrocarbon compounds, asbestos, hazardous ground gas (methane and carbon dioxide).

OFF-SITE SOURCES OF CONTAMINATION

The following potential off-site source of contamination have been identified:

- ✚ Made Ground fill deposits – Heavy metals and inorganic compounds, PAHs, hydrocarbon compounds, asbestos, hazardous ground gas (methane and carbon dioxide).

- ✚ 50 m E - Brass Foundry

- Heavy Metals: Copper, Zinc
- Mineral Acids
- Oils/Fuels
- Inorganic Compounds
- Organic Solvents
- Organic Acids
- Alkalis

- ✚ 70 m E - Iron Foundry

- Heavy Metals: Iron, Lead, Zinc
- Inorganic Compounds: Fluoride, Cyanide, Sulphates



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TABLE 6.1 INITIAL CONCEPTUAL SITE MODEL

SOURCE	PATHWAY		RECEPTOR
Human Health			
Heavy Metals, PAHs Associated Within Made Ground and nearby Brass and Iron Foundries	Dermal Contact and Ingestion. Consumption of Homegrown Produce.	Construction Workers. Residential End Users.	
Discussion: Made Ground associated with multiple historical phases of development is likely to be present across the whole site. Made Ground may be impacted by heavy metals, hydrocarbons, and polycyclic aromatic hydrocarbons (PAH). If present, heavy metals and non-volatile PAHs may pose a short-term risk to construction workers who may come into contact with impacted soils during earthworks. The proposed development will cover the ground entirely with hard standing; therefore, future site users are very unlikely to come into contact with impacted soils.			
Recommendation: An intrusive investigation will be required with chemical analysis to assess the potential contaminants.			
Asbestos-Containing Materials (ACMs) within Made Ground	Fibre/Dust Inhalation.	Construction Workers. Residential End Users. Third-Party Property.	
Discussion: Asbestos may be present in any localised Made Ground associated with the demolition of historic developments. ACM poses a risk through fibre and dust inhalation and if present may pose a risk to construction workers during any future earthworks/demolition and to adjacent third-party property should dust be generated during those works.			
Recommendation: An intrusive investigation will be required with chemical analysis to determine the presence and extent of asbestos.			



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SOURCE	PATHWAY	RECEPTOR
Hazardous Ground Gases		
Methane and Carbon Dioxide Associated with Possible On-Site Fill Material	Inhalation. Accumulation.	Construction Workers. Residential End Users.
Discussion: Made Ground is a potential source of hazardous ground gases such as carbon dioxide and methane which have associated asphyxiation and explosive risks. If present, the risks can be appropriately mitigated through the careful design of building structures, therefore, reducing the risk of direct contact to the end-user.		
Recommendation: Ground gas monitoring will be required to classify the site.		
Controlled Waters		
Mobile Contaminants within Made Ground	Vertical/Lateral Migration.	Primary Bedrock Aquifer. Secondary Undifferentiated Superficial Aquifer.
Discussion: No significant sources of mobile contamination have been identified, there is potential for some within localised impacted Made Ground. Clay-dominated drift deposits beneath the site would hinder the migration of any mobile contamination. The sensitivity of the underlying aquifer is reduced given the site is not within a source protection zone and there are no groundwater abstractions within 1 km.		
Recommendation: Intrusive investigation with chemical analysis of soil samples is recommended.		



SOURCE	PATHWAY	RECEPTOR
Buildings and Infrastructure		
pH and Sulphate	Corrosion of Concrete.	Foundations/Concrete.
Discussion: The presence of pH and sulphate within Made Ground deposits may result in corrosion of buried concrete within the proposed development. Assessment must be undertaken to confirm the levels of pH and sulphate within the underlying strata and any Made Ground deposits so that a concrete classification can be determined. Recommendation: A sampling of the soils is required.		



7. GROUND INVESTIGATION

7.1. GENERAL OVERVIEW

A ground investigation has been designed based on the findings of the desk study, with exploratory holes advanced to target specific potential contaminant sources summarised in Table 7.1. The investigation has also been used to collect geotechnical information to assist in the design and construction of the proposed development.

Exploratory fieldwork was completed on the 23rd of November 2021. The works are summarised in Table 7.1.

7.2. SCOPE OF INVESTIGATION

TABLE 7.1 SUMMARY OF FIELDWORK

POTENTIAL SOURCE/RATIONALE	LOCATION HOLE	TYPE	MAXIMUM DEPTH (m bgl)	MONITORING WELLS RESPONSE ZONE (m bgl)
Ground Investigation of in situ materials beneath existing and proposed building	WS101	Window Sample Probe hole	5.45	0.50 - 0.70
	WS102		5.45	1.00 - 5.00
	WS103		5.45	1.00 - 3.00
	WS104		5.45	0.50 - 1.00
	WS105		5.45	N/A

Window sample probeholes were advanced to undertake in-situ detailed geotechnical testing, obtain environmental samples and install groundwater and ground gas monitoring wells.

The sampling locations are illustrated in Drawing 15-018-005 (Appendix III). The ground conditions encountered are indicated on the logs, which are provided in Appendix IV.

7.3. IN-SITU STANDARD PENETRATION TESTING (SPT)

In-situ geotechnical testing was conducted using the standard penetration test (SPT) and, where the ground is granular, a 60° cone (SPT(C)) was used instead of the sampling tube. The results are shown in the probehole logs in Appendix IV and presented in Table 8.4 and discussed in Section 10.

7.4. LABORATORY ANALYSIS

Selected soil samples were submitted for a range of chemical analysis comprising:

-  Metals.
-  pH, total sulphate, water-soluble sulphate (2:1 extract).
-  Sulphide.
-  Cyanide.



-  Phenols.
-  Total and speciated polycyclic aromatic hydrocarbons (PAHs).
-  Asbestos identification.
-  Speciated and banded total petroleum hydrocarbon (TPH).

I2 Analytical undertook the analytical work and the testing results are included in Appendix VI and discussed in Section 9.

Selected samples were submitted to PSL Laboratory where the following geotechnical tests were undertaken:

-  Atterberg limits determinations
-  Moisture Content; and
-  Single-stage triaxial tests.

Laboratory analysis sheets are included in Appendix VIII and are summarised in Section 8.



8. GROUND AND GROUNDWATER CONDITIONS

8.1. SUMMARY OF GROUND CONDITIONS

The ground investigation generally confirms the published geology and identifies the strata set out in Table 8.1.

TABLE 8.1 SUMMARY OF STRATA

HOLE	DEPTH TO STRATUM (m bgl)		
	MADE GROUND	FIRM CLAY	STIFF CLAY
WS101	0.00–0.70	0.70-1.20	1.20-5.45
WS102	0.00–0.30	–	0.30-5.45
WS103	0.00–0.50	–	0.50-5.45
WS104	0.00–1.00	–	1.00-5.45
WS105	0.00–1.00	–	1.00-5.45

8.2. MADE GROUND

Made Ground deposits were encountered within all exploratory hole locations to depths of between 0.30 m to 1.00 m bgl at most.

Made Ground deposits comprise reworked topsoil of dark brown, clayey, sandy, gravel with brick, metal, ceramic and clinker in the majority of locations. In the northern sector, Made Ground deposits are slightly deeper.

A Depth of Made Ground Plan is presented as Drawing 15-018-006 in Appendix III.

8.3. DRIFT DEPOSITS

Drift deposits were encountered within all exploratory locations. The drift deposits are homogenous across the site, generally comprising a stiff to very stiff, medium to high strength, brown or grey mottled brown CLAY with gravel of sandstone and mudstone.

The CLAY contains localised lenses of orange, fine to medium SAND.

8.4. SOLID GEOLOGY

The solid bedrock geology was not encountered in any exploratory hole on site. BGS boreholes in the area suggest bedrock can be expected in excess of 20.00 m bgl.

8.5. GROUNDWATER

No groundwater strikes were encountered.

8.6. VISUAL AND OLFACTORY EVIDENCE OF CONTAMINATION

Visual evidence of potential contamination has been identified during the site investigation and these are summarised in Table 8.2.



TABLE 8.2 SUMMARY VISUAL AND OLFACTORY EVIDENCE OF CONTAMINATION

LOCATION	DEPTH (m)	STRATUM	NOTES
TP101	0.1	Made Ground	Clinker
TP102	0.2	Made Ground	Clinker
TP103	0.2	Made Ground	Clinker and burnt material
TP104	0.4	Made Ground	Clinker
TP105	0.6	Made Ground	Clinker

8.7. SOIL CONSISTENCY

Undrained shear strength values were measured using laboratory undrained triaxial tests. Results of the tests are presented in Table 8.3, which indicate the clay soils to be firm strength. Strength test data is generally consistent with the field descriptions of the aforementioned soils.

TABLE 8.3 SUMMARY OF UNDRAINED SHEAR STRENGTH TEST RESULTS

LOCATION	SAMPLE DEPTH (m)	LAB DESCRIPTION	UNDRAINED SHEAR STRENGTH (kN/m ²)	CONSISTENCY
WS101	1.50-2.00	Firm brown very sandy CLAY.	79	Firm
WS102	1.50-2.00	Firm brown sandy CLAY.	63	Firm

Results of the standard penetration tests, including undrained shear strengths derived from SPTs are included in Table 8.4.

8.8. SIDE STABILITY AND EASE OF EXCAVATION

The natural strata were excavated with relative ease. No obstructions were identified at the positions investigated.

It is anticipated that shallow excavations can be completed with normal plant in consideration of the potential neighbouring slabs and foundations that may step into the subject site.



TABLE 8.4 STANDARD/CONE PENETRATION TEST RESULTS

BOREHOLES	DEPTH (m bgl)	MATERIAL FIELD DESCRIPTION	CPT/SPT "N" VALUE	CORRECTED "N" VALUE (N ₁) ₆₀	TERZAGHI & PECK RELATIVE DENSITY (SANDS)	EUROCODE SOIL STRENGTH	CONSISTENCY (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m ²)	ALLOWABLE BEARING PRESSURE (kN/m ²)*
WS101	1.00	Gravelly CLAY.	9	9.07	N/A	Medium strength	Stiff	45.37	93.27
WS101	2.00	Gravelly CLAY.	18	16.44	N/A	High strength	Very Stiff	82.22	169.04
WS101	3.00	CLAY.	19	16.52	N/A	High strength	Very Stiff	82.62	169.86
WS101	4.00	CLAY.	15	12.67	N/A	Medium strength	Stiff	63.36	130.28
WS101	5.00	CLAY.	19	15.76	N/A	High strength	Very Stiff	78.81	162.04
WS102	1.00	Gravelly CLAY.	10	10.08	N/A	Medium strength	Stiff	50.41	103.64
WS102	2.00	Gravelly CLAY.	17	15.53	N/A	High strength	Very Stiff	77.65	159.65
WS102	3.00	CLAY.	17	14.78	N/A	Medium strength	Stiff	73.92	151.98
WS102	4.00	CLAY.	14	11.83	N/A	Medium strength	Stiff	59.14	121.59
WS102	5.00	CLAY.	19	15.76	N/A	High strength	Very Stiff	78.81	162.04
WS103	1.00	Gravelly CLAY.	12	12.10	N/A	Medium strength	Stiff	60.49	124.37
WS103	2.00	CLAY.	18	16.44	N/A	High strength	Very Stiff	82.22	169.04
WS103	3.00	CLAY.	19	16.52	N/A	High strength	Very Stiff	82.62	169.86
WS103	4.00	CLAY.	17	14.36	N/A	Medium strength	Stiff	71.81	147.65



BOREHOLES	DEPTH (m bgl)	MATERIAL FIELD DESCRIPTION	CPT/SPT "N" VALUE	CORRECTED "N" VALUE (N ₁) ₆₀	TERZAGHI & PECK RELATIVE DENSITY (SANDS)	EUROCODE SOIL STRENGTH	CONSISTENCY (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m ²)	ALLOWABLE BEARING PRESSURE (kN/m ²)*
WS103	5.00	CLAY.	20	16.59	N/A	High strength	Very Stiff	82.96	170.57
WS104	1.00	Gravelly CLAY.	14	14.11	N/A	Medium strength	Stiff	70.57	145.09
WS104	2.00	Gravelly CLAY.	21	19.18	N/A	High strength	Very Stiff	95.92	197.21
WS104	3.00	Gravelly CLAY.	18	15.65	N/A	High strength	Very Stiff	78.27	160.92
WS104	4.00	CLAY.	14	11.83	N/A	Medium strength	Stiff	59.14	121.59
WS104	5.00	CLAY.	21	17.42	N/A	High strength	Very Stiff	87.11	179.10
WS105	1.00	Gravelly CLAY.	12	12.10	N/A	Medium strength	Stiff	60.49	124.37
WS105	2.00	Gravelly CLAY.	26	23.75	N/A	High strength	Very Stiff	118.76	244.17
WS105	3.00	Gravelly CLAY.	23	20.00	N/A	High strength	Very Stiff	100.01	205.62
WS105	4.00	CLAY.	19	16.05	N/A	High strength	Very Stiff	80.26	165.02
WS105	5.00	CLAY.	23	19.08	N/A	High strength	Very Stiff	95.41	196.16

NOTES

* The Allowable Bearing Pressure (ABP) should be considered indicative.

The interpretation of in situ mass undrained shear strength (cu) data from SPT Blow Count (N) results and the influence of the Plasticity Index (PI) was reported in Standard Penetration Test in Insensitive Clays and Soft Rocks. Stroud (1974). The standard penetration test and the engineering properties of glacial materials subsequently. Stroud and Butler (1975) and (1989).

Allowable bearing pressure on sands. Soil Mechanics in Engineering Practice Terzaghi, K. & Peck, R.B. 1996.



8.9. SOIL PLASTICITY

The liquid and plastic limits of samples of natural in-situ clay are determined using the cone penetrometer method and the rolling thread test. These tests enable determination of an average plasticity index (PI) for each “type” of clay, although judgement is applied where variable results are reported.

PI can be related to shrinkability (low, medium or high) and then to minimum founding depth.

E3P typically only consider a soil to be shrinkable if the proportion finer than 63 µm is > 35%.

PI results are compared against guidance given in the NHBC standards, Chapter 4.2 (revised January 2014), which advocates the use of modified plasticity index (I_p), defined as:

$$I_p = I_p \times (\% < 425 \mu\text{m}/100)$$

In other words, if PI is 30%, but the soil contains 80% < 425 µm, then I_p = 30 × 80/100 = 24%.

It should be noted that in accordance with the requirements of BS 1377, the % passing the 425 µm sieve is routinely reported by testing labs.

E3P apply engineering judgement where PI results are spread over a range of classifications. Consideration is given to the average values for each particular soil type (differentiate between residual soil and alluvium), the number of results in each class and the actual values.

The Atterberg limits determinations, summarised in Table 8.5, show the clay to be of predominantly moderate plasticity.

TABLE 8.5 SUMMARY OF PLASTICITY INDEX TEST RESULTS

LOCATION	DEPTH (m)	NATURAL MOISTURE CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING 425 µm SIEVE (%)	MODIFIED PLASTICITY INDEX	NHBC VOLUME CHANGE POTENTIAL
WS101	1.00	19	22	48	26	100	26	Medium
WS102	2.00	18	21	44	23	100	23	Medium
WS102	3.00	19	21	43	22	100	22	Medium

The results of the Atterberg limits testing confirmed that the soils would be deemed to be Medium Volume Change Potential” in accordance with the classification system utilised by the LABC/NHBC industry guidance.

8.10. pH AND SULPHATE

Chemical analyses for pH and soluble sulphate content contained in Appendix V (summarised in Table 8.6), shows that the soils at the site generally meet Class DS-1, Aggressive Chemical Environment for Concrete Classification (ACEC) AC-1s in accordance with BRE *Special Digest 1* (2005).

Elevated sulphate concentrations meeting Class DS-2, AC-1s were noted within the Made Ground deposits in WS101 (0.10 m), WS102 (0.30 m), WS104 (0.30 m), WS105 (0.40 m).



TABLE 8.6 SUMMARY OF pH AND SULPHATE DATA

LOCATION	DEPTH (m)	SO ₄ IN 2:1 WATER/SOIL (g/l)	pH VALUE	CLASSIFICATION
WS101	0.10	0.56	7.8	DS-2, AC-1s
WS101	3.00	0.11	7.7	DS-1, AC-1s
WS102	0.30	0.60	8.2	DS-2, AC-1s
WS103	0.20	0.26	7.2	DS-1, AC-1s
WS103	4.00	0.029	8.2	DS-1, AC-1s
WS104	0.30	0.82	7.0	DS-2, AC-1s
WS105	0.40	0.52	7.0	DS-2, AC-1s
WS105	3.50	0.12	8.2	DS-1, AC-1s



9. TIER I QUALITATIVE CONTAMINATED LAND RISK ASSESSMENT

E3P has undertaken a Tier 1 qualitative risk assessment to determine if any potential contaminants within the underlying soils and groundwater pose an unacceptable level of risk to the identified receptors.

9.1. HUMAN HEALTH RISK ASSESSMENT

At Tier 1 stage, the long term (chronic) human health toxicity of the soil has been assessed by comparing the on-site concentrations of organic and inorganic compounds with reference values published in LQM/CIEH S4UL (S4UL3267).

Where Tier 1 screening values are not provided by LQM, other screening values have been used and these are referenced in Table 9.1.

The results of this comparison have been summarised within Table 9.1.

TABLE 9.1 SUMMARY OF INORGANIC AND HYDROCARBON TOXICITY ASSESSMENT FOR A RESIDENTIAL END USE WITHOUT PLANT UPTAKE

DETERMINANT	UNIT	GAC	N	MC	LOC. OF EX	PATH-WAY	ASSESSMENT
Arsenic	mg/kg	40	2	40	WS104 - 0.30 m	1	Further Action
Cadmium	mg/kg	85	2	< 0.2	N/A	1	No Further Action
Chromium (VI)	mg/kg	6	2	< 4.0	N/A	1	No Further Action
Lead	mg/kg	200	2	400	WS104 - 0.30 m	1	Further Action
Mercury	mg/kg	1.2	2	2.5	WS104 - 0.30 m	4	Further Action
Nickel	mg/kg	180	2	39	N/A	1	No Further Action
Selenium	mg/kg	430	2	< 1.0	N/A	1	No Further Action
Copper	mg/kg	7100	2	210	N/A	1	No Further Action
Zinc	mg/kg	40000	2	280	N/A	1	No Further Action
Cyanide – Total	mg/kg	791	2	< 1.0	N/A	1	No Further Action
Phenols – Total	mg/kg	210	2	< 1.0	N/A	1	No Further Action
Asbestos	Fibres	NFD	2	< 0.01	N/A	3	No Further Action
Naphthalene	mg/kg	2.3	2	< 0.05	N/A	4	No Further Action
Acenaphthylene	mg/kg	2900	2	< 0.05	N/A	2	No Further Action
Acenaphthene	mg/kg	3000	2	< 0.05	N/A	1	No Further Action
Fluorene	mg/kg	2800	2	< 0.05	N/A	1	No Further Action
Phenanthrene	mg/kg	1300	2	0.61	N/A	2	No Further Action
Anthracene	mg/kg	31000	2	< 0.05	N/A	2	No Further Action
Fluoranthene	mg/kg	1500	2	0.69	N/A	2	No Further Action
Pyrene	mg/kg	3700	2	0.68	N/A	2	No Further Action
Benzo(a)Anthracene	mg/kg	11	2	0.42	N/A	2	No Further Action
Chrysene	mg/kg	30	2	0.33	N/A	2	No Further Action
Benzo(b)Fluoranthene	mg/kg	3.9	2	0.39	N/A	2	No Further Action



DETERMINANT	UNIT	GAC	N	MC	LOC. OF EX	PATH-WAY	ASSESSMENT
Benzo(k)Fluoranthene	mg/kg	110	2	0.21	N/A	2	No Further Action
Benzo(a)Pyrene	mg/kg	3.2	2	0.34	N/A	2	No Further Action
Indeno(123-cd)Pyrene	mg/kg	45	2	< 0.05	N/A	2	No Further Action
Dibenzo(a,h)Anthracene	mg/kg	0.31	2	< 0.05	N/A	2	No Further Action
Benzo(ghi)Perylene	mg/kg	360	2	< 0.05	N/A	2	No Further Action
TPH C5-C6 (aliphatic)*	mg/kg	42	2	< 1.0	N/A	4	No Further Action
TPH C6-C8 (aliphatic)*	mg/kg	100	2	< 0.1	N/A	4	No Further Action
TPH C8-C10 (aliphatic)*	mg/kg	27	2	< 0.1	N/A	4	No Further Action
TPH C10-C12 (aromatic)*	mg/kg	250	2	< 2.0	N/A	4	No Further Action
TPH C12-C16 (aromatic)*	mg/kg	1800	2	< 4.0	N/A	4	No Further Action
TPH C16-C21 (aromatic)*	mg/kg	1900	2	< 1.0	N/A	1	No Further Action
TPH C21-C35 (aromatic)*	mg/kg	1900	2	< 1.0	N/A	1	No Further Action

Notes

PL1 = soil ingestion, PL2 = dermal contact and ingestion, PL3 = dust inhalation; PL4 = Vapour/Gas Inhalation; PL5 = Vertical / Lateral Migration; PL6 = Corrosion of concrete; PL7=Tainting of water supply; PL8 = Uptake by plants

Abbreviations: GAC = general assessment criteria, n = number of samples, MC = maximum concentration; Loc of Ex = location of exceedance; NFD = no fibres detected.

* The Tier 1 GAC for the hydrocarbon fraction is derived from the CIEH assessment for petroleum hydrocarbons Criteria Working Group (CWG) for both aliphatic and aromatic compounds. E3P has utilised the Tier 1 values for aliphatic compounds for the volatile and semi volatile fractions (C5-C12) and the Tier 1 values for aromatic compound for the non-volatile fractions (C12-C35). The comparison of a total (aliphatic/aromatic) compounds to an individual fraction is considered to be a conservative approach and satisfactory for the protection of human health.

Referring to Table 9.1, the results of this direct comparison indicates that the data exceeds the screening criteria for a residential end use (without plant uptake) for the following contaminants:

- ✿ Arsenic.
- ✿ Lead.
- ✿ Mercury.

No significant concentrations of VOCs were identified in the soils submitted for chemical analysis.

The laboratory analysis confirms the assessment within the initial conceptual site model that the main constituents of concern were likely to be Made Ground Heavy Metals.

In relation to these exceedances, the following can be determined:

- ✿ The main exposure pathways based on the Tier I exceedances are:
 - Soil ingestion;
 - Vapour inhalation (indoor);



- ✿ The exceedances for all determinants are associated with shallow Made Ground deposits within WS104 at 0.30 m bgl.

HUMAN HEALTH RISK ASSESSMENT AND MITIGATION

All of the identified elevated concentrations have primary exposure pathways related to ingestion of soils and vapour inhalation. The risk to chronic human health associated with the elevated concentrations of inorganic heavy metals can be mitigated through the application of hardstanding throughout the site footprint to remove any potential for direct exposure to impacted soils (other than vapours).

At this time it has not been possible to undertake a speciation of the identified mercury exceedance. mercury may present potential volatilisation to indoor air risk. The elevated concentration has only been identified within one discrete area of the site within the shallow Made Ground and is therefore considered to be a localised hotspot. Where mercury speciation returns results confirming no elemental mercury, then the GAC limits (1.2 mg/kg) will no longer apply as this is based on vapour inhalation. The detected level of 2.5 mg/kg will then be related to inorganic mercury and the associated GAC will be 40mg/kg. Where this is the case further assessment and mitigation measures will not be required.

Chemical analysis of the natural clay drift deposits has identified these soils to be acceptable for use within the context of a residential development. No garden areas are proposed for the plot and so no topsoil is likely required, and existing subsoil/Made Ground will be capped by the building slab and so no risk will remain.

9.2. CONTROLLED WATERS RISK ASSESSMENT

E3P has undertaken a controlled waters risk assessment for the site based on the consideration of the conceptual site model and the sensitive receptors which are summarised in Table 9.2.

TABLE 9.2 CONTROLLED WATERS CONCEPTUAL MODEL AND SENSITIVITY PROFILE

DISCUSSION	SENSITIVITY RATING
Contaminant Source	
Made Ground Heavy metals are present as a result of the potential Made Ground infill material from historic features at the site.	Moderate
Pathway	
Vertical Migration Due to the majority of the site being underlain by cohesive glacial till deposits, vertical migration of contaminants is unlikely to occur as a result of the low permeability of the drift deposits. According to nearby borehole data, these clay deposits are present beneath Made Ground across the site to depths in excess of 20.00 m. The presence of this low permeability drift will offer protection to the underlying aquifer and inhibit lateral migration of any contaminants towards the canal.	Low
Lateral migration Lateral migration of contaminants is considered unlikely due to the presence of cohesive glacial till deposits across the site, low contaminant risk and absence of viable receptors in the area surrounding the site.	Low



Receptor		
Aquifer Classification in Superficial Drift Deposits	Secondary Undifferentiated aquifer	Low
Aquifer Classification in Bedrock	Principal aquifer (overlain by in excess of 20 m cohesive materials)	Low
Groundwater Source Protection Zone or Drinking Water Safeguard Zone	The site is not affected	Low
Distance to the Closest Groundwater Abstraction Point	None identified within a 1 km radius.	Low
Is the Site Located Within 50 m of a Surface Watercourse?	The nearest surface watercourse is the Rochdale Canal located over 250 m southeast of the site.	Low
The ICSM developed within the context of the site setting does not have a viable pollutant pathway.		

To ensure a robust appraisal of the identified risk to controlled waters, E3P has identified the sources of potential contamination that represent a risk to controlled waters from the initial CSM, we have then assessed the availability of ground investigation data in the form of analysis of the solid phase (soil) and dissolved phase within the perched groundwater or aquifer. The results of this assessment are presented in Table 9.3.

TABLE 9.3 QUALITATIVE RISK TO CONTROLLED WATERS FROM SOIL ANALYTICAL RESULTS

CONTAMINANT	ASSESSMENT RATING	DISCUSSION
BTEX > 1 mg/kg	No samples were tested for VOCs given no source on site.	None
Total VOC > 1 mg/kg		
Total SVOC > 1 mg/kg	SVOC analysis was not undertaken due to no viable source on site. However, PAH analysis has identified levels above the laboratory LOD throughout the site.	Further discussion
C5-C10 > 5 mg/kg	All concentrations are below the laboratory LOD.	None
C10-C12 > 10 mg/kg	All concentrations are below the laboratory LOD.	None
C12-C16 > 50 mg/kg	All concentrations are below the laboratory LOD.	None
Phenols > 2 mg/kg	All concentrations are below the laboratory LOD.	None
Naphthalene > 2 mg/kg	All concentrations are below the laboratory LOD.	None
Total PAH > 10 mg/kg	All concentrations are below or slightly exceeding the laboratory LOD.	None
PCB > 1 mg/kg	No potential sources of PCB have been identified.	None
Heavy metals > 500 mg/kg	Concentrations of heavy metals above 500 mg/kg have not been identified. The greatest heavy metal concentration is 400 mg/kg within Lead at WS104 at 0.30 m bgl.	None

The Tier I assessment has included a comparison of leachate analysis from samples of the Made Ground to drinking water standards (DWS) due to the underlying principal aquifer and absence of viable surface water features in the area surrounding the site.

These are presented in Table 9.4 and Table 9.5.



TABLE 9.4 COMPARISON OF GROUNDWATER AND LEACHATE ANALYSIS WITH TIER 1 SCREENING LEVELS

DETERMINANT	UNIT	EQS ^{1,2,3}		DWS _{3,4,5}	NO. OF LEACHATE SAMPLES	MAX CONC. IN LEACHATE	LOCATION OF EXCEEDANCE	ASSESSMENT
		AA						
Arsenic	µg/l	50		10	2	11	DWS: WS101 - 0.1 m	Further Action
Cadmium	µg/l	0.08-0.25		5	2	0.21	N/A	No Further Action
Chromium (VI)	µg/l	3.4		–	2	< 5.0	N/A	No Further Action
Chromium (III)	µg/l	4.7		50	2	2.0	N/A	No Further Action
Copper	µg/l	1		2000	2	25	N/A	No Further Action
Total Cyanide	µg/l	1		50	2	5.0	N/A	No Further Action
Lead	µg/l	1.2		10	2	7.2	N/A	No Further Action
Mercury	µg/l	–		1.0	2	< 0.5	N/A	No Further Action
Nickel	µg/l	4		20	2	3.3	N/A	No Further Action
Selenium	µg/l	–		10	2	< 4.0	N/A	No Further Action
Zinc	µg/l	10.9		–	2	15	N/A	No Further Action
pH	6–9				2	7.7	N/A	No Further Action
Polycyclic Aromatic Hydrocarbons								
Naphthalene	µg/l	2		10*	2	< 0.01	N/A	No Further Action
Anthracene	µg/l	0.1		10*	2	< 0.01	N/A	No Further Action
Benzo[b]fluoranthene	µg/l	0.00017*		10*	2	< 0.01	N/A	No Further Action
Benzo[k]fluoranthene	µg/l	0.00017*		10*	2	< 0.01	N/A	No Further Action
Benzo(a)pyrene	µg/l	0.00017*		10*	2	< 0.01	N/A	No Further Action
Indeno(123-cd)pyrene	µg/l	0.00017*		10*	2	< 0.01	N/A	No Further Action
Fluoranthene	µg/l	0.0063		10*	2	< 0.01	N/A	No Further Action



DETERMINANT	UNIT	EQS ^{1,2,3}		DWS _{3,4,5}	NO. OF LEACHATE SAMPLES	MAX CONC. IN LEACHATE	LOCATION OF EXCEEDANCE	ASSESSMENT
		AA						
Benzo(ghi)perylene	µg/l	1.7–4		10*	2	< 0.01	N/A	No Further Action
Aromatic Hydrocarbon ⁵								
TPH C5-C6 (benzene)	µg/l	10		1	2	< 1.0	N/A	No Further Action
TPH C6-C8 (toluene)	µg/l	74		700	2	< 1.0	N/A	No Further Action
TPH C8-C10 (ethyl benzene)	µg/l	20		300	2	< 1.0	N/A	No Further Action
TPH C10-C12 (xylene)	µg/l	30		500	2	< 10	N/A	No Further Action
TPH C10-C12 (xylene)	µg/l	30		500	2	< 10	N/A	No Further Action
TPH C12-C16	µg/l	2		90 ⁵	2	< 10	N/A	No Further Action
TPH C16-C35	µg/l	50#		90 ⁵	2	< 10	N/A	No Further Action
Aliphatic Hydrocarbon ⁵								
TPH C5-C6	µg/l	–		15000	2	< 1.0	N/A	No Further Action
TPH C6-C8	µg/l	–		15000	2	< 1.0	N/A	No Further Action
TPH C8-C10	µg/l	–		300	2	< 1.0	N/A	No Further Action
TPH C10-C12	µg/l	–		300	2	< 10	N/A	No Further Action
TPH C12-C16	µg/l	–		300	2	< 10	N/A	No Further Action
TPH C16-C21	µg/l	–		300**	2	< 10	N/A	No Further Action
TPH C21-C35	µg/l	–		300**	2	< 10	N/A	No Further Action
Volatile Organic Compounds								
Tetrachloroethylene	µg/l	0.4		10	2			
Trichloroethylene	µg/l	10		10	2			
Trichlorobenzene	µg/l	0.4		–	2			



DETERMINANT	UNIT	EQS ^{1, 2, 3}	DWS _{3,4,5}	NO. OF LEACHATE SAMPLES	MAX CONC. IN LEACHATE	LOCATION OF EXCEEDANCE	ASSESSMENT
		AA					
Trichloromethane	µg/l	2.5	–	2			
Dichloromethane	µg/l	20	200	2			
Carbon Tetrachloride	µg/l	12	3	2			
Vinyl Chloride	µg/l	–	0.3	2			

Notes

Solubility <0.01µg/l

AA – Annual Average

MAC- Maximum Admissible Concentration

* Polycyclic aromatic hydrocarbons (PAH) - Benzo(a)pyrene (BaP), Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(g,h,i)-perylene and Indeno(1,2,3-cd)-pyrene. Benzo(a)pyrene can be considered as a marker for the other PAHs, hence only benzo(a)pyrene needs to be monitored for comparison with the biota EQS or the corresponding AA-EQS in water

** There are no WHO Guideline Values for aliphatic fractions C16-C21 and C21-C35, therefore the guideline value for aliphatic fractions inclusive of C8-C16 (300µg/l) has been applied.

1. The Water Environment (Water Framework Directive) (England and Wales) (Amendment) Regulations (2015)
2. Directive establishing a framework for Community action in the field of water policy (Water Framework Directive)
3. Council Directive on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (Dangerous Substances Directive) - List II substances
4. Council Directive on the quality of water intended for human consumption (Drinking Water Directive)
5. WHO Guidelines for Drinking Water Quality, Third edition (2004)



9.2.1. CONTROLLED WATER RISK ASSESSMENT AND MITIGATION

This comparison indicates that the data exceeds the DWS values for the following inorganic compounds:

 Arsenic

In relation to the above exceedances, Table 9.6 provides a summary.

TABLE 9.6 SUMMARY OF ELEVATED CONTAMINANTS IN GROUNDWATER

CONTAMINANT	WS101 (µg/l)	WS105 (µg/l)
	Contaminant Source	
	Former Warehouse	Former Warehouse
Arsenic	11	-

9.2.2. DISCUSSION OF CONTROLLED WATERS RISK ASSESSMENT

Historically, the site has been subjected to phases of infilling and a number of industrial uses including a factory and cold store. Chemical by-products of manufacturing processes and compounds within the Made Ground may have subsequently leached down into the underlying ground and contaminated the near-surface Made Ground deposits.

The site is underlain by cohesive clay in excess of 20.00m below ground level, which will afford protection to the underlying principal aquifer in the bedrock and the adjacent River Irwell and Medlock to the north and south of the site (considered outside of viable influencing distance). Low level impact identified in the above is not considered present in significant volumes to migrate laterally and vertically towards nearby controlled water receptors, including the canal, rivers and aquifers, as a result of this low permeability strata. Controlled water receptors are therefore deemed to be at a low risk of onsite contamination.

Heavy metal contamination has been identified in the soil and leachate analysis in the shallow Made Ground materials at the site. It is noted that where there are exceedances in soils, there are not exceedances within leachates in those locations, and, where there are exceedances within leachates, exceedances within soils are absent. Thus, the source of the contaminants cannot be attributed to one area or point source and the majority of the contamination is considered present on a site-wide basis.

Drawings within Appendix III show the extent of these exceedances as a DWS Exceedance Plan.

The groundwater, in general, is likely to be flowing in a south-westerly direction, following the flow direction of the Rivers Medlock and Irwell. Perched water strikes have been noted during the investigation but not considered to be representative of the groundwater regime beneath the site.

Prior to recent demolition works the site was covered by hardstanding (building and slab) in its entirety. The proposed development will maintain hardstanding cover across the site, thus maintaining the low amount of infiltration generated. This will in turn, maintain the conditions surrounding the identified contaminants present in leachate and reduce the risk to the underlying aquifer and surface water features. Given that the site is underlain by low permeability clay, the leaching of contaminants will be minimal as the Made Ground will be contained beneath the impermeable surface covering above and the natural clay aquitard below.

The results of the data review and Tier 1 qualitative risk assessment has allowed E3P to draw the following conclusions in respect to the risk to controlled waters:



- ✿ The ground investigation has enabled reasonable characterisation of the pollution risk and potential to impact the critical receptors;
- ✿ The primary receptors are identified as the canal and River Medlock to the south, River Irwell to the north and the underlying principal aquifer;
- ✿ The canal and rivers are at a significant distance from the site and therefore are not considered to be in hydraulic continuity with the site. As such these are not considered to be viable receptors.
- ✿ The identified heavy metal contaminants are of low level and low mobility present within the shallow Made Ground and unlikely to migrate in sufficient volumes over the required distance to create a risk.
- ✿ The existing hardstanding throughout the site will be reformed as part of the proposed development and therefore maintaining the protection from surface water percolation and therefore migration of contaminants will be restricted.
- ✿ Given the absence of a viable receptor and low level, low mobility contaminants identified it is considered the site poses a low risk to controlled waters.

9.3. GROUND GAS ASSESSMENT (RB17 APPROACH)

The potential impact on the development from ground gases has been assessed with reference to standards and guidelines published in CIEH Research Bulletin 17 *A Pragmatic Approach to Ground Gas Risk Assessment* (RB17).

This approach is considered appropriate given the age and limited thickness of Made Ground identified. Based on desk-based analysis and subsequent ground investigation the following can be concluded:

- ✿ No areas of discernible Made Ground are present within on or immediately adjacent to the proposed development.
- ✿ No infilled ponds or features with potential decaying organic matter are identified.
- ✿ The site is not located within an area that is at risk from natural emissions of Radon Gas.

Given the low sensitivity of the site with respect to hazardous ground gas, it was considered that a ground gas assessment undertaken in accordance with the latest guidance provided by CL:AIRE in their research bulletin RB17 would be suitable.

CL:AIRE Research Bulletin RB17 provides an alternative framework for the investigation and assessment of ground gas that takes into account other factors such as site history and the nature of the ground conditions beneath a site.

It has been prepared to allow gas well installation and monitoring to be avoided where appropriate and may also be used in conjunction with gas monitoring to reduce the monitoring period or to avoid extra gas monitoring where anomalous results are recorded. The assessment is summarised in Table 9.7.



9.3.1. RB 17 ASSESSMENT

TABLE 9.7 RB17 GROUND GAS RISK ASSESSMENT

ITEM	OUTCOME	ACTION	RISK SCORE
Have any credible OFF SITE ground gas sources been identified within the Desk Study & ICSM that would include: <i>Registered landfill within 250m; Historical landfill; Infilled pond within 50m; Infilled ground 100m.</i>	No	There are no credible off-site ground gas sources within 250 m of the site.	1
Is the site located within close proximity to a variable groundwater regime (river or tidal) that could potentially influence the ground gas regime.	No	The River Irk is 760 m northwest of the site which is considered outside of influencing distance.	1
Has a credible pathway for the migration of gas from historical mine workings been identified.	No	None	1
Average depth of Made Ground >5.0m	No	None	1
Average depth Made Ground >3.0m	No	None	1
Average Depth Made Ground >1.0m	No	The greatest thickness of made ground is 1.00 m and the average is 0.70 m.	1
TOC <1	Yes	2 of 8 samples are <1 TOC	1
TOC 1-3	Yes	4 of 8 samples are 1-3 TOC	1
TOC >3	Yes	2 of 8 samples are >3 TOC (limited to shallow Made Ground)	1
Made Ground In-situ >20 Years	Yes	None	1
Made Ground In-situ <20 Years	No	None	1
Only natural soils with no potential to generate CH ₄	Yes	None	1
Recorded coal gas emission	No	None	1
Radon Protection Measures Required	No	None	1
Risk Score			14

Notes for E3P RB17 Gas Risk Assessment

This risk assessment is an internal tool kit developed by E3P in due consideration of the guidance published within CL:AIRE RB17. The minimum score attributed is 1 with the assessment to be completed by a suitably qualified person deemed capable of making a reasoned and informed assessment.



9.3.2. RISK SCORE

-  1 = Low
-  2 = Moderate
-  3 = High

9.3.3. RISK PROFILE

-  Cumulative risk score is ≤ 14 the site is deemed to be very low risk and thus conforms to Characteristic Situation 1
-  Cumulative risk score is ≥ 15 but ≤ 20 the site is deemed to be very low risk and thus conforms to Characteristic Situation 2
-  Cumulative risk score is > 20 the site is deemed to be very low risk and thus conforms to Characteristic Situation 3

9.3.4. RB17 CONCLUSION

The RB17 assessment indicates a cumulative score of 14 and that suggests Characteristic Situation 1.

A moderate risk was noted in two locations where >3 TOC was recorded are all within the Made Ground strata. This is likely the result of the presence of clinker in the Made Ground which can generate higher TOC concentrations but does not pose a higher risk in respect of potential gas generation (noted in Section 5 RB17 November 2012) The risk for this item to low, allowing the site overall profile to be Characteristic Situation 1.

9.4. POTABLE WATER SUPPLY

This section provides a summary of the site investigation data with reference to the selection of potable water supply pipework. The assessment is made with reference to the UK Water Industry Research (UKWIR) publication "Guidance on the selection of Water Supply Pipes to be used in Brownfield Sites"

TABLE 9.8 PIPELINE SELECTION PE THRESHOLD CONCENTRATIONS

Contaminant Group	PE-threshold (mg/kg)	Concentrations at <u>Current</u> pipeline depth (mg/kg)
Total VOC	0.5	N/A
Total BTEX And MTBE	0.1	N/A
Total SVOCs (Excluding PAH and those substances marked with an *)	2	N/A
EC5-EC10 Aliphatic and Aromatic Hydrocarbons	2	N/A
EC10-EC16- Aliphatic and Aromatic Hydrocarbons	10	N/A
EC16-EC40 Aliphatic and Aromatic Hydrocarbons	500	N/A
Phenols (From SVOC Analysis)*	2	N/A



Contaminant Group	PE-threshold (mg/kg)	Concentrations at <u>Current</u> pipeline depth (mg/kg)
Cresols and Chlorinated Phenols (From SVOC Analysis)	2	N/A
Ethers*	0.5	N/A
Nitrobenzene*	0.5	N/A
Ketones*	0.5	N/A
Aldehydes*	0.5	N/A
Amines	Fail	N/A
Other Consideration		
Are there any exceedances of the PE threshold outside of the pipeline depth?	There are no TPH fractions above the limit of detection within or outside of the pipeline depth.	
Is free product present in soil and groundwater?	None	
Could hydrocarbon impact at greater depth than current pipeline depth be mobilised by rising groundwater levels?	No hydrocarbon impact was identified within or outside of the pipeline depth.	
Will soils impacted with the above determinants likely be utilised elsewhere on-site?	No	
Will soils be imported to site as part of any future earth works	Currently unknown, however, it is unlikely soils will be required to be imported to the site. If materials are imported to the site this may affect the WIR Risk Assessment which should be updated after completion.	

Notes - Pipe line depth normally between 0.75m–1.35m

Based on the assessment of current site conditions it is likely that polyethylene (PE) pipe will be suitable for the proposed development.



9.5. CONCEPTUAL SITE MODEL

Following the completion of the intrusive site investigation, chemical analysis and risk assessment, the conceptual model shown in Table 9.9 has been prepared for the site.

TABLE 9.9 CONCEPTUAL MODEL

POLLUTANT LINKAGE	CONTAMINANT (SOURCE)	PATHWAY	RECEPTOR	PROBABILITY	CURRENT RISK	RESIDUAL RISK AFTER MITIGATION
PL1 PL2	Heavy Metal (Made Ground)	Dermal contact. Dermal contact and ingestion.	Future site users. Off-site receptors.	Likely	Moderate	LOW
Discussion: Heavy metals (arsenic, lead and mercury) have been identified through the shallow Made Ground soils in the area of WS104 at 0.30 m bgl. Recommendation: Given the proposed development, hardstanding throughout the entire site footprint will prevent exposure to future site users. Construction works should be completed with appropriate PPE and provision of welfare.						



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POLLUTANT LINKAGE	CONTAMINANT (SOURCE)	PATHWAY	RECEPTOR	PROBABILITY	CURRENT RISK	RESIDUAL RISK AFTER MITIGATION
PL4	Volatile Contaminants such as hydrocarbons, Mercury (Made Ground)	Inhalation of vapours. Migration through permeable strata and preferential pathways.	Future site users. Off-site receptors.	Likely	Low	LOW
Assessment: No TPH exceedances have been identified. However, mercury may present potential volatilisation to indoor air risk. The elevated concentration has only been identified within one discrete area of the site within the shallow Made Ground and is therefore considered to be a localised hotspot. Where mercury speciation returns results confirming no elemental mercury, then the GAC limits (1.2 mg/kg) will no longer apply as this is based on vapour inhalation. The detected level of 2.5 mg/kg will then be related to inorganic mercury and the associated GAC will be 40mg/kg. Where this is the case further assessment and mitigation measures will not be required. Where the speciation is confirmed to be elemental mercury a hotspot removal or vapour membranes within the building footprint will be required as mitigation measures.						
Recommendation: The site is suitable for a residential end use without any mitigation measures.						
PL4	Methane, carbon dioxide (Made Ground)	Inhalation of gas. Migration through permeable strata and preferential pathways. Explosion in confined spaces.	Future site users. Buildings. Off-site land users.	Low likelihood	Low	LOW
Assessment: No significant source of hazardous ground gas has been identified.						

