GEO-ENVIRONMENTAL PHASE 1
DESK STUDY
Land at Pioneer Park
Exploration Drive, Leicester

JANUARY 2018
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Geo-Environmental Phase 1 Desk Study
Land at Pioneer Park

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VERSION CONTROL

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<td>01</td>
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This report dated January 2018 has been prepared for Leicester City Council (the “Client”) in accordance with the terms and conditions of appointment dated (the “Appointment”) between the Client and Arcadis (UK) Limited (“Arcadis”) for the purposes specified in the Appointment. For avoidance of doubt, no other person(s) may use or rely upon this report or its contents, and Arcadis accepts no responsibility for any such use or reliance thereon by any other third party.
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1 Introduction

Arcadis (UK) Limited (Arcadis) was commissioned by Leicester City Council (LCC) to complete a “Phase 1” geo-environmental desk study assessment for land off Exploration Drive, Leicester within Pioneer Park. LCC intend to acquire the site with a view to developing it as a future employment site, in line with the LCC Economic Action Plan and the Pioneer Park masterplan.

A site location plan is presented on Figure 1 within Appendix A.

1.1 Aims & Objectives

The aim of the Phase 1 geo-environmental assessment was to provide LCC with and understanding of the potential issues associated with the site and to recommend what additional assessment would be reasonable to manage LCC’s risk prior to site acquisition.

The objectives of the geo-environmental desk study were to:

- Assess the environmental condition of the site including development of a conceptual site model, in line with UK regulatory guidance;
- Assess potential environmental or geotechnical constraints which could affect the proposed development; and,
- Provide recommendations for additional geotechnical and environmental investigations at the site.

1.2 Proposed Redevelopment

It is understood that should LCC acquire the site the plan is for the site to be developed for light commercial / office use comprising two storey buildings. At the time of writing, the preferred design option was “Scenario 02B – 5 Blocks” as shown below. More detailed plans are provided in Appendix B.

Proposed Development: Scenario 02B – 5 Blocks
1.3 Scope of Works
To achieve the objective the following scope of work was defined:

- Carry out a site reconnaissance visit including preparation of a photographic log.
- Review the published and readily available information concerning the site including:
  - Obtain and review Landmark Envirocheck Report (incl. historical ordnance survey (OS) plans);
  - Obtain and review public utility plans;
  - BRE Radon Atlas for England;
  - British Geological Survey (BGS) published maps and online GeoIndex including relevant archive borehole records;
  - The Coal Authority website;
  - The gov.uk website;
  - The Environment Agency (EA) website; and
  - Leicester City Council Planning Portal.
- Unexploded Ordnance (UXO) Screening assessment; and
- Develop a Conceptual Site Model and prepare a Preliminary Risk Assessment.

1.4 Reliability of Information / Limitations
Arcadis warrants that the services performed were conducted in a competent and professional manner in accordance with sound consulting practices and procedures.

Arcadis cannot warrant the actual property conditions described in this report beyond matters amenable to confirmation within the limits of this report.

The reader is referred to the Study Limitations, presented in Appendix C.
2 Site Setting

2.1 Site Location

The site is located within Pioneer Park in land off Exploration Drive, Leicester close to post code LE4 5NU. The centre of the site is located at National Grid Reference 458550, 306500. The site comprises an area of approximately 1.17ha.

2.2 Site Description

A site reconnaissance visit was undertaken on 12 January 2018 by Mr Harry Wrigley of Arcadis. Photographs taken during visit are presented in Appendix D.

Surrounding land uses:

1. Car dealership / Garage
2. Commercial / office buildings
3. Supermarket
4. Petrol Filling Station (linked to supermarket)
5. Residential Properties
6. National Space Centre
7. River Soar

The site is currently undeveloped land generally surfaced in grass in the east and gravel hardcore in the west. The site was broadly level with a shallow ditch (approximately 0.3m deep) running along southern and eastern boundary, assumed to aid drainage. Some small puddles / standing water was observed across the site.
A row of trees (including some low-level shrubs/landscaped vegetation) are present along the northern, southern and eastern boundaries. No other significant contaminative sources or geotechnical constraints were noted.
3 Environmental Setting

The Envirocheck report is presented as Appendix E. Pertinent information obtained from the report, historical maps and other freely available sources (as outlined in Section 1 above) are presented below.

3.1 Geology

3.1.1 Published Geological Maps

The regional geological information pertaining to the site was gained from a review of the BGS 1:50,000 scale map (Sheet 156, Leicester. Bedrock and Superficial Deposits 2007) and BGS online GeolIndex website.

<table>
<thead>
<tr>
<th>Geology</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Made Ground (undivided)</td>
<td>Man-made superficial deposit. Mainly constructional and quarry waste</td>
</tr>
<tr>
<td>Superficial Deposits</td>
<td></td>
</tr>
<tr>
<td>Head</td>
<td>comprises sand and gravel, locally with lenses of silt, clay or peat and organic material</td>
</tr>
<tr>
<td>Alluvium</td>
<td>Soft to firm consolidated, compressible silty clay, but can contain layers of silt, sand, peat and basal gravel. A stronger, desiccated surface zone may be present</td>
</tr>
<tr>
<td>Syston Member (River Terrace Deposit)</td>
<td>Brown sand and flinty gravel, locally with head and organic-rich silts and clays</td>
</tr>
<tr>
<td>Wanlip Member (River Terrace Deposit)</td>
<td>As Syston Member</td>
</tr>
</tbody>
</table>
3.1.2 Borehole Records

The following data sources have been reviewed in relation to the geological sequences likely to be encountered within the site:

- BGS borehole records SK50NE626-630 and SK50NE110-119 approximately 100m north of the site
- BGS Borehole records SK50NE321-325 approximately 150m south of the site
- Borehole records (taken from the Leicester Planning Portal) immediately to the west undertaken by BWB Consulting (BWB). The results of which are discussed in Section 3.8 below.
- LCC provided Arcadis with a report of are located 20m to northeast undertaken by Iodom Merebrook Limited (Merebrook). The results of which are discussed in Section 3.8 below.

Copies of the pertinent borehole information is provided within Appendix F.

Made Ground

The made ground described is highly variable, however, generally comprises a mixture of demolition waste including bricks, concrete, reinforced concrete obstructions, ash and clinker to variable depths (up to 3.2m below ground level (bgl)).

Four BGS records located approximately 50m north (SK50NE626, 627, 628 and 630) recorded made ground as very soft dark wet noxious smelling organic material (Sewage Screenings) up to 2.9m bgl. The base of this deposit was not proven.

Superficial Deposits – Alluvium

Alluvium was described in the area northeast of site and southeast of site (which directly corresponds to the published maps).

Alluvium was encountered up to 3.6m bgl comprising firm to stiff becoming soft and very soft variably sandy variably gravelly silts and clays with common shell fragments.

Superficial Deposits – River Terrace Deposits

River Terrace Deposits were encountered up to 5.3m bgl and generally comprised gravelly sand and sandy gravel with varying amount of silt and clay content. Densities increased with depth ranging from loose to dense, however, were generally encountered as medium dense.

Two BGS trial pit records located approximately 150m north (SK50NE117 and 118) identified impacted River Terrace Deposits with a phenolic odour.
Bedrock

Weathered Mercia Mudstone deposits have generally been described as red brown friable silty clay and clayey silt with relicts of very weak mudstone at shallower depths becoming extremely weak to medium strong, commonly weak, thinly laminated mudstone with depth. Gypsum has also been noted.

The mudstone was encountered between 3.4 and 4.9m bgl in the BGS and BWB boreholes (north, west and south of site), and from 6.0 to 7.0m bgl in the Merebrook boreholes (located east of site). Given that the general area is relatively flat, it is anticipated that bedrock is likely to be encountered at approximately 4 to 6m bgl of the study site.

3.1.3 Radon Affected Areas

A review of the Envirocheck report indicates that the site is not located in an area considered to be at risk of radon.

3.1.4 Mining and Non-Mining Related Activity

A review of the Envirocheck report indicates that the site is not located in an area considered to be at risk of coal mining, other non-coal related mining activity or dissolution features.

3.2 Hydrogeology and Groundwater Vulnerability

3.2.1 Hydrogeology

The previous investigations (BWB and Merebrook) and the BGS boreholes indicate that a shallow groundwater may be present, but is likely to be discontinuous. Some water strikes were noted within the made ground, the Alluvium, the River Terrace Deposits and the Mercia Mudstone. However, many of the exploratory holes were reported as dry.

<table>
<thead>
<tr>
<th>Geological Unit</th>
<th>Strike Depth (m bgl)</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Made Ground</td>
<td>1.0m &amp; 2.2m</td>
<td>Merebrook boreholes MBH1 and MBH2</td>
</tr>
<tr>
<td>Alluvium</td>
<td>3.7m</td>
<td>Merebrook borehole MBH3</td>
</tr>
<tr>
<td>River Terrace Gravel</td>
<td>Strikes between 3.1m &amp; 3.7m (Frequently dry)</td>
<td>BGS Boreholes SK50NE111, 117, 118,321, 323, 325</td>
</tr>
<tr>
<td>Mercia Mudstone</td>
<td>Strikes between 5.9m &amp; 7.5m</td>
<td>BGS Boreholes SK50NE110, 112, 113</td>
</tr>
</tbody>
</table>

The previous BWB reports indicate that groundwater within the Mercia Mudstone had a north westerly or westerly flow direction. This differs to the Merebrook investigations which indicate an easterly or southerly flow direction.

It is considered that the differences are likely to have been a result of the discontinuous nature of the groundwater in the local area.

3.2.2 Aquifer Classification

The EA's aquifer classification indicates the superficial deposits (both the Alluvium and River Terrace Deposits) beneath the site comprise a Secondary A Aquifer. The bedrock geology beneath the site is classified as a Secondary B Aquifer.

Secondary A Aquifers are defined as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.
Secondary B aquifers are predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.

### 3.2.3 Groundwater Abstraction

The Envirocheck Report indicates that there is a licensed groundwater abstraction on site, operated by Leicester Dyers Ltd. The abstraction is for “other industrial/commercial/public services: process water”.

In addition, there are records of four licensed groundwater abstractions located within a 1km radius of the site. The nearest license is 356m east of the site, used for industrial processes.

There closest groundwater abstractions for public water supply is located 955m east of the site operated by Leicester City Council.

### 3.2.4 Source Protection Zones

The site is not located within a Source Protection Zone (SPZ) as designated by the EA.

### 3.3 Hydrology

#### 3.3.1 Surface Water Features

The closest surface water feature to the site is the River Soar located approximately 125m east.

#### 3.3.2 Surface Water Abstractions

There is one active surface water abstraction recorded within 1km of the Site, located 646m south and used for irrigation.

#### 3.3.3 Flooding Risk

The uk.gov online mapping tool was accessed on 5 January 2018.

<table>
<thead>
<tr>
<th>Flood Type</th>
<th>Risk</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivers and Sea</td>
<td>Flood Zone 1 (low risk)</td>
<td>n/a</td>
</tr>
<tr>
<td>Surface Water</td>
<td>Mostly very low to low risk.</td>
<td>Some areas of medium and high risk</td>
</tr>
</tbody>
</table>

#### 3.3.4 Discharge Consents

According to the Envirocheck Report, there are two permitted discharge consents within a 250m radius of the Site. Both operated by Severn Trent Water, however, neither are currently in operation (revoked 2000/2001).

#### 3.3.5 Pollution Incidents to Controlled Water

The Envirocheck Report contains records of three incidents that have been entered into the pollution incident register that have occurred within a 250m radius of the Site; all reported as “Category 3 – Minor Incident”.

### 3.4 Landfills and Waste Management Activities

A historical landfill (EA historical and Local Authority recorded) has been identified partially on site. The EA website indicates ([http://maps.environment-agency.gov.uk/wiyby](http://maps.environment-agency.gov.uk/wiyby)) that the landfill (known as Corporation Road, Belgrave) accepted the following wastes; inert, industrial, commercial, household and liquid/sludge (including chemical waste and sewage sludge).
In addition, there is a registered waste treatment or disposal site located within the site boundary. Authorised waste includes; car batteries, degradable waste, food waste, household waste, waste oil, special waste and sewage sludge.

### Landfills & Waste Treatment

<table>
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<tr>
<th>Reference</th>
<th>Description</th>
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</thead>
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<tr>
<td>110 / 121</td>
<td>Historical landfill (EA historical &amp; Local Authority recorded)</td>
</tr>
<tr>
<td>155 / 156</td>
<td>Waste treatment site</td>
</tr>
<tr>
<td>148</td>
<td>Waste transfer site</td>
</tr>
</tbody>
</table>

There are seven registered waste transfer sites within 250m of site, the closest is located 5m east (license since revoked, ceased or cancelled) for construction and demolition wastes. The closest operational transfer site is located 76m southeast and authorised for inert and non-hazardous waste.

#### 3.5 Industrial Land-use

The Envirocheck report records 57 potentially contaminative industrial sites within 250m of the site, the closest (within 100m of the site) and most pertinent of which are listed below:

- Garage services / vehicle repair – 14m west, 55m west, 95m west
- Clothing and fabric manufacturers / dyers – 20m southwest, 76m west
- Petrol Filling Station – 24m west, 34m south, 54m southwest
- Tanks (unknown content) – 5m north

#### 3.6 Invasive Plants & Protected Habitats/Species

During the site walkover, no palpable evidence of invasive plants / protected species was observed. Notwithstanding, this aspect will be assessed further on a site-specific basis by a separate Ecological appointment.

With respect to protected habitats, the site does not lie within 500m of one of the following protected sites: Site of Special Scientific Interest (SSSI), National Nature Reserve, Marine Nature Reserve, Ramsar Site, Special Area of Conservation, Special Protection Area or World Heritage Site.
3.7 Unexploded Ordnance (UXO) Screening Assessment

A Pre-Desk Study Assessment has been prepared by Zetica Limited (Appendix G) which indicates that no readily available records of bombing or other significant military activity on the site were found. It is considered that the site is likely to have a low Unexploded Ordnance (UXO) hazard level. A detailed desk study is likely to do no more than confirm a low UXO hazard level for the Site.

3.8 Previous Assessment Findings

Previous site-specific information was not obtained. However, reports were reviewed on parcels of land adjacent to the site.

3.8.1 Leicester City Council Planning Portal

The Leicester Planning portal was accessed 08 January 2018 (https://www.leicester.gov.uk/planning-and-building/planning-applications/search-planning-applications/) and the following reports were reviewed for neighbouring sites:

- BWB Consulting (BWB) – Phase 1 Geo Environmental Assessment Report, Office Development on Abbey Lane/Exploration Drive. Dated September 2011, ref. NTS2000/02/V1.

Copies of pertinent borehole records contained within these reports have been included in Appendix F.

3.8.1.1 BWB Reports

The reports were undertaken for the site located immediately to the west of the study site. The BWB Phase 2 investigation comprised:

- 2no. cable percussion holes to 6m bgl;
- Environmental and geotechnical soil sampling;
- Groundwater monitoring and sampling; and
- Ground gas monitoring.

Both BWB assessments were undertaken for a proposed commercial development (which has since been constructed). The report made the following pertinent findings and conclusions:

- No significant sources of contamination were identified within the site, risk to human health and controlled water resources considered to be low.
- No specific soil remediation was recommended (other than 300mm capping in landscaped areas);
- For lightly loaded structures, shallow spread foundations formed within the underlying River Terrace Deposits are likely to be suitable (loads of 150-200kN/m² for conventional 2.5m² pads formed at 1m depth);
- Ground bearing floor slab (of 5kN/m²) could be achieved;
- Relict foundations were encountered (which would need to be broken up prior to the development); and
- Ground gas protection measures (for carbon dioxide and methane) were not required. However, basic radon protection measures were recommended.

The Phase 1 desk study report referenced a site investigation as part of a wider investigation (undertaken by BWB; Phase 1 and 2 Geotechnical and Environmental Site Investigation, Leicester Science Park, Plots 2 to 4. Reference NTH117SE/03/V1 Dated June 2009), however, this has not been reviewed. The report indicated that the investigation was undertaken to “the land to the east”, however, it is not clear where exactly this relates to. It also indicated that although low levels of contamination were identified, elevated soluble organic contamination was identified in groundwater and that free phase hydrocarbon product was encountered.

3.8.1.2 ARUP Report
The ARUP report was undertaken for the construction of the National Space Science Centre (NSSC) and associated infrastructure and parking. The desk study referenced previous intrusive investigations undertaken in 1969, 1994 and 1996, though this information was not provided. Although no site-specific information was obtained for the study site, information on the similar historical activities were assessed. Pertinent information includes:

- Gravel pits located approximately 150m north of the study site and subsequently backfilled (of note, the sewage screenings discussed in Section 3.1.2 were also identified and relates to the same area). A plan indicated that the limit of the screening waste and the gravel pits did not extend into the study site;
- Recommended that for car parking (where contaminated material identified, including aforementioned sewage screenings) material should be left *in situ*, suitably treated and capped; and
- Further works recommended to delineate and assess level of contamination across the NSSC site.

### 3.8.2 Client Provided

LCC provided Arcadis with an interpretative geo-environmental assessment undertaken by Idom Merebrook Limited (Merebrook) in 2016 to a parcel of land situated approximately 20m to the east and northeast of the site (*Geo-Environmental Assessment, Dock 2, Leicester. Dated May 2016, ref. GEA-19904-16-149*). The investigation comprised:

- 3no. cable percussion boreholes to a maximum depth of 15.15m bgl;
- 11no. machine dug trial pits to a maximum depth of 3.8m bgl;
- Environmental and geotechnical soil sampling;
- Groundwater monitoring and sampling; and
- Ground gas monitoring.

The assessment was undertaken for a proposed commercial development. The report made the following pertinent findings and conclusions:

- No contaminants were identified in excess of the respective human health screening criteria;
- Low levels of contamination were identified with respect to controlled water receptors. The risk to the controlled water receptors was considered to be low;
- Ground gas assessment had not been completed at time of issue, however, the report recommended that an allowance be made for basic protection measures;
- The report concluded that the significant thickness of made ground and soft Alluvial deposits are likely to preclude use of shallow spread foundations or ground improvement techniques. The report recommended a piled foundation solution forming within the mudstone at approximately 10-12m bgl be used.
4 Potential Development Constraints

4.1 Site History

Historical maps are provided within the Envirocheck report (Appendix E) and historical aerial photographs within Appendix H. A brief summary of the pertinent historical site uses and surrounding site uses are outlined in the table below.

<table>
<thead>
<tr>
<th>Map Dates</th>
<th>On-site</th>
<th>Off-site</th>
</tr>
</thead>
<tbody>
<tr>
<td>1887 – 1904</td>
<td>Filter beds / settlement tanks present in east of site associated with sewage works</td>
<td>Sewage works immediately adjacent to east of site (closest sewage pumping station (immediately adjacent to site) marked as disused on 1904 maps. Remainder of sewage works (including pumping house, storm tanks, settling tanks and reservoir) located 250m northeast continued in use to 1999</td>
</tr>
<tr>
<td>1915 – 1954</td>
<td>Allotment gardens marked across site</td>
<td>Dye works present 200m east of site (east of River Soar)</td>
</tr>
<tr>
<td>1929 – 1966</td>
<td>Area of raised ground in north of site (Mound present off-site too)</td>
<td>Mound on-site extends approximately 150m north off-site</td>
</tr>
<tr>
<td>1953 – 2005</td>
<td>Bakery present in west of site (extending south off-site), Extension to main building present from 1969 maps</td>
<td>Numerous works located north of site including garage (immediately north), engineering works (100m north), various depot and works (closest immediately south and southeast of site) Tanks present in garage site immediately north of site from 1955</td>
</tr>
<tr>
<td>1969 – 2005</td>
<td>Vehicle testing centre in centre of site (extending south off-site)</td>
<td>No significant change</td>
</tr>
<tr>
<td>1988 – 2002</td>
<td>Tank present in north of site (located within parking/storage area of “depot”, the buildings of which located off-site)</td>
<td>No significant change</td>
</tr>
<tr>
<td>2005</td>
<td>Eastern portion of site has been levelled</td>
<td>National Space Centre present 100m east</td>
</tr>
<tr>
<td>2006 – 2017</td>
<td>No significant change</td>
<td>Development of area 100m east of site, formerly part of sewage works/reservoirs</td>
</tr>
<tr>
<td>2008</td>
<td>All of site levelled. Ground appears stained in area of possible vehicle fuelling area associated with bakery</td>
<td>Exploration Drive is now present running along south and east of site</td>
</tr>
<tr>
<td>2011</td>
<td>No significant change</td>
<td>Residential housing developed immediately southeast of site</td>
</tr>
<tr>
<td>2013</td>
<td>West of site used as compound for construction works (for the building located immediately to west of site)</td>
<td>Dock 2 building being constructed immediately east of site</td>
</tr>
<tr>
<td>2016 – 2017</td>
<td>Site layout appears as per present day</td>
<td>No significant change</td>
</tr>
</tbody>
</table>
4.2 Identified Development Constraints

The key potential areas of concern (PAOC) and development constraints are present on the figure below. Aerial photography (provided by LCC, presented in Appendix H) was also used as an aid to identify the locations of more recent (i.e. 1997 to present) PAOC.

Section 5 below includes the conceptual site model and provides more detail on the potential environmental constraints.

### Development Constraints

1. Filter beds/Settlement Ponds – part of Sewage Works (1814-1903)
2. Raised ground (1929-1952) – Note that area same as historical Corporation Road landfill
5. Possible historical underground storage tanks UST (1997-2005)

4.3 Preliminary Geotechnical Appraisal

The following potential geotechnical constraints have been identified on-site:
<table>
<thead>
<tr>
<th>Ground / Groundwater Constraint</th>
<th>Consequence</th>
<th>Further Investigations / Actions</th>
<th>Anticipated Mitigation Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep Made Ground / Poor ground conditions</td>
<td>A thickness of made ground and Alluvium is anticipated to be present beneath the site. If of significant thickness, shallow foundations would unlikely to be suitable for the proposed development.</td>
<td>Shallow intrusive investigation to determine near surface ground conditions and deeper investigation in order to collect information to enable pile design.</td>
<td>Piled foundations are likely to be required to support structural loads (if thickness of made ground / alluvium encountered).</td>
</tr>
<tr>
<td>Relict foundations from previous development</td>
<td>Encountering of abandoned below ground structures leading to additional groundworks and consequential delays.</td>
<td>Carry out intrusive investigation in vicinity of historic structures. Risk that ground conditions may vary over short distances and relict foundations may not be apparent/encountered due to mapping inaccuracies.</td>
<td>Grubbing out and removing structures.</td>
</tr>
<tr>
<td>Heave and Settlement due to shrinkable soils</td>
<td>Risk of deterioration of hard standing or damage to foundations due to shrinking and swelling of clays due to moisture content changes.</td>
<td>Sampling and testing of soils to determine shrinking or swelling potential.</td>
<td>Foundations to be designed to NHBC standards at minimum foundation depth.</td>
</tr>
<tr>
<td>Differential Settlement</td>
<td>Risk of differential settlement if foundations straddle differing geologies/obstructions etc.</td>
<td>Shallow intrusive investigation to determine near surface ground conditions.</td>
<td>Suitable reinforcement of floor beams / foundations requires deepening / piled foundations.</td>
</tr>
<tr>
<td>Ground Gases</td>
<td>Risk of ground gas exposure associated with made ground (both general across site and associated with landfill material) and Alluvium.</td>
<td>Ground gas monitoring.</td>
<td>Gas mitigation measures in line with BS 8485 (likely to include Installation of an impermeable Membrane, and/or ventilated void.</td>
</tr>
<tr>
<td>Ground / Groundwater aggressive to concrete</td>
<td>Risk of deterioration of below ground concrete and mortar, loss of structural integrity, reduction in design life.</td>
<td>Sampling and testing of soils and groundwater to determine aggressivity to concrete.</td>
<td>Appropriate concrete class specified.</td>
</tr>
</tbody>
</table>

### 4.4 Ground Gas

The current guidelines for assessing permanent ground gas is set out in the following British Standards:

- BS 8576:2013 ‘Guidance on investigations for ground gas – Permanent gases and Volatile Organic Compounds (VOCs)’
- BS 8485:2015 ‘Code of Practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings’

The code of practice uses the concept of a borehole hazardous gas flow rate ($Q_{hg}$) which is calculated from individual borehole measurements of total gas flow emission and the concentration of the specific hazardous gas. A Gas Screening Value (GSV) is then determined for the site or zone which is derived from assessment of the borehole concentrations and flow rate measurements which take into account influencing factors (such as atmospheric pressure and weather conditions) and the conceptual site model. This then allows a characteristic gas situation (CS) to be determined which is defined as the ground gas regime assumed for design of gas protective measures from the refined model after an adequate site investigation.
Numerous potential sources of ground gas have been identified including sewage sludge, landfill material (likely from between 1920s – 1950s), Alluvium and general made ground material. As per the guidance as set out in BS8576:2013, it is considered that the site is at **moderate risk** from gas generation. This is primarily due to the sewage sludge and potential landfill material. The guidance indicates that for moderate risk sites, fortnightly monitoring over a period of two to six months could be undertaken.

It is considered that six to ten visits over a three to four month period would provide sufficient information to assess the permanent ground gas regime at the site. However, this assessment should be reviewed and refined (as necessary) following the results of an intrusive investigation.

### 4.5 Soakaway Drainage

The River Terrace Deposits underlying the site may have sufficient permeability for shallow soakaways to be suitable for disposing of surface water run-off from the site. However, the extent of this unit may be limited and the other identified geologies (Alluvium and Mercia Mudstone) are unlikely to be suitable for use of soakaway systems.

### 4.6 Waste Soils Management

Careful management of soils during the excavation works will ensure optimum utilisation of soil resources. For example, topsoil should be stripped and tested, and where suitable stockpiled for use in the development.

Natural uncontaminated soils excavated and reused on the same site are not classified as waste and therefore can be reused. If these soils were to be transferred directly to another site, they would require a Materials Management Plan (MMP)/ Design Statement in line with CL:AIRE document. Alternatively, they could be taken to a facility with an Environmental Permit that enables reuse.

In order to reuse made ground it would be necessary to demonstrate that the made ground was suitable for reuse and would require a MMP / Remediation Statement in line with the CL:AIRE document.

Given the anticipated nature of the soils on Site (potential thickness of made ground), it would be prudent that soils should be reused wherever possible on either this Site or another or taken to a facility that enables reuse elsewhere. As a last resort they would need to be classified as waste and taken to a landfill.

### 4.7 Potable Water Supplies

There are currently no (fully adopted) national standards for the protection of potable water supply pipes in potentially contaminated ground. However, the UKWIR has published guidance in this respect and testing should be undertaken with due recognition of this guidance.

### 4.8 Statutory Utilities

A review of the statutory utility plans has been made with the following pertinent features noted:

- Electricity cable running along northern boundary and part of eastern boundary;
- BT cable running along southern boundary in southwest of site; and
- 150mm to 225mm vitrified clay gravity fed foul sewage present in the east of site. Depth to invert level adjacent to site (approximately 15m east of site) marked at 2.98m below cover level.

Copies of the utility records are provided in Appendix I.
5 Conceptual Site Model

5.1 Introduction

This section summarises the findings of this desk-based assessment and site reconnaissance in the form of a geo-environmental conceptual site model (CSM).

The CSM provides a qualitative evaluation of potentially active “pollutant linkages” at the site; these being plausible scenarios whereby a contamination source is connected to a possible receptor by one or more pathways:

- Potential sources of contamination: these include any actual or potentially contaminating materials and activities, located either on or in the vicinity of the site;
- Potential pathways for contamination migration: these comprise the routes or mechanisms by which contaminants may migrate from the source to the receptor including environmental migration pathways and human health exposure pathways; and
- Potential receptors of contamination: these include present and/or future land users, ecological systems, water resources and property.

5.2 Contamination Sources

Based on the information reviewed in this report the following potential contamination sources have been identified:

5.2.1 On-Site

On-site sources have been identified associated with made ground and potential contaminants of concern associated with former site uses. The table below summarises the potential on-site sources and the primary contaminants associated with these sources.

<table>
<thead>
<tr>
<th>Potential On-Site sources</th>
<th>Primary Contaminants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Made Ground – Demolition waste</td>
<td>Metals (including heavy metals), Polycyclic Aromatic Hydrocarbons (PAHs), sulphate, asbestos.</td>
</tr>
<tr>
<td>Landfill / Waste Transfer Station</td>
<td>Depends on material. However, may include: Metals (including heavy metals), PAHs, asbestos, Total Petroleum Hydrocarbons (TPH), ammonia, Volatile Organic Compounds (VOC) and Semi-Volatile Organic Compounds (SVOC). Potential source of ground gas if found to be have a high organic content.</td>
</tr>
<tr>
<td>Made ground – Sewage sludge / Filter beds / Settlement Ponds</td>
<td>Metals, inorganics (including cyanide, sulphate, sulphide, chloride, fluoride, ammonium, nitrates), micro-organisms, elevated organic content, ground gas.</td>
</tr>
<tr>
<td>Vehicle testing centre</td>
<td>Metals, asbestos, TPH, PAH, VOC, SVOC, glycols.</td>
</tr>
<tr>
<td>Above ground storage tank (unknown contents)</td>
<td>TPH, PAH, VOC, SVOC.</td>
</tr>
<tr>
<td>Underground storage tank (unknown contents, potentially fuel)</td>
<td>TPH, PAH.</td>
</tr>
<tr>
<td>Free phase product (possible)</td>
<td>TPH, PAH.</td>
</tr>
</tbody>
</table>
5.2.2 Off-Site

Potentially contaminative land uses have been identified in the vicinity of the site, the most pertinent of which are presented in the table with potentially associated contaminants:

<table>
<thead>
<tr>
<th>Potential Off-Site sources</th>
<th>Primary Contaminants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landfill (part of which on site)</td>
<td>Depends on material. However, may include: Metals (including heavy metals), PAHs, asbestos, Total Petroleum Hydrocarbons (TPH), ammonia, Volatile Organic Compounds (VOC) and Semi-Volatile Organic Compounds (SVOC). Potential source of ground gas if found to be have a high organic content.</td>
</tr>
<tr>
<td>Sewage Works (part of which on site)</td>
<td>Metals, inorganics (including cyanide, sulphate, sulhide, chloride, fluoride, ammonium, nitrates), micro-organisms, elevated organic content, ground gas.</td>
</tr>
<tr>
<td>Above ground fuel tank (unknown contents)</td>
<td>TPH, PAH, VOC, SVOC.</td>
</tr>
<tr>
<td>Garage services / Petrol filling station</td>
<td>Metals, TPH, PAH, VOC, SVOC.</td>
</tr>
<tr>
<td>Clothing manufacturer / Dyers</td>
<td>Metals, inorganics, non-chlorinated and chlorinated solvents.</td>
</tr>
</tbody>
</table>

5.3 Pathways

Potential migration pathways based on the proposed school end use are discussed below.

5.3.1 Airborne Migration Pathways

- While a significant proportion of the total site area will be covered in some form of hard-standing; there will also be associated soft landscaped areas. As such, particulate inhalation due to dust generation is a potentially active pathway.
- Vapour inhalation pathways in relation to soil are potentially active irrespective of site status. Vapour inhalation pathways in relation to groundwater are unlikely to be present as groundwater may not be present, or if present discontinuous.
- During development works, sub-surface soils could be exposed at the surface and therefore dust has the potential to be generated. Notwithstanding this, typical dust suppression techniques would almost certainly be employed so that exposures would be minimised.
- Migration of permanent ground gases originating from the made ground and/or Alluvium and accumulating in confined spaces leading to asphyxiation and/or explosion is considered potentially active.

5.3.2 Direct Contact Exposure Pathways

- Under the developed scenario, a significant portion of the site area will be covered in some form of hard-standing (building floor slabs, paved areas etc.). However, landscaped open spaces are likely to be included and as such direct contact pathways in relation to soil are considered active. Given the likely depth to groundwater (potentially not present within Alluvium or River Terrace Deposits), direct contact pathways in relation to groundwater are not considered active.
- Direct contact pathways would be active throughout the construction phase; however, typical mitigation measures such as personal protective equipment (PPE; overalls, gloves etc.) would be used to mitigate this risk and no further consideration is given to this.

5.3.3 Aqueous Migration Pathways
Leaching of contaminants in the shallow soils is likely to be negligible in areas of hardstanding (buildings, pavement etc.) where infiltration of rainfall is minimal.

In areas of soft landscaping, infiltration of rainfall will occur and as such this pathway is considered to be potentially active.

Lateral migration of off-site impacts onto the site is considered limited given that shallow groundwater body within the superficial deposits or bedrock geology is unlikely to be present, or if present, discontinuous. This should be reassessed following an intrusive site investigation.

Certain types of substance have the potential to permeate plastic water supply pipes and impact upon drinking water quality; the responsibility for the protection of the supply lies with the water company and will be assessed using the prevailing risk assessment and risk management process as part of the future redevelopment.

5.4 Receptors

With reference to Part 2a of the Environmental Protection Act (1990), the potential receptors to be considered in any contaminated land scenario can be summarised as follows:

5.4.1 Human Health

The proposed development is for commercial end use and as such the future commercial workers are the primary receptor of concern for contamination risk.

Construction workers/contractors could also be exposed to contaminants during any construction processes (i.e. during any demolition/redevelopment) as would any maintenance workers (working in the ground) following completion of any development.

Users of the adjacent buildings (neighbouring residents) could also be at risk. However, for exposure to occur, active cross-boundary migration pathways would be required.

5.4.2 Eco-systems

The site is not located within 500m of a statutory protected site.

5.4.3 Property (buildings, etc.)

The proposed development will include new structures and associated infrastructure, which could be subject to potential sulphate attack in relation to buried concrete.

5.4.4 Controlled Water

Groundwater is a Controlled Water; therefore, the groundwater beneath the site requires consideration and protection. The underlying aquifers have been classified as Secondary A (Alluvium and River Terrace Deposits) and Secondary B (Mercia Mudstone). However, investigations adjacent to the site indicate that the groundwater is likely to be discontinuous and as such, the likelihood of this being used as a resource is low (therefore overall risk to the resource would be considered to be low). However, intrusive investigation should be undertaken to confirm this assumption.

Surface water courses are also considered Controlled Water receptors; however, the identified potential receptor (i.e. River Soar) for this site are considered sufficiently distant from the site to be at negligible risk from the site.

5.5 Qualitative Risk Appraisal

Based on the CSM the following table presents the plausible pollutant linkages that apply to this site. An indicative qualitative assessment of the likelihood that a risk could be realised is provided in the table below:
| Potential Receptor | Potential Source                                                                 | Potential Pathway                                                                 | Risk       | Justification                                                                                                                                                                                                                                                                                                                                 |
|--------------------|----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|------------|                                                                                                                                                                                                                                                                                                                                 |
| **Future Site Users** |                                                                                 |                                    |            |                                                                                                                                                                                                                                                                                                                                 |
| Ground Gas         | Made Ground / Landfill / Alluvium on site                                         | Migration through future site structures                                          | Medium     | Some form of protection measures likely to be required. However, previous investigations surrounding the site have not identified extensive gas regime.                                                                                                                                                                                                 |
| On site materials  | including those associated with landfill, vehicle testing, sewage sludge,       | Particulate inhalation / dermal contact / ingestion                                | Low        | This Source-Pathway-Receptor is potentially active, but for the proposed end use direct contact pathway easily mitigated against (likely to install capping layer).                                                                                                                                                                                                 |
|                    | demolition rubble, AST, UST and free phase product                                | Vapour inhalation (indoor and outdoor)                                            | Medium     | This Source-Pathway-Receptor is potentially active. Risk dependent upon material within the made ground constituents.                                                                                                                                                                                                 |
| Off-site industrial sources (including Landfill, AST, PFS) | Vapour inhalation (indoor and outdoor)                                            | Low                                                                                |            | While there is the potential for contaminants to migrate onto site via groundwater within the sand and gravel deposits the risk is considered to be low given the limited extent of groundwater.                                                                                                                                                                                                 |
| **Neighbouring Residents** | Permanent Ground Gas (Made Ground / Landfill / Alluvium on site)            | Migration through granular superficial deposits then migration through existing neighbouring resident structures | Low - medium | Limited given the previous site investigations at the Site and presence of off-site landfill sources.                                                                                                                                                                                                                                                                 |
| Leaching of potential contaminants from Made Ground to shallow groundwater. | Lateral migration of on-site impacts off Site with resulting potential inhalation pathway. | Low                                                                                   |            | This Source-Pathway-Receptor is potentially active, but is low risk based on understood extent of groundwater. The risk is dependent upon assessment of materials and potential contaminants of concern.                                                                                                                                                                                                 |
| **Future Construction Worker** | Made Ground                                                                 | Particulate inhalation / dermal contact / ingestion /                             | Low - medium | This Source-Pathway-Receptor is potentially active, but is likely to be local in extent, associated with any areas of Made Ground on Site. The risk is dependent upon assessment of materials and potential contaminants of concern within the made ground.                                                                                                                                                                                                 |
| **Controlled Waters (Secondary A & B Aquifers)** | Off-site industrial sources (including PFS, garages, dye/clothing works) | Vapour inhalation (indoor and outdoor)                                            | Low        | While there is the potential for contaminants to migrate onto site via groundwater within the sand and gravel deposits the risk is considered to be low given previous investigations indicate groundwater to be discontinuous.                                                                                                                                                                                                 |
6 Conclusions and Recommendations

6.1 Conclusions

6.1.1 Preliminary Risk Assessment Outcome

Potential pollutant linkages have been identified which merit further characterisation investigation works to confirm the presence or absence of risks in the context of the proposed redevelopment.

The key environmental constraints and contaminants are associated with:

- Historical landfill and made ground material (may include sewage sludge);
- AST and UST (unknown contents) both on site and adjacent to site;
- Vehicle testing centre; and
- Free phase hydrocarbon (though unclear if on site).

6.1.2 Geotechnical Constraints

The following key potential geotechnical constraints have been identified on-site:

- Piles may be required if a substantial thickness of made ground or Alluvium is encountered;
- Settlement of made ground/Alluvium;
- Potential for historical relict structures which would require breaking up and grubbing out; and
- Ground gases within the made ground and/or Alluvium.

6.1.2.1 Foundation Considerations

Should a significant thickness of made ground and or Alluvium be encountered, shallow spread foundations may not be suitable. As such, a piled foundation solution may be required.

The River Terrace Deposits (if of adequate thickness) or the Mercia Mudstone are likely to provide a suitable founding stratum for foundations pending further detailed intrusive investigation and further assessment of the ground conditions.

6.1.3 Other Development Constraints

6.1.3.1 Soakaway Drainage

The River Terrace Deposits underlying the Site could potentially have sufficient permeability for shallow soakaways to be suitable for disposing of surface water run-off from the site, however, extent of this unit would need to be confirmed and subject to detailed site-specific testing.

6.1.3.2 Unexploded Ordnance

The pre-desk study UXO assessment undertaken by Zetica indicated that the level of risk at the site is low.

6.2 Intrusive Investigation Recommendations

The objective of LCC is to understand potential development constraints as part of a due diligence exercise prior to acquiring the site. As such, a preliminary site investigation is proposed to further assess the presence of potential sources of contamination and geotechnical constraints identified within this report. The investigation is not designed to enable future detailed design, however, should provide a good insight into likely abnormal costs for the proposed development.

The investigation will include:

- Up to 6no. window sample boreholes (including SPT) to 5m bgl or refusal, (2 days on site);
- Up to 13no. trial pits / trial trenches up to 3.5m bgl or refusal (3 days on site);
- Environmental analysis to confirm the level of risk;
- Geotechnical analysis; and
- Installations for groundwater and gas monitoring (1 visit).
A proposed exploratory hole plan is shown below and also presented in Appendix J.

Proposed Exploratory Hole Location Plan

Showing PAOC / Development Constraints
Proposed Exploratory Hole Location Plan

Showing Superficial Deposits

Showing Approximate Location of Utilities
APPENDIX A

Figures
APPENDIX B

Proposed Development Plan
APPENDIX C

Study Limitations
APPENDIX D

Site Walkover Photos
APPENDIX E

Envirocheck Report
APPENDIX F
BGS and Planning Portal Borehole Records
APPENDIX G
Pre-Desk Study UXO Assessment
APPENDIX H
Aerial Photography
APPENDIX I
Utility Plans
APPENDIX J

Proposed Exploratory Hole Location Plan
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