14 Soils, Geology and Contamination

14.1 Introduction

The EIA that was undertaken for the original 2009 application (and which enabled the Phase 1 development to proceed) included a site investigation and contamination assessment. Since that time there have been no activities on the site that are likely to have added pollutants to the Phase 2 and 3 site or altered the local ground conditions. As such this ES section is based on a review of the original Chapter 14 of the Environmental Statement entitled Soils, Geology and Contamination (Beorma Phase 1)[1]. Where necessary it has been summarised or re-assessed in the following sections.

14.2 Legislation and Policy Context

14.2.1 National Planning Policy

The National Planning Policy Framework (NPPF) sets out the Government's planning policies for England and how these are expected to be applied. The NPPF constitutes guidance for local planning authorities and decision-takers both in drawing up plans and as a material consideration in determining applications. Fundamental to the NPPF is a presumption in favour of sustainable development.

The NPPF states that in order "to prevent unacceptable risks from pollution and land instability, planning policies and decisions should ensure that new development is appropriate for its location. The effects (including cumulative effects) of pollution on health, the natural environment or general amenity, and the potential sensitivity of the area or proposed development to adverse effects from pollution, should be taken into account. Where a site is affected by contamination or land stability issues, responsibility for securing a safe development rests with the developer and/or landowner".

Planning policies and decisions should also ensure that:

- "the Site is suitable for its new use taking account of ground conditions and land instability, including from natural hazards or former activities such as mining, pollution arising from previous uses and any proposals for mitigation including land remediation or impacts on the natural environment arising from that remediation";

[1] Environmental Statement Beorma Quarter, Salhia Investments Limited, ENVIRON UK Limited, January 2009

- "after remediation, as a minimum, land should not be capable of being determined as contaminated land under Part IIA of the *Environmental Protection Act 1990*"; and
- "adequate site investigation information, prepared by a competent person, is presented". The NPPF specifies that the minimum information that should be provided by an applicant is the report of a desk study and site reconnaissance.

The NPPF replaces the key Planning Policy Statements (PPS) which formed national planning policy, including PPS23 directly relevant to land contamination. PPS 23 stressed that land contamination, or the possibility of land contamination, is a material planning consideration in taking decisions on individual planning applications. This remains a fundamental part of the NPPF.

The planning process can influence how contaminated sites are managed through planning policy and development control. In terms of the latter, planning conditions often require detailed site assessment or, in some cases, the restoration of a site to render it suitable for its proposed new use.

14.2.2 Contaminated Land Legislation

Part 2A of the *Environmental Protection Act 1990* ("Part 2A") provides the legislative framework for the contaminated land regime in England, Wales and Scotland. It provides for contaminated land to be identified and dealt with in a risk-based manner. The *Contaminated Land (England) Regulations 2006* (SI 2006/1380) set out provisions for procedural matters under Part 2A. The 2006 regulations have recently been modified with the introduction of *The Contaminated Land (England) (Amendment) Regulations 2012*, which came into force on 6th April 2012. This includes an amendment to Regulation 3(c) to take account of the updated definition of "controlled waters" in Section 78A(9) of the *Environmental Protection Act 1990*.

Section 78A(2) of Part 2A of the EPA 1990 defines contaminated land as "land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land, that:

- significant harm is being caused or there is a significant possibility of such harm being caused; or
- pollution of controlled waters is being, or is likely to be caused".

The implementation of Section 86 of the *Water Act 2003* on the 6th April 2012 by *The Water Act 2003 (Commencement No. 11) Order 2012* (SI 2012/264) modifies the definition of contaminated land to also include land where there is “significant possibility of significant pollution of controlled waters”. This applies to England only and not Wales.

Contaminated Land Statutory Guidance published in April 2012 provides for a new four category test which is intended to clarify when land does or does not need to be remediated, where Category 1 is deemed as being high risk and Category 4 as being low risk.

“Significant harm” is defined in the Guidance on risk based criteria and must be the result of a significant “pollutant linkage”. The presence of a pollutant linkage relies on the Source-Pathway-Receptor concept, where all three factors must be present and potentially or actually linked for a potential risk to exist. An initial assessment of pollutant linkage can be made qualitatively (*i.e.* through identifying these factors) and may be assessed using qualitative risk assessment models.

14.2.3 Water Resources Legislation

The aim of water legislation and policy in England is to protect both public health and the environment by maintaining and improving the quality of natural waters. These include surface water bodies (e.g. rivers, streams, lakes, ponds) and groundwater.

The Department of the Environment, Food and Rural Affairs (Defra) is responsible for all aspects of water policy in England. Management and enforcement of water policy is the responsibility of the Environment Agency (EA).

A summary of key relevant UK water legislation is:

- Environmental Protection Act (1990): sets out a range of provisions for environmental protection, including integrated pollution control for dangerous substances;
- Water Resources Act (1991): consolidated previous water legislation with regard to both the quality and quantity of water resources;
- Environment Act (1995): established the EA with responsibility for environmental protection and enforcement of legislation. This Act introduced measures to enhance protection of the environment including further powers for the prevention of water pollution;
- Water Industry Act (1999): consolidated previous legislation relating to water supply and the provision of sewerage services;

- Anti-Pollution Works Regulations (1999): provide powers to the EA to stop any activity (e.g. construction) that is giving or is likely to give rise to environmental pollution or to adequately enforce pollution control measures;

- Control of Pollution (Oil Storage) (England) Regulations (2001): Impose general requirements for preventing pollution of controlled waters from oil storage, particularly fixed tanks or mobile bowsers. The Regulations make contravention a criminal offence;

- Water Act (2003): extends the provisions of the Water Resources Act (1991) and the Environment Act (1995) with regard to abstractions and discharges, water conservation and pollution control;

- Water Environment (Water Framework Directive) (England and Wales) Regulations (2003): require the development and implementation of a new strategic framework for the management of the water environment and establish a common approach to protecting and settling environmental objectives for groundwater and surface waters; and

- Flood and Water Management Act (2010): makes provisions about the management of risks in connection with flooding and coastal erosion.

14.2.4 Regional Policy

No regional policies have been identified.

14.2.5 Local Policy

The Birmingham City Council (BCC) Contaminated Land Team is part of the City Council's Regulatory Services Division and was formed in 2000 to implement the Council's duties under the provisions of the *Part II (A) Section 78 A Environmental Protection Act 1990*, details of which can be found in the BCC Contaminated Land Inspection Strategy (2nd edition, March 2008). The two main functions of the team are to:

- inspect all the land in the city to identify any contaminated land and take appropriate action to ensure risks or pollution of controlled waters are controlled and

- provide guidance to the Department of Planning in respect of development on brownfield land and liaise with developers as necessary. Information for Developers of Contaminated Land.

14.3 Assessment Methodology

The assessment on the baseline documentation reviewed remains unchanged from the original Environmental Statement, although three additional groundwater and ground gas monitoring visits have been undertaken by Ground Investigation and Piling Ltd (GIP) on the 26^{th} March 2013, 12^{th} April 2013 and 24^{th} April 2013. The findings of this work do not change the baseline condition assessment.

The assessment of contaminated soils in the UK follows a risk based approach and is structured in a tiered manner. As well as having a systematic approach to collecting the data it is also necessary to adopt recognised techniques and standards in assessing them and particularly with regard to environmental risk assessment.

The initial study involved the combination of a desk-based study and site based investigation. The site investigation was designed based upon the findings of the desk-based environmental study, known site conditions from an earlier site investigation (dated October 1994) in the north eastern area of the site, geotechnical requirements for the development and the need to characterise those materials most likely to be disturbed and excavated during the proposed redevelopment of the site.

14.3.1 Desk-based Review

The methodology employed in completing the desk-based review of the site and surroundings involved the following:

- a review of historical maps of the site and surrounding area to identify any potentially contaminative activities on or within the vicinity of the site;
- a search of the EA website regarding flood risk;
- a review of records held on a commercial environmental database, including records of landfills, water abstractions, pollution incidents, enforcements and prosecution actions;
- interpretation of the British Geological Survey Solid and Drift Map for Birmingham (Sheet 168, scale 1:50,000);
- interpretation of the EA Groundwater Vulnerability Map of the area (Sheet 22, South Staffordshire and East Shropshire, 1:100,000) and the Policy and Practice for the Protection of Groundwater Regional Appendix;
- a review of archaeological desk-based assessments for the site and surrounding area (*Digbeth Cold Store, Birmingham, An Archaeological Assessment 2008, Birmingham*

Archaeology, report reference PN1864 and An Historic Environment Study 2005, Birmingham Archaeology report reference PN 1274, and *An Archaeological Assessment of the Digbeth Economic Regeneration Area and Cheapside Industrial Area, Birmingham, Birmingham University Archaeological Unit, Report no. 337, April 1995*);

- a review of a previous intrusive investigations of the north eastern area of the proposed development site. This investigation facilitated the assessment of chemical and geotechnical conditions across the north eastern site area;
- a review of an explosive ordnance desk-based assessment for the site (Explosive Ordnance Threat Assessment 2007, Bactec International Ltd, report reference 9465 TA 06/12/07); and
- site visit to assess current site activities, environmental setting and sensitivity.

The site investigation methodology is described below, with the findings and interpretation presented later in this report section.

14.3.2 Site Investigation Methodology

A site-wide geotechnical and environmental site investigation was undertaken in 2007 to support the design of the development proposals and provide characterisation of the site for the planning application and associated EIA. In addition, prior to the site investigation, a number of archaeological trial trenches were excavated at the site at the end of 2007, as part of the initial archaeological investigation of the site. The opportunity was taken during the excavation of these trial trenches to obtain some shallow soil samples to also assist in the characterisation of the site.

Sampling locations were positioned to provide a representative spatial assessment of the ground conditions, to target identified areas of potential contamination (e.g. former Cold Store engine house) and to provide preliminary geotechnical information. The intrusive investigation was undertaken over a period of three weeks, from the 14th January 2008 to the 5th February 2008, with subsequent periods of sample analysis, monitoring and assessment of results. The archaeological trial trenches were undertaken throughout November and December 2007, during which time a limited number of shallow soil samples were obtained for chemical analysis. Details of the archaeological trenching investigation are presented in *Chapter 08: Archaeology and Cultural Heritage*; the results of the chemical analysis of soil sample obtained from these trenches are discussed later in this section.

The field site investigation comprised the following elements:

- the drilling of nine boreholes by rotary drilling methods and installation of permanent groundwater and gas monitoring wells;
- the drilling of six shallow window sample holes by hydraulic sampling equipment;
- the excavation of one trial pit (to expose a small area of the Cold Store foundations);
- field examination and sampling of soil and groundwater;
- chemical analysis of selected soils and groundwater samples for a range of contaminants, which are likely to be associated with historical activities on the site;
- submission of selected soil samples for geotechnical testing; and
- monitoring of installed locations for land gases.

The sampling locations associated with this investigation are presented in *Figure 14.1*.

Boreholes

The investigation involved the excavation of nine boreholes (BH1 to BH9) to depths of between 20.0m bgl and 50.0m bgl using rotary drilling with mist flush techniques (addition of water to lubricate the drilling). These were drilled to establish the characteristics of the underlying strata at depth and to facilitate gas and groundwater sampling. For geotechnical purposes, all of the boreholes were progressed into the sandstone bedrock.

Upon completion of the geotechnical testing, boreholes BH1, BH3, BH4, BH6 and BH9 were grouted back up with cement/bentonite to c. 15m bgl to enable the monitoring and sampling of groundwater. The remaining four boreholes (BH2, BH5, BH7 and BH8) were grouted up to the base of the made ground horizon in order to provide information on any land gas being produced in the shallow soils at the site.

The rotary drilling rigs used temporary steel casing to prevent the boreholes from collapsing and to prevent influx of contaminated soils and groundwater that may potentially have been present. No fluids or foams were used during the drilling operations other than small amounts of clean water to assist the driving of the casing. The drilling tools and casing were cleaned by washing down with mains water after completion of each borehole to prevent possible cross contamination between borehole locations.

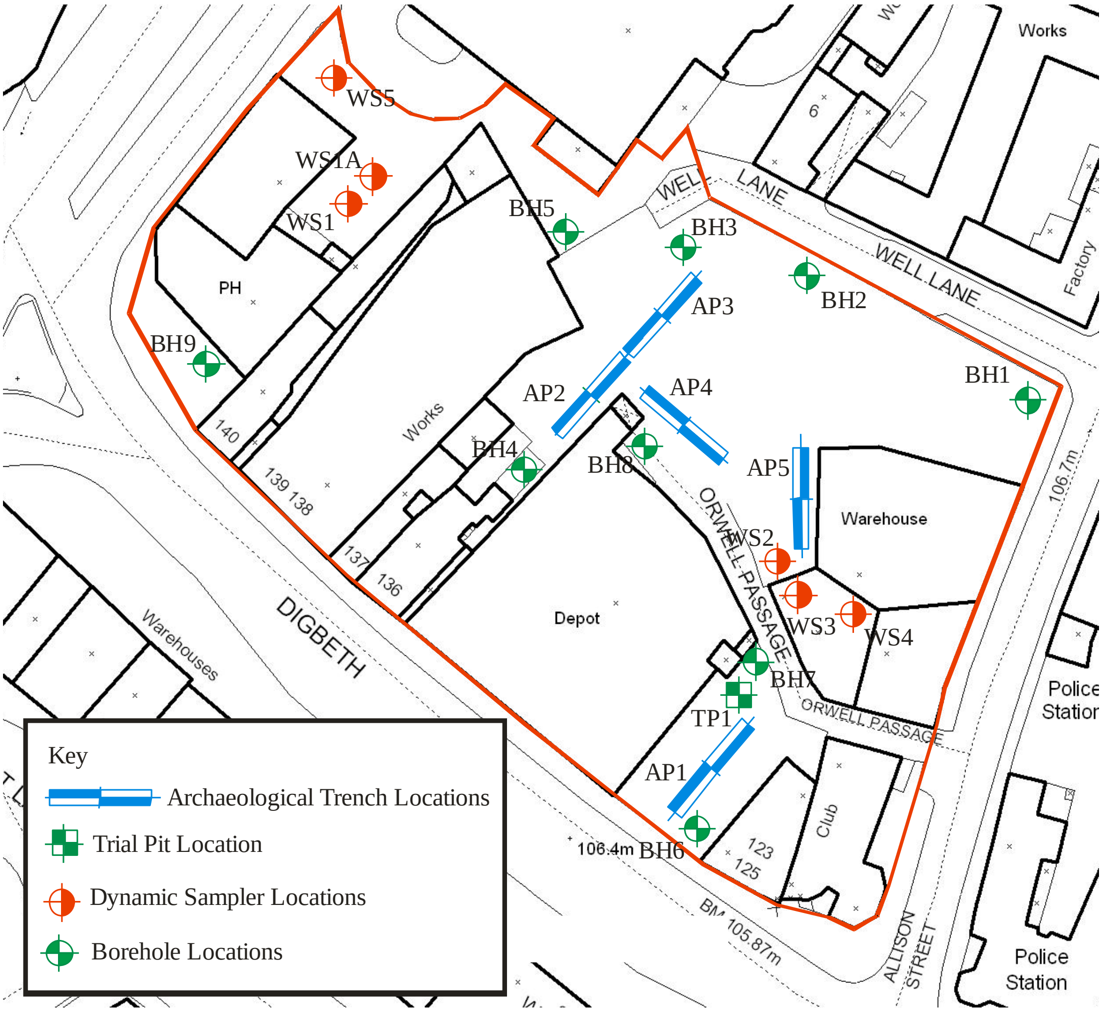

Figure 14.1: *Sampling Location Plan*

The boreholes were completed as gas and groundwater monitoring wells using 50mm diameter high density polyethylene (HDPE) standpipes with a combination of solid casing and slotted well screen, set within a 2-5mm gravel filter pack. The wells were completed with flush steel monitoring well covers.

Window Sample Holes

In addition to the boreholes the excavation of five window sample holes was undertaken (WS1, WS1A, WS2 - WS4) to depths of up to 4.00m bgl, using hydraulically-powered sampling equipment, to enable the visual assessment and logging of shallow ground conditions in hard-surfaced or difficult to access areas of the site. It should be noted that WS1 was terminated early, c. 0.7m bgl, due to the presence of cobbles and whole bricks and was subsequently moved to a new position (WS1A).

All five window samples were reinstated (grouted) following the visual assessment, logging of the ground conditions and the collection of soil samples.

Trial Pit Sampling Location

A single trial pit was excavated for the purpose of assessing part of the Cold Store's foundations. The trial pit was excavated by hand to a depth of 1.2m bgl and continued using a JCB excavator until 1.9m bgl.

It should be noted that the positioning of all excavations was restricted due to the presence of the current buildings, the presence of live services and by on-going operational activities at the site.

Sample Acquisition and On-site Analysis

Soil

Soil samples were obtained from the boreholes, window sample holes and trial pit location at regular intervals, on changes in strata, or horizons of observed potential contamination. The samples were collected using clean instruments, and examined for visual and olfactory evidence of contamination and selected samples were then subjected to headspace testing for Volatile Organic Compounds (VOCs) on-site using a Photocheck +1000 Photo-Ionisation detector (PID) fitted with a 10.6eV lamp. Due to the general absence of visual and olfactory evidence in samples taken from across the site not all samples were headspace tested.

Headspace testing involves analysing the sealed atmosphere of a soil sample for volatile hydrocarbons. The presence of hydrocarbon vapours acts as an indication of contamination in the soil, although not an absolute measurement of the concentration of volatile hydrocarbons. A wide spectrum of organic vapours including aromatics, amines, alkanes ($>C_4$), certain chlorinated solvents, alkenes and heterocyclics can be detected by the PID. The limit of detection for most species is 0.2ppmv (parts per million by volume), the operating range of the PID is 0.1 - 2000ppmv.

Groundwater

Groundwater samples were obtained from the borehole locations after completion of the well installations. Prior to sampling the groundwater in each well, the depth to groundwater was first measured and the well developed by the removal of water, using disposable Waterra tubing, until the dissolved oxygen, pH and conductivity of the water extracted was stable. The groundwater levels were then allowed to recover before sampling to ensure that the samples were of "fresh" groundwater, representative of the surrounding water bearing strata. Samples were then obtained using a disposable HDPE bailer, which were specifically dedicated to each well to avoid cross-contamination between sampling locations. These were disposed of following use. The groundwater samples were assessed in the field for sheens, colour and odours and particularly examined for the presence of free-phase product (*i.e.* a distinct layer of contaminated non-aqueous liquid such as oil).

Gas Monitoring

Soil gas concentrations were recorded in each of the boreholes on several occasions. Measurements were taken using a fully calibrated portable infra-red gas analyser (Geotechnical Instruments Gas analyser GA2000) and soil gas was monitored for the presence of flammable gas (calibrated as methane), carbon dioxide, oxygen, hydrogen sulphide, carbon monoxide and atmospheric pressure. Gas flow rates were additionally monitored using an integrated gas flow pod.

14.3.3 Data Interpretation and Risk Assessment

In accordance with the current legislation and statutory guidance, a site specific conceptual model has been developed based on the principles of CLR11 and interpretation of information gathered. This allows the identification of potential pollutant linkages and whether these linkages have the potential to comprise significant harm and/or pollution of controlled waters in relation to the Site. Based on this interpretation, the implications for potential liability associated with soil or water contamination at the Site can be evaluated.

The CSM concludes with potential pollutant linkages for the Site given the current setting:

- **SOURCES** – the identification of contaminants within the soils and groundwater that represent potential pollution sources;
- **PATHWAYS** – the identification of the potential exposure mechanisms and migration pathways from the potential sources; and
- **RECEPTORS** – the identification of the potential receptors that could be sensitive to harm if exposed to these pollution sources.

Collectively, each of these scenarios would be considered a potential pollutant linkage that may require further assessment.

Soils

Assessment of contaminated soils in the UK follows a risk based approach and is structured in a tiered manner. As well as having a systematic approach to collecting the data it is also necessary to adopt recognised techniques and standards in assessing them and particularly with regard to environmental risk assessment.

The information gathered during the site investigation was utilised to develop a conceptual site model based on the risk assessment principles of source, pathway and receptor.

The soil analytical results have been compared against an appropriate set of assessment criteria:

- Soil Guideline Values (SGV's) for the 11 compounds published in 2009 by the Environment Agency (EA); and
- Suitable 4 Use Levels (S4UL) for 89 substances published by the Chartered Institute of Environmental Health (CIEH) and the Land Quality Management Group (LQM) in 2015[2]. S4UL replaces the 2nd edition of the LQM/CIEH generic assessment criteria published in 2009. The LQM/CIEH S4ULs are intended to provide a complete and updated replacement for the LQM/CIEH General Assessment Criteria (GAC).

The SGV values for soil assessment were developed in accordance with current UK legislation and Environment Agency policy using the Contaminated Land Exposure Assessment (CLEA) risk assessment model (CLEA Version 1.06). The S4UL values are based on health criteria values, updated to reflect changes since 2009. They are derived for the standard CLEA land uses and the two public open space scenarios outlined in document SP1010[3] (CL:AIRE, 2014). The S4ULs are also compliant with EA document SR2[4] and the long standing principle of *'suitable for use'* whilst also reflecting changes to exposure parameters outlined in document in SP1010 (CL:AIRE, 2014).

In essence the S4UL values are intended to be *'trigger values'* that mark the concentration of a substance in soil at or below which human exposure can be considered to represent a 'tolerable' or 'minimal' level of risk such that the land is suitable for its use.

Neither of these guidelines referred to have any legal status in the UK, they merely provide a useful screening guide to help identify where more site specific risk assessment may be required *i.e.* exceedence of a guideline value should trigger further consideration and not be presumed to imply remediation is needed. Where known contamination exists above

[2] Nathanail, C.P.; McCaffrey,C.; Gillett, A.G.; Ogden, R.C. & Nathanail, J.F. (2015), LQM/CIEH Suitable 4 Use Levels, Land Quality Press, Nottingham, ISBN: 978-0-9931084-0-2

[3] Contaminated Land: Applications in Real Environments (CL:AIRE) (2014), SP1010 – Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination, Final Project Report (Revision 2)

[4] Environment Agency (2009), Human health toxicological assessment of contaminants in soil, Science Report – Final SC050021/SR2

guideline values and this presents a significant risk to potential receptors then more sophisticated site specific Quantitative Risk Assessment (QRA) can be undertaken to better define the risks and identify appropriate remediation target values for the substances of concern.

Groundwater

With regard to the protection of specific water resources, the main legislative directive within the UK and Europe pertinent to the protection of water quality is:

- EC Water Framework Directive (WFD) (2000/06/EC) aims to introduce a simpler approach which will result in greater protection. In addition, the WFD establishes a legal framework for the provision of sufficient quantities of good quality water across Europe. It requires EU member states to aim to achieve '*good ecological and chemical status* in all water bodies (both groundwater and surface water) by 2015.

In the UK, much of the implementation work will be undertaken by competent authorities. It came into force on 22 December 2000, and was incorporated into UK law (transposed) in 2003:

- *The Water Environment (Water Framework Directive) (England and Wales) Regulations 2003*

The groundwater analytical results have initially been compared to Environmental Quality Standards (EQS) for freshwater. In August 2010 new EQS's were published under the *Priority Substances Directive*, a daughter directive of the *Water Framework Directive*. In the UK the European EQS's have been adopted in the *River Basins Districts Typology Standards and Groundwater Threshold Values (Water Framework Directive) (England and Wales) Direction 2010*. The EQS's are detailed in Part 4 (Specific Pollutants) and Part 5 (Priority Substances) of the Directive.

In the absence of an EQS under the WFD, reference has been made to the former EQS under the *Dangerous Substance Directive* or the *UK Water Supply (Water Quality) Regulations 2000* (known as the Drinking Water Standards (DWS)). The values provided within the latter legislation generally represent conservative reference values and they should not be applied prescriptively for all situations, particularly where water is not abstracted for drinking water supplies as is the case on this site.

Land Gas

A number of new guidance documents have been produced for new developments on gassing sites. BRE Report 465 (2004)[5] is aimed at providing a framework for planners to ensure 'contaminated land' issues are adequately addressed, including guidance for methane and other ground gases. The framework includes CIRIA's report 149 (1995)[6], which provides further guidance and an initial attempt at characterising gassing sites in terms of volume of gas rather than just concentrations. This was further developed by Wilson and Card's paper in 1999[7], which provided an approach considering the distribution of gas concentrations and flow rates. For the purpose of this assessment, reference has been made to the more recent CIRIA report 665[8], which provides the most up to date and comprehensive reference criteria for assessing land gas, by providing advice relevant to existing or planned development and a step-wise approach to risk assessment.

The CIRIA C665 document uses both gas concentrations and borehole flow rates to define a characteristic situation for a site based on the limiting borehole gas volume flow for methane and carbon dioxide. This provides a Gas Screening Value (GSV), based on the maximum gas concentrations (methane or carbon dioxide) and flow rates recorded at the site (Gas Screening Value (l of gas per hour) = borehole flow rate (l/hr) x gas concentration (%)), which then enables an appropriate Characteristic Situation to be determined. The GSV should only be considered as a guideline value and not an absolute threshold.

14.4 Baseline Conditions

14.4.1 Current Site Activity

The baseline condition in respect of current activities on site remains as previously identified, although the Beorma Phase 1 development area is currently under construction (*Figure 14.2* and *Figure 14.3*).

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[5] P Tedd, P Witherington, D Earle, S Hollingsworth, B Furlong, L Bradley, H Mallett, D Laidler (2004), BRE Report 465, BR465 Cover systems for land regeneration - thickness of cover systems for contaminated land

[6] Construction Industry Research and Information Association (1995), CIRIA Report 149 - Protecting Development from Methane, January 1995

[7] Wilson SA, Card GB (1999) Reliability and risk in gas protection design. Ground Engineering, February 1999

[8] Construction Industry Research and Information Association (2007), CIRIA Report C665 - Assessing risks posed by hazardous ground gases to buildings, London 2007

Figure 14.2: *Current site layout, Aerial view looking northwest*

Figure 14.3: *Proposed Site location*

Google Earth Imaging with the permission of Google – Licensed to Earth & Marine Environmental Consultants Ltd.

The initial study concluded that the site overall had the potential for contamination to be present as a result of current site activities to be low to moderate.

14.4.2 Historical Land Uses

A number of historical maps were examined as part of the desk based review. A summary of the historical development of the site, together with the local surrounding off-site areas is detailed below.

Site

The earliest available map on the database, dated 1890, indicates that the site was already located within the Digbeth area of the City of Birmingham, by which date the site appeared to have been developed with a number of residential or commercial properties. By 1905, a number of the buildings appeared to have been removed in the south-eastern portion of the site, with a larger unidentified building having been constructed on the southern boundary. By 1927, there had been further reconfiguration of the buildings on site and a picture house and public house were annotated on the western boundary.

By 1937, the large building on the southern boundary was annotated as an ice factory, and by 1952, as cold storage. A number of warehouses (including the former picture house), a weighing appliances works and a social club were also located on the site. Orwell Passage had been developed leading from the eastern boundary through to the centre of the site. By 1971, the ice factory and cold storage were annotated as a cold storage depot, which by 1978 was annotated as a depot.

By 1992, the warehouse on the northern boundary of the site was no longer shown. No significant changes to the site were apparent on subsequent maps dated 1994, 1996, 1999 and 2006.

An archaeological desk study of the site undertaken by Birmingham Archaeology in 2008 (Digbeth Cold Store, Birmingham, An Archaeological Assessment 2008, report reference PN1864) and in 2005 (An Historic Environment Study 2005, report reference PN 1274) confirmed that the site in fact dates back to medieval times in terms of development, when the town of Birmingham was first developed. The site would have been laid out in burgages, plots of land usually longer than they were wide so as to enable as many properties as possible to access the street frontage (the Digbeth frontage was already built up by 1688). In addition, a twelfth century boundary ditch (Hersum Ditch) is thought to extend onto the site from the Park Street car park development adjacent to the north-west of the site.

By 1795 the George Inn was located in the south western corner of the site and Allison Street had been constructed; Well Lane was constructed by 1828. The larger scale map of 1860 shows that the site is well developed with burgages and identifies a museum, public house and music hall in the western site area, along the western boundary, and a cistern in the north eastern site area. The first edition OS map indicates that the area in the north of the site does not follow the burgage plot system; this area is more open and spacious and is likely to have been laid out in the nineteenth century. By the mid nineteenth century many of the yards behind the Digbeth properties contained courtyard housing (these were in fact recorded in the 1832 rate book and some of which may be even older). These courtyard houses remained until the end of the 19th century, where numbers 120 to 134 were demolished for the construction of the Cold Store, which was accompanied by the construction of Orwell Passage.

The reports go on to summarise the development histories of each of the individual plots at the site. From this it is apparent that a range of individuals and small businesses have been present at the site since its first development including, but not limited to, public houses, grocer, chandler, cabinet maker, woolcomber, dyer, saddlers tools and pinking irons maker, butcher, poulter, tailors, shear maker, brazier/tin plate maker, wood and bone brush maker, milliner, saddler, boot maker, wholesale druggists, and tallow chandler and tea dealer.

Information gleaned from the 2008 archaeology assessment and a 1995 archaeological study for the site (Birmingham University Field Archaeology Unit (BUFAU) 1995, as commissioned by Birmingham City Council) noted that the former Digbeth Mineral Springs (mineral water manufacture from 1850) was situated in the north eastern area of the site, on the south side of Well Lane, at the corner of Well Lane and Allison Street, which reportedly was originally built as a school. Adjoining this three storey building was a cistern (as shown on an 1860 map) at the same location as a spring (as shown on an 1808 map). In 1889 workmen came across a large tank whilst lowering the yard (the tank was dated 1854), which was fed by a 400 feet deep (122m) artesian bore. The bore was connected via culverts to a series of wells, which in turn were connected to an underground reservoir circa 40 feet (12m) long. Workmen noted from the pattern of brick work that this was already quite dated. The wells were amongst many on the Park Street side of upper Digbeth, which was called Well Street in the 18th century, and included wells in many of the cellars fronting Digbeth, which would have provided an extensive water supply.

Surroundings

On the earliest available map, dated 1890, the surrounding land use appeared to generally comprise residential and commercial properties as part of the Digbeth area of the City of Birmingham. Allison Street Works (furniture) was annotated immediately north of the site with further small-scale industrial operations located in the wider surrounds. A large area annotated as Smithfield Market was annotated 60m south of the site. A series of railway lines were annotated 130m north of the site.

By 1927, Moor Street Station had been constructed 80m north of the site; beyond the railway to the north larger scale industry had developed. By 1937, a metal works had been developed 15m east of the site and an omnibus depot was annotated 150m south-east. By 1952, the metal works had expanded and was annotated as a metal perforating works. Moor Street Station had also expanded with a large goods shed and a number of additional railway sidings, one of which led to a point 30m north of the site. An engineering works, printing works, factory and warehouse had all developed in the area 10m north of the site, with Smithfield Garage and a number of warehouses having been developed 80m east.

By 1960, the majority of the buildings that had been immediately west of the site were not annotated. By 1971, the Bull Ring Centre had developed 120m west of the site and a garage and a multi-storey car park had developed 20m north-west.

By 1992, a car park had developed adjacent to the north-eastern boundary of the site. Smithfield Market had expanded and renamed as Wholegale Markets. The goods sheds associated with the railway was no longer depicted. On subsequent maps dated 1996 and 1999, no significant changes were apparent. On the latest available map dated 2006, the Bull Ring Centre had been redeveloped and extended to c. 10m to the west of the site. The garage and multi-storey car park that had previously been located 20m north-west were no longer present.

Other Sources of Historical Information

Tunnels

In major city centres there is often a network of tunnels associated with communications and civil defence and in that respect Birmingham is no exception. The Birmingham Anchor Exchange comprises a number of tunnels beneath Birmingham City Centre. These were constructed in the 1950s when the government planned to protect essential communications by building a series of underground telephone exchanges, designed to protect the chain of communications should an atomic bomb destroy the city above. Due to advances in weapons the tunnels were obsolete by the time they were complete, however they still played an important part in national communications. Construction of the new exchange started in 1953 with a cover story was that a new underground rail network was being built. Work progressed until 1956 when the public were told the project was no longer economic. According to a plan of the tunnel system, none of these tunnels appear to run beneath the site.

A number of borehole logs were obtained from BGS for proposed "Birmingham tunnels". A plan accompanying the logs (dated 1969) indicates that one of these proposed tunnels may have passed close to the site. However, EAME is not aware of these tunnels having ever been constructed.

Explosive Ordnance Threat Assessment

Bactec International Ltd was commissioned to undertake a desk-based explosive ordnance threat assessment of the site (report reference 9465TA06/12/07), given that the city would have been the subject of bombing campaigns during WWII and thus unexploded ordnance could exist. Pertinent information from the report is detailed below; however, the entire report is presented in *Appendix 14.3*. It was concluded that:

- there is a low-medium risk of encountering explosive ordnance at the site; and
- there is a low-medium risk of unexploded ordnance remaining within the boundary of the site. This is due to the fact that three incendiary bombs were recorded to within the site boundary.

Summary of Potential for Contamination from Historical Activities

The site since its initial development in the 12th century has been occupied by a wide variety of trades people and small businesses prior to the 1900s. Since the 1900s, the site has been under commercial and industrial usage with uses of the site including a Cold Store (ice works) and a weighing appliance works. Currently the site is, in the main, in commercial use with offices, a book retailers, public house, small shop (food). In addition, there are a number of vacant disused buildings and car parking areas.

The potential for historical contamination to be present on the site is considered to be moderate. The demolishment of buildings over the years and the presence of the Cold Store (ice works), a weighing appliance works, and more recently a car park (a large percentage of which is unsurfaced) located in the north eastern area of the site, may have led to contaminants such as ammonia, metals, hydrocarbons, Polycyclic Aromatic Hydrocarbons (PAHs), volatile and semi volatile organic compounds (VOCs and SVOCs) and asbestos.

The Cold Store had a boiler house associated with it. If this was oil fired and there was an oil storage tank on the site and/or underground pipelines conveying the oil to the boiler, this does represent a potential pollution risk.

There is also a possibility that tanneries existed in the area, but as a medieval practice this would have utilised vegetable dyes which would degrade and would not involve the pernicious pollutants typically associated with 19th and 20th century tanneries.

Surrounding Area

Historically, the surrounding area has contained some medium to large scale industrial activity, which has the potential to cause contamination of soils and groundwater, but this is likely to be limited and localised in nature.

14.4.3 Regulatory Authority Information

Birmingham City Council's Environmental Health department provided the following information, as detailed in their Environmental Search Report which is presented in *Appendix 14.2*:

- *the site has not yet been assessed as part of Birmingham City Council's Contaminated Land Inspection Strategy. However, the Council has examined the Departments' records in order to express an opinion as to the potential for land contamination to have taken place, and therefore whether the site might be considered to be 'contaminated land' for the purposes of Part IIA of the Environmental Protection Act 1990. The Council has stated the site does not appear to have been associated with any past uses that may have potentially resulted in significant land contamination taking place, and the current use is not thought to pose significant exposure to receptors, then the Council is of the opinion that when the land is assessed during the implementation of the Council's Contaminated Land Strategy it will be identified as not being a priority for further detailed inspection, and as such this department is unlikely to take may further action in respect of Part IIA of the Environmental Protection Act 1990;*

- *the Council is not aware of any leaks or spills on the site and hold no site investigation data for the site;*

- *according to the Council's records, there are no landfill sites within 250m of the site. However, there are two former waste transfer stations within the same search radius;*

- *there are no entries on the Environmental Health database regarding nuisance issues, prosecutions or enforcements;*

- *there are two entries on the Local Authority Private Water Supply Register within 2km of the site. One is located c. 490m north-west of the site and is registered to Burlington Hotel, 126 New Street. The second entry is located 700m north-west of the site and is registered to Grand Hotel, Colmore Row;*

- *according to the Air Raid Warden (ARP) records there was significant bomb damage within the vicinity of this property during World War II;*

- *the site or land within the vicinity of the site does not lie within a known floodplain; and*
- *there is one Part A process within 250m of the site. This is registered to Attenborough & Peacock (BHam) Ltd (ref: AS 7540) and is located 155m north-east of the site. The site is authorised to process non-ferrous metals.*

The Planning Department of Birmingham City Council was contacted with regards to any current or historic planning records pertaining to the site. The information provided is summarised in *Table 14.1* below.

Table 144.1: *Planning History of the Site*

Application No.	Description	Decision	Date
C/04279/06/FUL	123 Digbeth, Hennessey's Bar – external alterations including new windows and doors to ground and first floor	Approve - conditions	17/08/2006
C/02549/06/FUL	123 Digbeth, Hennessey's Bar – two storey front extension comprising ground and first floor terraces, external alterations	Refuse	*Date not provided*
C/07666/04/FUL	136 Digbeth, Makepeace House – change of use of ground floor from use class A1 to use class A2	Approve – conditions	13/01/2005
C/00070/03/FUL	137 Digbeth, City – new shop front	Approve – conditions	29/03/2003
C/04848/03/FUL	Well Lane, land off – renewal of consent for public car park	Approve temporary	18/10/2003
C/03853/02/FUL	138 Digbeth, city – erection of office extension	Approve – conditions	08/10/2002
C/02499/01/FUL	138 Digbeth, city – installation of 3 antennas, 2 dishes and equipment cabin	Approve – conditions	01/11/2001
C/00685/00/FUL	Well Lane, (land off) – continuation of use of public car park (on former derelict land)	Approve temporary	11/08/2000

Application No.	Description	Decision	Date
C/00862/00/FUL	137 Digbeth, Deritend – use of disused building for 4 flats	Approve – conditions	12/06/2000
C/02071/00/FUL	125 Digbeth, City – continued use as private taxi hire office	Approve – conditions	16/06/2000
C/01355/99/FUL	125 Digbeth, Digbeth Cold Store – use as private taxi hire office	Approve temporary	24/05/1999
C/01316/98/ENF	123 Digbeth, Digbeth – appeal against discontinuance notice – 1 x 48 sheet display panel	Refuse	08/07/1998
C/02145/97/FUL	125 Digbeth, Digbeth cold Store – use as private hire vehicle office.	Approve temporary	11/12/1997
C/01677/97/FUL	123 Digbeth – change of use to café bar/lounge and function room (A3 Use Class)	Approve – conditions	07/08/1997
C/01378/96/FUL	125 Digbeth – establishment of a radio controlled mini cab business with office and ancillary car parking	Invalid application	*Date not provided*
C/04258/96/FUL	138 Digbeth – Birmingham Voluntary Service Council – rear extension to BVSC premises to provide meeting rooms and ancillary staff office space on mezzanine	Approve conditions	06/02/1997
C/03366/96/FUL	Well lane – land off, Digbeth – formation of car park and associated boundary treatment	Approve temporary	06/03/1997
C/03850/94/FUL	140 – 140A Digbeth, city – use of land for parking	Approve – conditions	15/12/1994
C/02581/92/BCC	Well Lane/Allison Street, provision of a temporary pay and display car park	Withdrawn	17/05/1993
C/02369/91/FUL	140/140A Digbeth, Birmingham – 1st 2nd floor change of use from domestic to office	Invalid application	*Date not provided*

Application No.	Description	Decision	Date
C/01764/91/FUL	135 – 136, Digbeth, Birmingham – C/O/U PT ground floor to A2 finance/professional services C/O/U PT Ground/ 1ST Floor to office use/erect glazed atrium/alter elevations/new fire escape	Approve – conditions	27/06/1991
59739/000	Premises in Orwell Passage, Digbeth – change of use to wholesale warehouse	Approve – conditions	10.09.1981
52884/000	Union Cold Store, Digbeth near corner of Allison Street, Birmingham – widening of the existing entrance to the store	Approve	21.02.1980
31762/000	135 – 136 Digbeth – conversion to flat second floor and part of first floor	Approve	09.04.1970
31762/001	135 Digbeth Birmingham – use of ground floor as a licensed restaurant with ancillary storage at basement level	Approve	04.05.1983
31762/002	135/6 Digbeth – change of use of second floor to offices , demolition of outbuilding and garage for car parking and loading	*Not provided*	*Date not provided*
31762/003	135/6 Digbeth Birmingham – change of use of first floor to private members club	Approve – conditions	30.04.1987
31442/001	123 Digbeth – retention of extension for use as foyer toilers and storeroom	Approve – conditions	10.01.1980
31442/000	123 Digbeth, ext to existing premises	Approve	15.01.1970
31442/002	123 Digbeth, proposed extension to function room at first floor level and new cellar at ground floor level	*Not provided*	*Date not provided*
14410/003	142 Digbeth Bham – retention of existing building as florist shop	Approve	07.01.1960
14410/000	142 Digbeth, Birmingham – shop	Approve	11.08.1955

Application No.	Description	Decision	Date
14410/001	Site of No 142 Digbeth Bham – erection of temporary florists and greengrocers shop	Approve	25.01.1956
14410/002	142 Digbeth Bham – retention of existing building	Approve	04.12.1958
12143/00	Well Lane, Digbeth – covered yard	Approve	03.09.1953
12143/001	Well Lane (Baragwanath Ltd) – covered yard	Approve	25.02.1954
07738/000	137 Digbeth – change boot repair service to café on ground floor	Approve	22.06.1950
07738/001	137 Digbeth, Use of manufacture of florists sundries, etc	Withdrawn by appcnt	*Date not provided*
07738/002	137 Digbeth, warehouse with office accommodation	Approve	02.11.1971
07738/003	137 Digbeth, change of use from retail shop to wine bar	Approve – conditions	11.01.1979
07315/000	140 Digbeth Bham – change of use to leather warehouse	Approve	06.04.1950
07315/001	140 Digbeth Bham – use as leather warehouse	Withdrawn	22.06.1950
07315/002	140 Digbeth – extension of existing premises	Approve	21.11.1963
07315/003	140 Digbeth City – change of use and shop front	Approve	01.12.1971
07315/004	140 Digbeth – change of use to Indian restaurant with living accommodation for staff above	Approve	11.01.1973
06332/002	139 Digbeth, alterations to provide office and storage accommodation	Approve	06.08.1975
06332/001	Rear entrance to 138 Digbeth Wall Lane – yard covering	Approve	17.01.1957

Application No.	Description	Decision	Date
06332/003	138 & 139 Digbeth – refurbishment of existing offices and ground floor show room demolition of outbuildings in yard and ….. [no further information provided].	*Not provided*	*Date not provided*

14.4.4 Environmental Database

The following information has been obtained from a search of a publicly available third-party environmental database:

Landfills

There are no records of former or operational landfill sites on the site or within a 1km radius of the site.

Waste Transfer/Treatment/Disposal Sites

There are four registered waste transfer sites within 1km of the site. The nearest is located c. 370m to the east of the site, and is authorised for builders wastes and household wastes. This site is categorised as a small site (equal to or greater than 10,000 tonnes and no more than 25,000 tonnes of waste per year).

There are six waste treatment or disposal sites within 1km of the site. The nearest is located circa 600m to the south east. The site, Kang Refinery Services, is authorised to accept ceramic wastes, electronic computer equipment, jewellery cuttings/sweepings/polishings, metals, paper/rags, and contaminated non-ferrous metals.

Waste Management Sites

There are thirteen licensed waste management facilities within 1km of the site. The nearest facility is located c. 300m east. This relates to a waste transfer station, which is permitted for the transfer of household, commercial and industrial wastes.

Discharge Consents

There are no current licensed surface water discharge consents associated with the site.

There are thirteen discharge consents within 1km of the site. The nearest is located 34m to the south of the site and authorises Severn Trent Water Limited for the discharge of storm sewage overflow into the River Rea via a surface water sewer.

EPR (formerly IPC/IPPC) Authorisations

There are three facilities permitted under the Environmental Permitting (EP) Regulations within 1km of the site. The nearest permitted facility is located 434m to the east of the site. Anopol Limited is permitted to operate a process involving the surface treatment of metals & plastics (>30m^3).

LAPPC Authorisations

There are twenty nine Local Authority Pollution Prevention and Control (LAPPC) permitted facilities within 1km of the site. The nearest LAPPC permitted facility is 150m to the east. Hartwell Smithfield Plc. is permitted to operate a process involving the coating of metals and plastic.

Pollution Incidents

The EA has one record of a pollution incident associated with the site. This involved the release of firewater into an unnamed watercourse in 1999. This was classified by the EA as a minor incident.

Prosecution and Enforcement

There have been no enforcement or prohibition notices issued to the site or any other sites within a 1km radius.

Radioactive Consents

No consents are listed for the holding or disposal of radioactive material at the study site or within a 500m radius of the site.

COMAH

There is one COMAH facility within 1km of the site. Macdermid Plc is located 863m to the east, and is classified as an upper tier COMAH facility.

Explosive Sites

There is one explosive site within 1km of the site. The Birmingham Gun Barrel Proof House is located c. 550m to the north east.

Planning Hazardous Substances Consents

There are three Planning Hazardous Substances Consents within 1km of the site. The nearest is located c. 278m to the north east of the site. This consent authorises Travel Gas (Midlands) Limited for the storage of liquefied gas and natural gas.

Contaminated Land Register

According to the database there are no Contaminated Land Register Entries or notices associated with the study site or any other sites within a 1km radius.

Fuel Station Entries

There are two operational fuel stations within 1km. The nearest, operated by Texaco, is located *circa* 740m to the south west.

14.4.5 Review of Previous Investigation Report

Well Lane, Digbeth – Factual and Interpretive Report on Geotechnical and Environmental Ground Investigation, Birmingham City Council, October 1994 (Report Ref 114247)

A geotechnical and environmental investigation was undertaken in the north-eastern part of the site in 1994. The key aspects of this report are summarised within this section.

A desk study undertaken by Birmingham City Council for this part of the site identified various historical uses including terraced housing, retail warehouses and works buildings. Anecdotal information suggests that a well was present on the site, where Well Lane and Alison Street meet.

The site investigation involved:

- the drilling of four 150mm diameter shell and auger boreholes (BH2-BH5) between 4.0m (BH2) and 6.5m (BH5). Monitoring standpipes were installed in boreholes BH2, BH4 and BH5 (to avoid a pathway for the migration of any contaminants the base of each borehole was grouted up with bentonite to made ground level); and
- the excavation of six trial pits between 1.9m (TP2 and TP5) and 4.1m (TP1).

Published geology for the area indicates that the site is located on Bromsgrove Sandstone (formerly known as Lower Keuper Sandstone), which outcrops at the site surface. The Birmingham Fault appears to follow along the line of Alison Street, and to the south east of this Mercia Mudstone is shown to outcrop at the surface. To the north and west of the site are glacial Sands and Gravels overlying the sandstone and to the south and west of the outcropping Mudstone, the Mudstone is overlain by alluvial deposits associated with the River Rea.

Ground conditions encountered at the site can be summarised as:

Made Ground (ranging from 1.3m bgl (BH3 and BH5) to 2.4m bgl BH4): highly variable but included:

- grey brown slightly sandy gravel and cobble-sized fragments of bricks and reinforced concrete and boulder sized fragments of reinforced concrete, with fragments of metal, wire rope, steel bars and frames, wood, plastic, polystyrene, electrical wire, textiles, slag, paper and ceramics.
- grey black silty sandy clay with gravel, clinker, slag, coal and partially decomposed wood.
- black silty sandy clay with gravel, clinker, slag, ash, rootlets and brick.
- black silty clayey sand with gravel, clinker, slag, ash, plastic and rootlets.
- concrete slab.

Note that the base of the made ground was not proven in trial pits TP2, 3, 4 and 5 in which concrete slabs (possible former basements) were encountered between 1.9m and 2.4m.

Natural strata:

Glacial Drift Deposits

Sand and gravel was encountered in TP1 only (1.4 – 2.2m bgl) comprising yellow to orange brown slightly silty sand with much gravel and some pockets of silty sandy clay and a thin band of red brown silty very sandy clay with occasional gravel and fragments of semi-decomposed organic material.

Bromsgrove Sandstone

Completely weathered sandstone was encountered in boreholes BH2, BH3 and BH4 and trial pit TP1 (2.2m bgl (TP1 and BH2) to 4.4m bgl (BH3)) comprising silty fine to course sand with occasional gravel.

Highly weathered sandstone was encountered from 3.6m bgl (TP1 and BH2) to 5.3m bgl (BH3) comprising red brown silty fine to medium grained sandstone, strength ranged from weak to moderately strong.

Mercia Mudstone

Completely weathered Mercia Mudstone was encountered in BH3, BH5 and TP6, ranging from 1.3m bgl (BH5) to 3.5m bgl (BH3), comprising red brown silty clay and brown silty clay with many mudstone lithorelics. Moderately weathered Mudstone was encountered in BH5 (4.0m bgl) and TP6 (3.5m bgl).

Groundwater

Groundwater was encountered in BH2, BH3 and BH4. Groundwater was struck between 3.5m (BH2) to 4.5m (BH4) in the Bromsgrove Sandstone. Depths, after twenty minutes, rose to between 2.65m bgl (BH2) and 3.3m bgl (BH4).

In BH5 only groundwater seepage was encountered at 4.7m bgl (Mercia Mudstone). Slight groundwater seepage was encountered in TP6 at 3.5m bgl.

Standing water levels:

- BH2 ranged from 1.5m bgl to 2.0m bgl (standpipe installed at 2.0m bgl);
- the standing water level for borehole BH3 have not been recorded, however during drilling of the borehole, that water level rose to 3.10m bgl after 20 minutes; and
- BH4 and BH5 were dry (base of standpipes 2.2m and 1.2m respectively).

Chemical Analysis

Selected soil samples were submitted for chemical analysis for pH, metals, chloride, total Poly Aromatic Hydrocarbons, cadmium, total cyanide, total phenols, total extractable matter (TEM), sulphate and sulphide.

Groundwater (one sample) was analysed for the above as well as aluminium, ammoniacal nitrogen, manganese and conductivity.

Geotechnical testing included moisture content, Atterburg Limits, particle size distribution (coarse grain), undrained triaxial test, one dimensional consolidation test, pH and total sulphate.

Gas Monitoring

Gas monitoring was undertaken on six weekly occasions. The results can be summarised as:

- methane <1.0% to 0.2% (BH2);

- carbon dioxide <0.1% to 11.0% (BH2); and
- oxygen 21.1% to 5.7% (BH2).

If the above monitoring results are indicative of site-wide concentrations *i.e.* slightly elevated carbon dioxide concentrations, then some degree of risk assessment of whether or not gas protection measures would be required in built structures would be necessary. The development works, however, will involve large scale removal of site soils (Made Ground) down to natural levels which will also more than likely remove the organic matter in that soils that is probably giving rise to the gas levels observed.

14.4.6 Geology, Hydrogeology and Hydrology

Published Geology

According to the British Geological Survey (BGS) 1:50,000 solid and drift map of the area (Sheet 168, Birmingham) the site is located directly on Bromsgrove Sandstone, which generally comprises red brown sandstone, pebbly in parts, interbedded with mudstone in upper parts. Overlying the solid strata in the western site area is made ground. .

The southern eastern corner of the site is shown to be very close to the Birmingham Fault, a normal fault, that trends in a north-east to south-west direction and downthrows to the south-east. The Mercia Mudstone Group, which is younger and typically overlies the Bromsgrove Sandstone Formation, outcrops at surface on the south-eastern side of the fault. The Mercia Mudstone is understood to attain maximum thicknesses in the order of 400m in the middle of the Knowle Basin, 5 – 10km to the east of the city centre but at the site, it is interpreted to be in the order of 100m thick

According to data issued by the National Radiological Protection Board (2002), the land is located in an area where less than 1% of residential properties are above the action level for radon as set by the National Radiological Protection Board. No radon protection measures are considered necessary by the British Geological Survey.

Geological Field Observations

During the 2007 site investigation, the field observations of the geological conditions at the site were found to be largely consistent with published information and generally comprise the following strata:

- **Made Ground** was encountered in all sampling locations. This generally comprised either: hardstanding (asphalt) of varying thickness (BH1, BH2 and BH4), cemented brick (BH6, BH7 and TP1), a pre-formed concrete slab (BH9), gravel 'black-top' (BH3 and BH8), rough vegetation (WS1, WS1A, WS2 and BH5) or concrete (WS3 and WS4). These surfaces were underlain by a brown/grey sand, silt or clay with various quantities of brick, gravel concrete, whole cobbles and ash. At BH4, a possible infilled basement with a red-brick floor was observed. TP1 was terminated within the made ground, whilst all other locations were terminated within the natural strata.

- **Natural deposits** comprised a variable depth of silty gravelly sand (possible head deposits) at sample locations BH1, BH6, WS3 and WS4. At all other locations, the made ground was found to be directly underlain by the solid geology of either Bromsgrove Sandstone or Mercia Mudstone. The solid geology at the site can be broadly stated as comprising Mercia Mudstone on the southern and eastern elevations of the site, with the Bromsgrove Sandstone Formation on the northern and western elevations.

The ground investigation indicated that a normal fault traverses through the site, with Mercia Mudstone encountered beneath the south-eastern elevation of the site and Bromsgrove Sandstone outcropping beneath the remaining (north-western) area of the site. The fault appears to pass through the site beneath the Cold Store and could either be the Birmingham Fault, or possibly a separate fault associated with and running parallel to the Birmingham Fault. The fault is not considered to be geologically active and no significant movement is anticipated.

<u>Summary of Geological Observations</u>

The geological strata for the whole development site is summarised in *Table 14.2*.

Table 144.2: *Summary of Site Geology*

Strata	Description	Depth Encountered (m bgl)	Thickness
Made Ground	Black-top, concrete, pre-formed concrete slab, concreted brick, asphalt or soil/clay matrix.	From ground level.	Generally between 0.1 - 0.4m
	Variable reddish brown – dark grey gravelly/sandy clayey brick fill with localised pockets of black ashy sandy gravel, cobbles.	Between 0.1 and 0.6m bgl.	Between 0.8 -2.4m
Head Deposits	Light grey silty gravelly sand	Between 0.9 and 1.3m bgl.	Between 0.3 - 0.9m

Strata	Description	Depth Encountered (m bgl)	Thickness
Bromsgrove Sandstone	Reddish brown silty fine-medium SAND with occasional very thin to thin beds of calcareous, well-cemented and uncemented silty sand.	Between 1.2 and 2.5m bgl.	Not proven in excess of 48.50m thickness
Mercia Mudstone	Very weak reddish brown fractured MUDSTONE with clay partings and occasional thin light grey dolomite beds.	Between 1.2 and 2.1m bgl.	Not proven, in excess of 48.6m thickness.

Published Hydrogeology

According the Groundwater Vulnerability Map of South Staffordshire and East Shropshire (Sheet 22), the site is located on a Major Aquifer, relating to the sandstone solid stratum. Major aquifers are highly permeable formations, being highly productive, capable of supporting large abstractions for public supply and other purposes.

Source Protection Zones (SPZs) are defined for groundwater sources such as wells, boreholes and springs used for public drinking water supply. The site is not located within a designated SPZ, however, there are a number of designated SPZs and a groundwater source in the surrounding area.

According to a publicly available third-party environmental database, there are four licensed groundwater abstractions within a 1km radius of the site. The nearest is located 525m to the west. Burlington Hotel (formerly known as the Midland Hotel) is authorised for the abstraction of groundwater for general use. In addition, there is a public water supply abstraction borehole located c. 716m to the south. Water for water supply related use (transfer between sources) is abstracted by Severn Trent Water Limited.

In addition, according to the borehole logs obtained from BGS, there is a groundwater abstraction well beneath the former Cold Store on the site. The well (86m/282.6 feet in depth) appears to have been sunk for abstraction purposes when the site manufactured ice, the abstracted water being for ice making and general usage. The well was constructed *circa* 1899 directly beneath the works, the water being pumped to the surface at approximately 1,200 gallons per hour. A note with the borehole log, dated September 1942, stated that the borehole overflowed in 1900. Another note, dated October 1981, states that the well has been disused since 1965 and is sealed at present. The note goes on to state that the cellars and lift shaft have recently become flooded and that the borehole may possibly be opened for investigation.

From the drilling log for this borehole, dated c. 1918, it is apparent that the former cold store is located directly on sandstone bedrock. A note on the log, dated 1948, states that the well was dry and that it had failed in 1937 due to falling yields between 1899 and 1935.

Hydrogeological Field Observations

No shallow groundwater strikes/seepages were encountered in the made ground horizon. Instead the groundwater strikes were encountered in the solid geology of the Bromsgrove Sandstone in three of the nine boreholes (BH2, BH8 and BH9), whilst a water strike was observed within the Mercia Mudstone in BH1.

No discernible groundwater strikes were observed during the excavation of the remaining four boreholes (BH3, BH4, BH5 and BH6) due to the addition of clean water as a flushing medium. However, all of the boreholes subsequently 'made water' following well installation. It should be noted that large quantities of water were encountered during the intrusive investigation, particularly when drilling through the Bromsgrove Sandstone.

Details of the groundwater strikes are presented in *Table 14.3*.

Table 14.3: *Groundwater Strike Details*

Position	Depth to Strike m bgl	Strata	Rise m bgl (after 20 minutes)	Date
BH1	6.00	Mercia Mudstone	4.70	31.01.08
BH2	5.00	Bromsgrove Sandstone	2.60	21.01.08
BH8	3.10	Bromsgrove Sandstone	2.00	30.01.08
BH9	4.80	Bromsgrove Sandstone	3.10	22.01.08

Resting groundwater levels were monitored following the installation of the wells and prior to purging and sampling. The resting groundwater levels provide a more accurate representation of groundwater levels across the site compared to inflow depths. Following the conclusion of the investigation, the groundwater levels of all nine boreholes were normalised in relation to ordnance datum, as shown in *Table 14.4*:

Table 14.4: *Groundwater Levels*

Position	Date	Groundwater level (m bgl)	Ground Elevation (m AOD)	Groundwater level (m AOD)
BH1	18.02.2008	6.80	106.887	100.087
	25-26.03.2008	2.39	106.887	104.497
	23.04.2008	2.48	106.887	104.407
BH2	13.02.2008	DRY	108.237	-
	18.02.2008	DRY	108.237	-
	25-26.03.2008	DRY	108.237	-
	23.04.2008	DRY	108.237	-
BH3	13.02.2008	1.83	108.524	106.694
	25-26.03.2008	1.79	108.524	106.734
BH4	13.02.2008	1.67	108.336	106.666
	25-26.03.2008	1.61	108.336	106.726
	23.04.2008	1.67	108.336	106.666
BH5	13.02.2008	DRY	109.610	-
	25-26.03.2008	2.63	109.610	106.98
	23.04.2008	DRY	109.610	-
BH6	13.02.2008	1.41	105.920	104.51
	25-26.03.2008	1.42	105.920	104.5
	23.04.2008	1.61	105.920	104.31
BH7	13.02.2008	DRY	106.822	-
	25-26.03.2008	DRY	106.822	-
	23.04.2008	DRY	106.822	-
BH8	13.02.2008	1.87	108.465	106.595
	18.02.2008	0.75	108.465	105.715
	25-26.03.2008	1.72	108.465	106.745

Position	Date	Groundwater level (m bgl)	Ground Elevation (m AOD)	Groundwater level (m AOD)
	23.04.2008	DRY	108.465	-
BH9	13.02.2008	2.90	109.686	106.786
	25-26.03.2008	2.58	109.686	107.106
	23.04.2008	2.90	109.686	106.786
m AOD = m Above Ordnance Datum BH2, BH5, BH7 and BH8 installed with a 50mm diameter standpipe within the Made Ground deposits. BH1, BH3, BH4, BH6 and BH9 installed with a 50mm diameter standpipe within the solid geology.				

One groundwater body has been identified at the site within the depth range of the site investigation. The groundwater within the Sherwood Sandstone (predominantly in the south and western elevations of the site) appears to be slightly higher (above ordnance datum) than the groundwater within the Mercia Mudstone (northern and western elevations). This would indicate that groundwater would travel in an easterly direction. The deposits are possibly in hydrologically continuity with the River Rea to the east of the site.

Hydrology

The nearest identified surface watercourse to the site is the River Rea, which lies approximately 364m east of the site at its closest point. This water feature was classified by the EA under the General Quality Assessment scheme as being of Grade D condition, i.e. poor quality, during the last monitoring round in 2000.

According to the EA's website and an independent third party environmental database, the site is not located within a designated flood zone.

According to an independent, third party environmental database, there are two licensed surface water abstractions within a 1km radius of the site. The nearest is located 495m to the east. Francis D Wilmott Limited (Forward Works) is authorised for the abstraction of surface water for cooling purposes.

Significance of Geology, Hydrogeology and Hydrology

The site is considered to be situated in an area of **high** sensitivity with respect to groundwater resources, given that it is located on a major aquifer (the underlying Sandstone). The underlying geology is highly permeable and could therefore provide a pathway for mobile contaminants (if present) to migrate onto the site from off-site sources, or away from the site onto third-party land. Additionally, the site is likely to be in hydraulic continuity with the nearby River Rea, potentially providing a pathway for any site-derived mobile contaminants, if present, to the river.

The site is considered to be located in a **low** sensitivity location with regard to surface water resources. The closest surface watercourse is the River Rea, located approximately 364 m east of the site at its closest point. Given the distance of this watercourse the site is not considered to be located in particularly sensitive setting in terms of potential for direct impacts on the water course. In addition, there are only two surface water abstractions within 1km of the site, which would further reduce the sensitivity of these resources to site derived contamination.

On the basis of the above information, EAME concludes that there is a **low** risk of the site posing a pollution risk to the River Rea and a **moderate** risk of representing a pollution risk to the aquifer. That is not to say that such pollution is actually occurring or likely to occur.

14.4.7 Baseline Conditions – Chemical Contamination

Field Evidence of Contamination

Minor visual field evidence of potentially contaminated materials was noted during the investigation in the form of frequent gravel size fragments of brick, concrete and clinker. These were evident throughout the Made Ground and interspersed with granular ashy layers. Ash and clinker in particular can have elevated levels of heavy metals present. However, no olfactory or visual field evidence of hydrocarbon odours, hydrocarbon contamination (oily stains) or hydrogen sulphide odours were noted at the site.

Field evidence of contamination was noted and is summarised in *Table 14.5.*

Table 14.5: *Field Evidence of Potentially Contaminated Materials*

Position	Strata	Depth m bgl	Observations
BH1	Made ground	0.13 – 0.20	Reddish brown sandy brick fill with localised pockets of black ashy sandy gravel
BH3	Made ground	0.2 – 0.5	Grey ashy sandy brick and concrete rubble
BH5	Made ground	0.9 – 2.5	Dark brown/black silty very sandy ashy clay with occasional fine-medium pockets of subrounded medium gravel-sized sandstone and fine gravel and occasional fine rootlets and organic material.

Position	Strata	Depth m bgl	Observations
BH6	Made ground	0.35 – 0.9	Dark grey brown sandy silty clay with medium gravel-sized pockets of red brown silty clay with many concrete, clinker and brick fragments.
BH7	Made ground	0.12 – 0.30	Dark grey brown sandy gravel with brick, concrete and clinker.
BH7	Made ground	0.3 – 0.6	Dark grey sandy gravelly clay with gravel sized fragments of brick, concrete, tile and clinker.
BH7	Made ground	0.6 – 1.1	Brown and red brown slightly sandy clay with some gravel size fragments of brick, concrete, clinker and occasional rounded quartzite.
BH8	Made ground	0.05 – 0.3	Black ashy sand with many angular stone cobbles.

It should also be noted that asbestos-containing materials were observed within Trench 4 of the archaeological trial trenching exercise. This was subsequently identified as containing crocidolite and chrysotile variants of asbestos. This is probably present from previous maintenance or demolition activities on this site or on a site where material was imported from as fill to make up levels. Its occurrence was not widespread.

All samples from the boreholes, window sample and trial pit locations were headspace tested for the presence of volatile organic compounds. The results of the headspace testing did not reveal the presence of significant concentrations of volatile hydrocarbons in any of the samples tested. All readings were recorded below the detection limit of the instrument.

During the purging and sampling of groundwater from each of the installed borehole locations, any evidence of contamination *i.e.* free phase product, hydrocarbon sheens or odours, was recorded.

No evidence of such contamination was observed during the purging and sampling of groundwater of the five installed groundwater monitoring wells.

Land Gas Assessment

Land gas is generally produced as a result of the decomposition of organic materials such as paper, vegetation, wood, *etc* but can also be present from the breakdown of solvents and petroleum hydrocarbons or be present from coal measures (mines gas). The principal components of landfill gas are methane (CH_4) and carbon dioxide (CO_2), however, other gases such as hydrogen sulphide (H_2S) and carbon monoxide can also be present. Land gas can present a hazard to site workers during construction activities and can enter buildings and services, thus presenting a toxic, asphyxiation or explosion hazard.

Methane is a flammable asphyxiating gas, the flammable range being 5 to 15% by volume. In air, carbon dioxide is a non-flammable, toxic gas, with a long-term exposure limit of 0.5% by volume, and a short-term exposure limit of 1.5% by volume. Hydrogen sulphide can be both flammable and toxic as can Carbon monoxide.

Monitoring was undertaken for methane, carbon dioxide, oxygen, carbon monoxide (indicative of underground fires) and hydrogen sulphide using a fully calibrated portable infra-red gas analyser (Geotechnical Instruments Gas analyser GA2000) in all locations. The instrument provides quantitative analysis of methane and carbon dioxide by infra-red detection and oxygen by galvanic cell. Additionally, it measures flow by an internal transducer. The analytical range for the gases analysed are 0% to 100% in 0.1% increments. The minimum detection limit is 0.1%.

Five gas monitoring visits have been completed at the site. Only the wells installed as gas monitoring wells have been monitored. The results are summarised below:

- Concentrations of **methane** ranged from non-detectable (<0.1% v/v) to 0.4% v/v (BH5). These levels are not considered to be a concern with regards to potential risk to buildings;

- Concentrations of carbon dioxide were recorded in all monitoring wells at some point during the five monitoring rounds, the maximum concentration being 9.1% v/v (BH5). The presence of carbon dioxide in wells corresponds to the presence of fill material;

- Where depleted concentrations of **oxygen** were recorded, these coincided with the elevated carbon dioxide and/or methane levels;

- **Hydrogen sulphide** concentrations ranged between <1ppm and 1ppm, which was recorded at BH5, BH7 and BH8 all on the fourth monitoring round. These concentrations are considered to be low and insignificant;

- Concentrations of **carbon monoxide** ranged between <1 ppm and 5 ppm (BH5, second monitoring round). These concentrations are considered to be low and insignificant;

- **Flow rates** in the four wells ranged between -0.3 l/hr to + 4.0 l/hr over the monitoring period. These flow rates are not considered to be representative of land gases being positively released on site, at any significant rate; and

- The **GSV'**s for methane and carbon dioxide have been calculated as 0.016 l/hr and 0.36l/hr respectively. Therefore, using the modified Wilson and Card classification, the site has been determined as being 'Characteristic Situation 2', *i.e.* low risk. However, Situation 2 states that gas protection measures may be necessary, but that does not take account of the fact that large volumes of the Made Ground will be removed from the site to enable the basements to be constructed and thus the source of the carbon dioxide will be removed.

Soil Analysis – Review of Results

The soil chemical analysis results are summarised in *Table 14.5* and are discussed below. *Table 14.*5 has been updated using appropriate screening values, for commercial land use, as discussed in *Section 14.3.3*.

The first stage of assessment was to screen out those compounds that were not recorded above the laboratory analytical method detection limits (MDLs). These are provided in the below, and have thus not been considered further:

- Exchangeable ammonium as N;
- Phenol;
- Total monohydric phenols;
- Selenium;
- Naphthalene;
- TPH CWG: Aliphatic >C8-C10;
- TPH CWG: Aromatic >C6-C7 and >C7-C8;
- Typical fuel constituents (MTBE, BTEX, 1,3,5-Trimethylbenzene and 1,2,4-Trimethylbenzene); and
- VOCs.

Table 14.5: *Summarised Soil Analytical Results*

Determinand	Concentration Range (mg/kg)	Location of Maximum Concentration	Tier 1 Screening Values	Number and Location of samples exceeding Tier 1 Values
General Parameters				

Determinand	Concentration Range (mg/kg)	Location of Maximum Concentration	Tier 1 Screening Values	Number and Location of samples exceeding Tier 1 Values
pH (value)	7.1 – 11.1	Archaeology Trench 1: 0.3m	NG	-
Organic Carbon	<MDL – 0.4	Archaeology Trench 4: 1.2 – 1.3m	NG	-
Sulphate as SO_4 (g/l)	<MDL – 1.5	BH5: 0.3m	NG	-
Total Cyanide	<MDL – 3.3	Archaeology Trench 4 : 0.2 – 0.3m	NG	-
Asbestos	-	Archaeological Trench 4	-	**1 (Archaeological Trench 4)**
Metals and Metalloids				
Arsenic	<MDL - 44	Archaeology Trench 5 : 1.3 – 1.5m	640*[1]	0
Cadmium	<MDL - 2.1	BH3: 0.3m	190*[1]	0
Chromium	<MDL - 110	BH3: 0.3m	8,600*[1]	0
Copper	<MDL - 320	WS3: 0.5 – 0.6m	68,000*[1]	0
Lead	<MDL - 950	Archaeology Trench 5: 1.3 – 1.5m	750*[2]	**1 (Archaeology Trench 5: 1.3 – 1.5m)**
Mercury	<MDL - 2.5	BH3: 0.3m	58*[1A]	0
Nickel	6.7 - 69	BH3: 0.3m	980*[1]	0
Zinc	16 - 400	BH9: 0.35m	730,000*[1]	0
PAHs				

Determinand	Concentration Range (mg/kg)	Location of Maximum Concentration	Tier 1 Screening Values	Number and Location of samples exceeding Tier 1 Values
Acenaphthylene	<MDL – 0.13	BH3: 0.3m	83,000*[1B]	0
Acenaphthene	<MDL – 0.26	BH5: 0.3m	84,000*[1B]	0
Fluorene	<MDL – 0.13	BH3: 0.3m	63,000*[1B]	0
Phenanthrene	<MDL – 2.3	BH5: 0.3m	22,000*[1B]	0
Anthracene	<MDL – 0.63	BH5: 0.3m	520,000*[1B]	0
Fluoranthene	<MDL – 5.3	BH5: 0.3m	23,000*[1B]	0
Pyrene	<MDL – 4.9	BH5: 0.3m	54,000*[1B]	0
Benzo(a)anthracene	<MDL – 2.30	BH5: 0.3m	170*[1B]	0
Chrysene	<MDL – 1.7	BH5: 0.3m	350*[1B]	0
Benzo(b)fluoranthene	<MDL – 2.8	BH5: 0.3m	44*[1B]	0
Benzo(k)fluoranthene	<MDL – 1.3	BH2: 1.0m	1,200*[1B]	0
Benzo(a)pyrene	<MDL – 1.9	BH5: 0.3m	35*[1B]	0
Indeno(1,2,3-cd)pyrene	<MDL – 1.2	BH5: 0.3m	500*[1B]	0
Dibenzo(a,h)anthracene	<MDL – 0.32	BH2: 1.0m	13.5*[1B]	0
Benzo(g,h,i)perylene	<MDL – 1.5	BH5: 0.3m	3,900*[1B]	0
PAH (Sum of Dutch 10)	<MDL – 17.98	BH5: 0.3m	NG	-
PAH (Sum of EPA 16)	<MDL – 26.28	BH5: 0.3m	NG	-
Petroleum Hydrocarbons				

Determinand	Concentration Range (mg/kg)	Location of Maximum Concentration	Tier 1 Screening Values	Number and Location of samples exceeding Tier 1 Values
EPH (C10-C20)	6 – 51	WS2: 0.6 – 0.8m	500[*4]	0
EPH (C20-C30)	16 - 820	WS2: 0.6 – 0.8m	500[*4]	**1 (WS2: 0.6 – 0.8m)**
EPH (C30-C40)	12 – 2,300	WS2: 0.6 – 0.8m	500[*4]	**1 (WS2: 0.6 – 0.8m)**
EPH (C10-C40)	7 – 3,200	WS2: 0.6 – 0.8m	500[*4]	**1 (WS2: 0.6 – 0.8m)**
Aliphatic C5-C6	<MDL – 0.02	BH2: 1.0m, BH5: 0.3m, WS1A: 1.8 – 2.0m)	3,200*[1B]	0
Aliphatic >C6-C8	<MDL – 0.03	BH5: 0.3m	7,800*[1B]	0
Aliphatic >C10-C12	<MDL – 0.02	WS1A: 1.8 – 2.0m	9,700*[1B]	0
Aliphatic >C12-C16	<MDL – 41	WS1A: 1.8 – 2.0m	59,000*[1B]	0
Aliphatic >C16-C21	<MDL – 180	WS1A: 1.8 – 2.0m	1,600,000*[1C]	0
Aliphatic >C21-C35	<MDL – 1,800	WS1A: 1.8 – 2.0m	1,600,000*[1C]	0
Total Aliphatics (C5-C35)	<MDL – 2,100	WS1A: 1.8 – 2.0m	NG	-
Aromatic >C8-C10	<MDL – 0.01	WS1A: 1.8 – 2.0m	3,500*[1B]	0
Aromatic >C10-C12	<MDL – 0.03	BH2: 1.0m & WS1A: 1.8 – 2.0m	16,000*[1B]	0
Aromatic >C12-C16	<MDL – 18	WS1A: 1.8 – 2.0m	36,000*[1B]	0

Determinand	Concentration Range (mg/kg)	Location of Maximum Concentration	Tier 1 Screening Values	Number and Location of samples exceeding Tier 1 Values
Aromatic >C16-C21	<MDL – 110	WS1A: 1.8 – 2.0m	28,000*1B	0
Aromatic >C21-C35	<MDL – 1,900	WS1A: 1.8 – 2.0m	28,000*1B	0
Total Aromatics (C5-C35)	<MDL – 2,000	WS1A: 1.8 – 2.0m	NG	-
Volatile Hydrocarbons (C5-C12)	0.01 – 0.10	WS1A: 1.8 – 2.0m	NG	-
Extractable Hydrocarbons (C12-C35)	<MDL - 4100	WS1A: 1.8 – 2.0m	NG	-
Total Hydrocarbons (C5-C35)	<MDL – 4100	WS1A: 1.8 – 2.0m	NG	-
SVOC's - Discussed Separately				
All results expressed in mg/kg except were stated *1 LQM/CIEH (Commercial S4ULs) *1A LQM/CIEH (Commercial S4ULs) Elemental Mercury *1B LQM/CIEH (Commercial S4ULs) 1% SOM *1C LQM/CIEH (Commercial S4ULS) Aliphatic EC>16-35 *2 Former SGV (2002) used for Lead value *in lieu* of any other criteria NG = No Guideline available <MDL = Below the Method Detection Limit				

Soil **pH** values were recorded as ranging from neutral to alkaline in the range of pH 7.1 – pH 11.1. These values are not normally considered significant in themselves; the main relevance of soil pH in environmental terms is its effect on the mobility of metals. Metal species are generally less mobile under alkaline conditions, which generally appear to be present across the site. The potential for leaching of metal species at the site, is therefore, considered to be reduced under these alkaline conditions.

Water soluble sulphate concentrations ranged from <0.02g/l to 1.5g/l (BH5: 0.3m). No environmental guidelines are currently available for sulphate and elevated sulphate levels are of limited significance in environmental terms. However, sulphate rich conditions are aggressive to building materials and this issue will be a consideration during the redevelopment.

Total cyanide concentrations were all recorded below the analytical limit of detection (<1 mg/kg), with the exception of one sample (Trench 4: 0.2 – 0.3m) (3.3mg/kg).

Monohydric phenol concentrations were recorded below the analytical detection limit (<1 mg/kg) in all thirty samples analysed and are therefore not of environmental concern.

The concentrations of **exchangeable ammonium** were not found above the laboratory detection limit (40mg/kg in this instance) at any of the nine locations.

Thirty-one soil samples recovered from the made ground and the underlying natural strata were submitted for a range of metals. Elevated concentrations of **lead** (Archaeology Trench 5: 1.3 – 1.5m (950 mg/kg)) were detected above the respective Tier 1 guideline values at one location.

Extractable Petroleum Hydrocarbon (**EPH**) analysis is a general assay of middle distillate compounds. No relevant guidelines are available at present and the value for inert material for Waste Acceptance Criteria (WAC) (500mg/kg) has been used for comparison. The results indicate that of the eleven samples submitted for EPH analysis, exceedances of this guideline at the C20-C30, C30-C40 and C10–C40 fractions were only detected from a sample collected from the Made Ground (0.6 – 0.8m) at WS2.

Twenty-one samples were submitted for total petroleum hydrocarbons (**TPH**) split into aromatic/aliphatic carbon bands as per the TPH Criteria Working Group (CWG) guidance. This analysis provides an indication of the relative concentrations of aromatic and aliphatic compounds and thus the relative potential for harm (the aromatic component being more environmentally harmful than the aliphatic component). No elevated concentrations of hydrocarbons were observed.

A total of 31 samples were submitted for total and speciated **PAHs**, none were found elevated above relevant screening values.

Asbestos screening was undertaken on nineteen samples recovered from the made ground horizon. Asbestos was detected at a depth of 1.1m bgl in Archaeological Trench 4. This was subsequently classified by the laboratory as crocidolite and chryostile. It was not observed in any other locations.

Volatile Organic Compound (**VOC**) analysis targets certain volatile aromatic compounds (specifically petroleum based hydrocarbons associated with fuels) and solvents (notably chlorinated solvents which were often used in engineering and metal processing activities or in general maintenance for degreasing). Nine samples were submitted for VOC analysis; these were chosen on the basis of field observations (i.e. most likely to contain hydrocarbons) and also to provide spatial coverage of the made ground profile and natural deposits where there was no field evidence (which was generally the case). None of the individual compounds were detected at concentrations above their respective analytical detection limit.

Nine samples recovered from the made ground and the underlying natural strata were also submitted for Semi-Volatile Organic Compound (**SVOC**) analysis. The SVOC analysis includes PAHs, phenols, phthalates, ethers and branched benzenes. The results of the individual determinants, which were recorded above the analytical level of detection are presented in *Table 14.6*

Table 14.6: *Summary of SVOC Analytical Results (mg/kg)*

Determinand	Sample Reference		
	BH1: 1.3 – 1.5m	Trench 3	Trench 4: 1.0 – 1.1m
Bis (2-ethylhexyl) phthalate	0.5	ND	ND
Dibenzofuran	ND	0.6	0.87

These are widespread contaminants and the concentrations of these two SVOCs are low and are therefore not of environmental concern in the context of this site.

Total Organic Carbon (**TOC**) analysis was undertaken on seven soil samples recovered from the natural strata that were free of obvious contamination, in order to establish a baseline indication of the total organic matter in the soil. TOC concentrations ranged between <0.1% (below laboratory detection) and 0.40% (Trench 4: 1.2 -1.3m). There is no guideline criteria for TOC, however, the results will be of relevance for more detailed quantitative risk assessments that may be required post planning consent if significant contamination is found to be present.

Leachability Analysis

Due to the elevated concentration of hydrocarbons, although not above current screening criteria, in the sample collected from WS1A: 1.8 – 2.0m, a leaching test was undertaken on the sample for leachable TPHCWG. This analysis is used to assess the potential for leaching of contaminants from soil into groundwater and watercourses.

The leachate results show, that under laboratory conditions, the fractions of TPH are not in a readily soluble form and are below the laboratory's level of detection. Hence they do not represent a risk to groundwater and surface water quality.

Groundwater Analytical Results

Analysis was undertaken on five samples of groundwater, obtained from the installed boreholes BH1, BH3, BH4, BH6 and BH9. Groundwater monitoring was undertaken on 18th February 2008. The groundwater chemical analysis results are summarised in *Table 14.7*.

The first stage of assessment was to screen out those compounds that were not recorded above the laboratory analytical method detection limits (MDLs). These are provided in the below, and have thus not been considered further:

- Total cyanide;
- Metals and metalloids – arsenic, cadmium, lead, mercury, selenium and copper;
- Monohydric phenols;
- Total PAH EPA-16;
- Volatile Hydrocarbons (C5-C12);
- TPH CWG Aliphatics C5 – C6, >C6 – C8, >C8 – C10, >C10 – C12, >C12 – C16 and >C16 – C21;
- TPH CWG Aromatics >C6 – C7, >C7 – C8, >C8 - C10, >C10 – C12, >C12 – C16 and >C16 – C21;
- Typical fuel constituents (MTBE, BTEX, 1,3,5-Trimethylbenzene and 1,2,4-Trimethylbenzene); and
- SVOCs

Table 14.7: *Summarised Groundwater Analytical Results*

Determinand	Concentration Range (mg/l)	Location of Maximum Concentration	Tier 1 Screening Values (mg/l)	Number and Location of samples exceeding Tier 1 Values
Metals/Non Organics				
Dis. Boron	0.3 – 0.88	BH6	2*1	0
Dis. Chromium	<MDL – 0.009	BH4	0.0047*2(4)	0
Dis. Nickel	<MDL – 0.008	BH6	0.02*2(5)	0
Dis. Zinc	<MDL – 0.037	BH4	0.125*2(4)	0
pH	6.9 – 7.3	BH6	6 – 9*1	0
Sulphate as SO_4	53 – 310	BH6	400*1	0
Hydrocarbons				
Extractable Hydrocarbons (C12-C35)	<MDL – 0.45	BH3	0.05[3]	**1 (BH3)**
Aliphatics >C21 – C35	<MDL – 0.3	BH3	NG	-
Total Aliphatics (C5 - C35)	<MDL - 0.3	BH3	0.05[3]	**1 (BH3)**
Aromatics >C21 – C35	<MDL – 0.16	BH3	NG	-
Total Aromatics (C5 -C35)	<MDL – 0.16	BH3	0.05[3]	**1 (BH3)**
Total Aliphatics and Aromatics C5 - C35	<MDL – 0.45	BH3	0.05[3]	**1 (BH3)**
VOCs are discussed separately				

Notes

*1 = List 2 dangerous substances (Freshwater EQS), EC Dangerous Substances Directive (76/464/EEC)

*2(4) = Part 4 (Specific Pollutants) of the River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010 (annual means used where available)

Determinand	Concentration Range (mg/l)	Location of Maximum Concentration	Tier 1 Screening Values (mg/l)	Number and Location of samples exceeding Tier 1 Values
[3] = The Surface Waters (Abstraction for Drinking Water) (Classification) Regulations 1996 = shaded areas exceed relevant Tier 1 Screening Value All results expressed in mg/l except for pH. <MDL = Below the Method Detection Limit NG = No Guideline - = Not Relevant				

The **pH** values were found to be slightly acidic to neutral (in the range pH 6.9 – 7.3), and are within what is considered to be a natural range.

Total cyanide concentrations were recorded below the analytical detection limit (<0.02mg/l) in all of the five samples analysed.

Concentrations of **monohydric phenol** were not found above the laboratory's limit of detection and are therefore not of environmental concern.

The majority of samples returned **metal** concentrations below the analytical limits of detection and subsequently below relevant guideline criteria. Low concentrations of **boron** (all five locations), **nickel** (BH4 and BH6), **chromium** (BH4), **selenium** (BH6) and zinc (BH3 and BH4) were recorded; however, these concentrations were below the relevant guideline values.

All samples were submitted for total petroleum hydrocarbons (**TPH**) split into aromatic/aliphatic carbon bands as per the TPH Criteria Working Group (CWG). This analysis provides an indication on the concentrations of aromatic and aliphatic compounds. Only one sample (BH3) indicated the presence of hydrocarbons over the limit of detection at a concentration of 0.3mg/l (total aliphatics) and 0.16 mg/l (total aromatics). Although these concentrations are above the relevant guideline values, it is important to note that the Surface Water (Abstraction for Drinking Water) (Classification) Regulations are conservative as they are generally applied where the water is abstracted for potable water supply, which is not the case at the subject site. They are of no consequence in terms of the proposed site uses.

Of the five samples submitted for the analysis of **speciated PAHs**, all samples recorded concentrations below the analytical limits of detection.

Chloroform, a **VOC,** was detected in three samples (BH3, BH4 and BH9) of the five samples analysed. A maximum concentration of 0.009mg/l was recorded at BH9; however, this concentration is considered to be low and is not of any environment significance. No other VOCs were recorded above the analytical limit of detection.

No **SVOCs** were detected above laboratory detection limits in any of the five samples analysed.

Total organic carbon was analysed in order to provide a generic baseline assessment of the organic content in the groundwater across the site. The concentrations ranged between 6.1 mg/l (BH1) and 1.6mg/l (BH9). No guideline criteria are available for this parameter but these levels are indicative of a low organic content.

Summary of Analytical Results

Chemical testing of the soil and groundwater has revealed that whilst minor levels of contamination are present, this is entirely within expectations for a site of this age with mixed uses in a city centre location. Where minor levels of contamination do exist, this does not appear to be impacting upon groundwater and the site does not pose a pollution risk to the wider environment.

Furthermore, where these low levels of contaminants have been observed this has been in relation to the shallow Made Ground, the majority of which is scheduled to be removed from the site to enable the basements to be developed as part of the development design. The residual ground will be largely natural ground containing the identified chemicals at levels typical of natural background.

The presence of isolated fragments of asbestos within the Made Ground does not represent a significant risk to site occupiers under the current site usage, however, it does represent a potential risk through inhalation during any excavation works, to construction workers and archaeological surveyors if such material is widespread and disturbed. It is not expected that this will be the case, however, appropriate PPE and site health and safety procedures, as well as vigilance by experienced field scientists during the excavation works will ensure this potential issue is well managed. If asbestos is identified in areas during excavation the area will be damped down and works ceased in that area until appropriate additional precautions can be put in place.

The additional groundwater and ground gas data obtained by GIP in 2013 fell within the ranges recorded in the previous investigation reports and as such this additional information does not change the assessment of baseline condition.

14.5 Assessment of Project Impacts & Mitigation

Sources of Contamination

The analytical results have highlighted a limited number of contaminants at concentrations greater than the initial screening levels.

Receptors

The following potential receptors have been identified:

- visitors and trespassers;
- Site buildings and structures (i.e. foundations, buildings and services);
- Site workers (*i.e.* current and future employees located at the site);
- Groundworkers *(i.e.* construction workers, maintenance workers or other personnel who may be directly exposed to contaminated soil or groundwater in the course of their activities);
- Planted vegetation associated with the landscaping proposals;
- Groundwater, encountered within the solid geology of Bromsgrove Sandstone and Mercia Mudstone; and
- third party land (*i.e.* the possibility of contamination migrating off-site onto third party via contaminated groundwater).

Potential Pollutant Pathways

The following potential pollutant pathways have been identified at the site:

- Migration of land gases into buildings and service conduits;
- Migration of contaminants to shallow groundwater bodies and aquifer via leaching and run-off, or transmission along conduits;
- Inhalation, ingestion or skin contact with contaminated soils or waters (although generally risks to construction workers or maintenance workers should be manageable by standard health and safety procedures); and
- Leaching and capillary rise into landscaped areas.

A conceptual model for the site, presenting the identified sources of contamination, pathways and receptors is detailed in tabular form graphically in *Figure 14.4*.

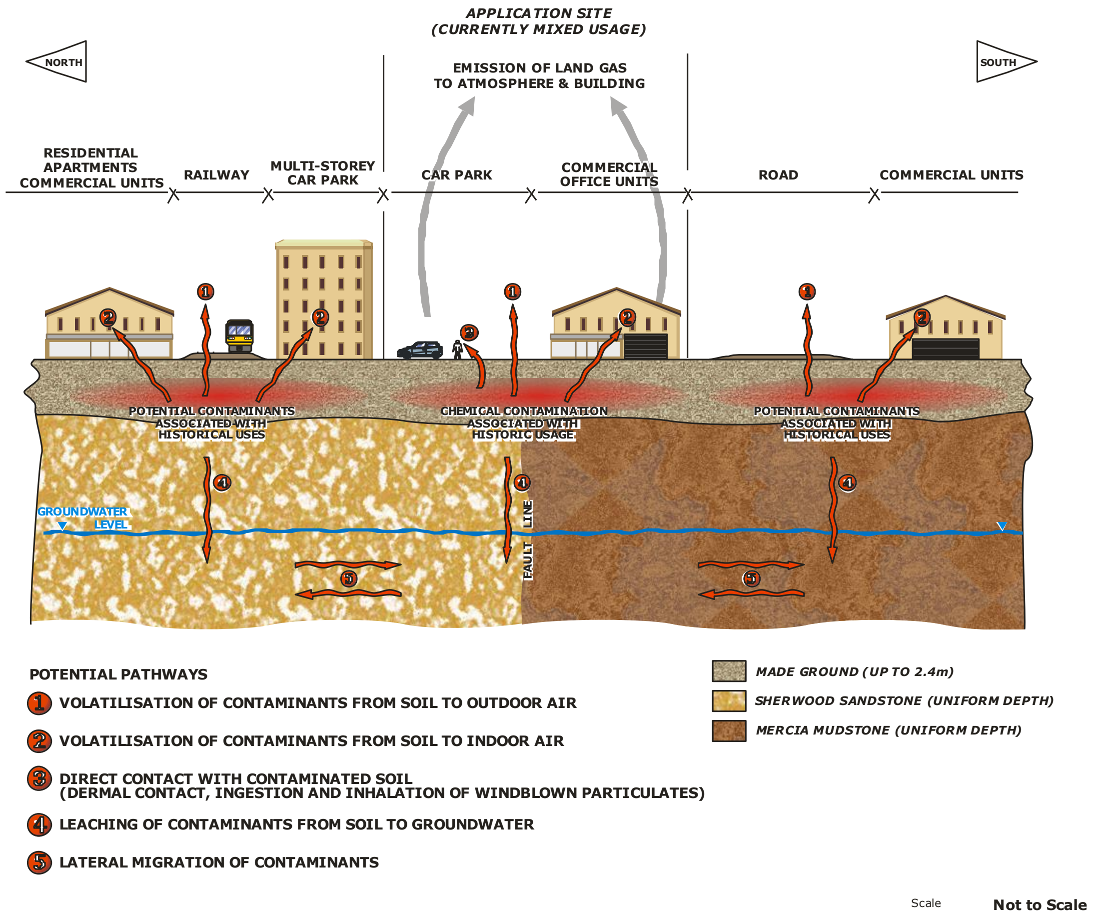

Figure 14.4: *Conceptual Site Model*

The following provides a discussion of the risk assessment for the site, based on the current understanding and whether plausible pollutant linkages such as those illustrated above are present or likely to be present.

Potential Risks to the Current or Future Site Occupiers

Marginally elevated concentrations of contaminants were detected during the site investigation. If excavations are undertaken at the site there is the potential for human exposure to these contaminated soils. Where hardstanding exists this eliminates the exposure pathway and under the development proposals the area of hardstanding will be increased substantially. Furthermore the landscaping scheme will also provide a barrier between site occupiers and the contaminated soils so the risk of these contaminants, even if they were left undisturbed would be insignificant. Notwithstanding this, the removal of the majority of the Made Ground on the site to create the basement voids will remove the bulk of the pollution source such as it is.

In effect the proposed development will lessen the risk of exposure of site users to contaminated soils once developed as there will effectively be an impermeable physical barrier (hardstanding and managed landscaping) between the residual contaminants and site users. It should be stressed, however, that the contamination source such as it is, is small in magnitude and this site is not significantly contaminated.

Potential Risks to Construction Workers

The planned redevelopment activities will involve excavation and earthworks *(i.e.* laying new services, cut and fill operations, maintenance of existing services and piling activities during the construction phase) and may bring construction workers into direct contact with contaminated ground materials (soils and groundwater) through direct skin contact, inhalation and ingestion. These risks are considered to be low. The construction phase environmental protection and health and safety management plan for the site will ensure that appropriate measures are adopted to minimise and control the levels of exposure and to ensure all site workers are adequately informed of the risks to themselves and the environment.

Potential Risks to the Groundwater - General

The shallow groundwater encountered at the site appears to be within the natural deposits. The made ground is underlain by Head deposits, which are further underlain by Mercia Mudstone or Sherwood Sandstone. It should be noted that the head deposits are not continuous across the site. Overall, the risk to groundwater from site-derived contamination is considered to be low as there is limited potential for contaminants to leach from the soils into the groundwater body and there is no evidence of significant groundwater contamination on the site at present. This situation will not be changed by the development proposals which if anything will remove much of the potential contamination source and lessen the risk. There will be no activities associated with the proposed site that will bring significantly polluting activities onto the site, but there is a slightly heightened risk associated with plant refuelling during the construction phase. This can be adequately controlled by appropriate management techniques.

The current hardstanding cover on-site will reduce the potential impact of leached contaminants to migrate downwards and impact upon the quality of the groundwater, but the hard cover is poor or absent in places and does not form an effective barrier to infiltration of rainwater through the site. The proposed development will have a much greater area of hard cover and this will thus reduce the potential for percolating rainwater to leach contaminants from the unsaturated zone into the saturated zone.

The current coverage of hardstanding equates to around 55% of the site area. Once the development proposals are complete, this will have increased to almost 100%.

It is recognised, however, that during the construction phase more soils will be exposed and there may be a temporary increase in infiltration rates during this period depending upon weather conditions, but there is a general absence of leachable contaminants.

Potential Risks to the Surface Waters

The closest watercourse to the site is the River Rea, which lies approximately 364 m east of the site at its closest point. This water feature was classified by the EA under the General Quality Assessment scheme as being of Grade D condition, i.e. poor quality, during the last monitoring round in 2000. There is a small potential for the migration of contaminants in shallow groundwater into the river directly if they are contiguous (which is not proven). Regardless of the prevailing quality of the receiving water, the migration of contaminants into it from the site would be regarded as significant. The investigation has shown that there is negligible contamination on the site and what is present is not leachable so even though there may be a plausible pathway between the site and the river, the risk of impact is negligible.

As already stated, the development proposals will involve substantially increasing areas of hard surfacing on the site which will serve to both greatly reduce rainwater infiltration (and thus flushing and leaching of contaminants) and will also provide a “clean” barrier between incident rainfall and the contaminated soils, thus leading to uncontaminated surface run-off. In addition, the site drainage system will effectively be replaced with a new high integrity drainage system, removing another potential contaminant migration pathway. This too will lessen the already low risk to insignificant levels.

Ground Gas Assessment

Based on the field gas monitoring data obtained to date, slightly elevated methane and carbon dioxide concentrations have been detected at the site. Using relevant guidelines, Gas Screening Values for methane and carbon dioxide were calculated and have indicated that the site is low risk. With the subsequent removal of large volumes of Made Ground from the site, the gas risk will be reduced further to insignificant levels.

14.6 Assessment of Cumulative Impacts

There are no cumulative effects from surrounding schemes affecting soils, geology or contamination.

14.7 Summary

Given the foregoing, there has been very little change in terms of Soils, Geology and Contamination to the situation presented in the Environmental Statement prepared in 2009. As such, the original assessment that 'the development proposals will have an insignificant impact on the soil and groundwater quality' still applies. Key aspects are outlined briefly below:

- The nature and level of contaminants identified at the site, although low to moderate, are not considered to pose a significant health risk to occupants.
- The nature and level of contaminants identified at the site, although low to moderate, are not considered to pose an ongoing source of groundwater contamination.
- Removal of contaminants is likely to occur due to the excavations associated with the basement construction and general site earthworks.
- On demolition of the site infrastructure further areas of the site which have not been investigated, due to access constraints, will be exposed, especially by the archaeological investigation works. Should significant contamination in these areas be encountered during these works this will be assessed and dealt with at that time, with remedial options being discussed and agreed with Birmingham City Council and/or the EA. Given the historical uses of the site and the low level of soil and groundwater contamination identified to date, EAME does not consider that further works are necessary to characterise the areas that are currently inaccessible.
- The completed site will be hard surfaced which will prevent infiltration and percolation of rainwater.
- the use of plant equipment on site may possibly lead to the potential for the release of contaminants to ground, such as fuel oils, coolants and lubricants. To avoid the accidental leakage of fuel oils and/or lubricants, all machines will be maintained to a safe and efficient working condition at all times. In most cases, leakage of oil is avoidable through regular checks for signs of wear and tear on plant and tanks. Refuelling is identified by the Environment Agency guidelines (Pollution Prevention Guidance Note 5) as the greatest risk of pollution during site work construction. Therefore, together with other routine maintenance, all servicing and refuelling will be carried out in a designated contained area.
- Excavations are likely to encounter groundwater at a shallow depth and provision for dewatering will need to be made.

In conclusion, given the contaminant levels observed are inconsequential as far as the development is concerned the development proposals will have an insignificant impact on soil and groundwater quality.

Based upon the appraisal of soils, geology and contamination impacts discussed above, the residual impacts associated with the **Construction Phase** are deemed to be of **LOW** significance and short-term and temporary in nature. The residual impacts associated with the **Operational Phase** are deemed to be of **LOW** significance and long-term or permanent in nature.