

Sinfin A & C - Rolls-Royce Aerospace Campus

Phase 1 Geo-Environmental Risk Assessment

Rolls-Royce

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Table of Contents

1.	Introduction.....	1
1.1	General.....	1
1.2	Proposed Development.....	1
1.3	Methodology.....	1
1.4	Sources of Information.....	2
2.	Environmental Setting and Sensitivity.....	3
2.1	General.....	3
2.2	Site Location.....	3
2.3	Site Description.....	3
2.4	Site Walkover.....	3
2.5	Topography.....	4
2.6	Geology.....	4
2.6.1	Made Ground.....	4
2.6.2	Superficial Deposits.....	5
2.6.3	Bedrock.....	5
2.6.4	Geological Faults.....	5
2.6.5	Mining.....	5
2.6.6	BGS Boreholes.....	5
2.6.7	Potential for Natural Ground Hazards.....	5
2.7	Hydrogeology.....	6
2.7.1	General.....	6
2.7.2	Groundwater Vulnerability.....	6
2.7.3	Groundwater Source Protection Zones (SPZ).....	6
2.8	Hydrology.....	6
2.9	Sensitive Sites.....	6
2.10	Unexploded Ordnance (UXO).....	6
2.11	Radon.....	6
3.	Historical Land Use.....	8
3.1	General.....	8
3.2	Summary of Potential Historical Sources of Contamination.....	8
3.3	Anecdotal Evidence.....	9
3.4	Potential Contaminative Activities.....	9
4.	Summary of Environmental Information.....	10
4.1	General.....	10
4.2	Water Abstractions.....	10
4.3	Discharge Consents.....	10
4.4	Pollution Incidents to Controlled Waters.....	10
4.5	Local Authority Pollution Prevention and Controls.....	11
4.6	Potentially Hazardous Sites.....	11
4.7	Environmental Prosecutions.....	11
4.8	Contemporary Trade Land Use.....	12
4.9	Local Authority Recorded Landfill Sites.....	12
4.10	Registered Landfill Sites.....	12
4.11	Historic Landfill Sites.....	12
4.12	Licensed Waste Management Facilities.....	12
4.13	Registered Waste Treatment or Disposal Sites.....	12
5.	Previous Ground Investigations.....	13
5.1	General.....	13
5.2	Ground Profile.....	14
5.3	Fieldwork Contaminant Observations.....	14

5.4	Soil Contaminant Concentrations	15
5.5	Groundwater Contaminant Concentrations	16
5.6	Ground Gas Monitoring	16
5.7	High Level Assessment of Remediation Requirements for Sinfin Estate (URS 2012)	17
5.8	Other Sub-Sites	17
5.8.1	Sinfin B	17
5.8.2	Sinfin D	17
5.8.3	Learning and Career Development Centre (LCDC)	17
5.8.4	Moor Lane Facility	18
5.8.5	Production Testing Facility (PTF)	18
6.	Conceptual Site Model	19
6.1	General	19
6.2	Sources of Potential Contamination	19
6.3	Potential Pathways	20
6.4	Potential Receptors	20
6.5	Potential Contaminant Linkages	21
7.	Environmental Risk Assessment Framework	22
7.1	Risk Assessment Principles	22
7.2	Preliminary Risk Evaluation	23
7.3	Evaluation of Risks to Future Site Users	24
7.4	Evaluation of Risks to Construction Workers	25
7.5	Evaluation of Risks to Controlled Workers	25
7.6	Evaluation of Risks to Development Infrastructure	25
7.7	Evaluation of Risks to Off-Site Receptors	25
7.8	Evaluation of Risks to On-site Flora and Fauna	25
8.	Preliminary Geotechnical Appraisal	27
8.1	General	27
8.2	Depth to Weathered Mudstone Bedrock	27
8.3	Weak and Compressible Ground	27
8.4	Buried Foundations	27
8.5	Aggressive Ground Conditions	27
9.	Conclusions and Recommendations	29
9.1	Conclusions	29
9.2	Recommendations	29
	Appendix A – Envirocheck Report	31

Drawings

60544336_DS_GE_001 – Site Location Plan

60544336_DS_GE_002 – Site Boundary

60544336_DS_GE_003 – Exploratory Hole Location Plan from Previous Ground Investigation

Tables

Table 1.	Summary of Historical Ordnance Survey Maps	8
Table 2.	On-site contamination Issues (Scott Wilson, 2002)	9
Table 3.	Discharge Consents	10
Table 4.	Pollution Incidents to Controlled Waters	11
Table 5.	Fuel Stations within 1km of the Site	12
Table 6.	Sinfin A and C Exploratory Works	13
Table 7.	Encountered concrete obstructions (URS, 2013)	14
Table 8.	Recorded hydrocarbon/solvent odours (URS, 2013)	15

Table 9. Sources of Potential Contamination.....	19
Table 10. Potential Pathways.....	20
Table 11. Potential Receptors	20
Table 12. Potential Contamination Linkages.....	21
Table 13. Severity of Risk.....	22
Table 14. Probability of Risk Occurring.....	22
Table 15. Risk Based on Comparison of Probability and Severity.....	23
Table 16. Risk Evaluation of Potential Contaminant Linkages	23

1. Introduction

1.1 General

AECOM Infrastructure & Environment UK Ltd (hereafter referred to as 'AECOM') was commissioned by Rolls-Royce to undertake a Phase 1 Geo-Environmental Risk Assessment for the Sinfin A & C Sites, herein referred to as the 'Site', of the Rolls-Royce Sinfin Aerospace Campus, Derby. The Site location is marked on Drawing 60544336_DS_GE_001 and the site boundary is marked on Drawing 60544336_DS_GE_002. The Sinfin A & C Site will be redeveloped to include the Project Genesis development.

A Phase I Assessment was carried out by AECOM in March 2015 for a large area of the Sinfin Aerospace Campus to support the outline planning application for the redevelopment of the campus. This area included Sinfin A and C Site. In addition, AECOM (as Scott Wilson Ltd and URS) has previously undertaken Phase I and Phase II studies on various sub-sites of the Campus. These previous studies were reviewed as part of the Phase I report for the Sinfin Aerospace Campus in 2015.

This Phase 1 report aims to identify and where present to characterise potential sources of contamination related to current and historical land use, which may be related to on and off-site sources, and to assess qualitatively the risks to receptors. This report will also provide a preliminary assessment of the geotechnical factors which have the potential to affect a future development scheme. In addition and where it is required, further details of any necessary ground investigation and associated monitoring will be provided. This report can be used to assist in addressing Condition 20 of the planning conditions attached to the outline planning permission for the Derby Aerospace Campus.

This Phase 1 Geo - Environmental Risk Assessment will review the existing information and the assessment encompasses the following:

- Geological conditions;
- Hydrology and hydrogeology;
- Contaminated land;
- Environmental risk assessment;
- Piling risk assessment;
- Geotechnical assessment; and,
- Outline Ground Investigation Proposals.

1.2 Proposed Development

Rolls-Royce is planning to redevelop its Sinfin facility to form the Derby Campus. This report refers to the development within the Sinfin A & Sinfin C part of the Campus which covers an area of approximately 210,000m².

Within the Sinfin A site, Rolls-Royce intends to develop Project Genesis which will provide a new flagship office/laboratory building with a footprint of approximately 20,000m². The area intended for the development of Project Genesis will be remediated as part of enabling works. Other areas of the Sinfin A and C site will be remediated as they become available for redevelopment. The enabling works will include the demolition of buildings, including floor slabs and foundations. As part of the demolition works, remedial works will be undertaken where contaminated materials are encountered.

1.3 Methodology

The assessment presented in this report and the recommendations provided have been prepared in accordance with the following guidance:

- Association of Geotechnical and Geo-environmental Specialists 'Guidelines for Combined Geo-environmental and Geotechnical Investigations' (2000);

- British Standards 10175 'Investigation of Potentially Contaminated Sites – Code of Practice' (2011);
- Contaminated Land Report (CLR) 11 'Model Procedures for the Management of Land Contamination' (2004);
- DEFRA Circular 01/2006 'Environment Protection Act 1990 Part 2a Contaminated Land' (2006); and
- Environment Agency (EA) GP3 'Groundwater Protection: Policy and Practice'.

This report considers the implications of Part 2a of the Environmental Protection Act 1990 and the associated Contaminated Land (England) Regulations 2006 and the Contaminated Land (England) (Amendment) Regulations 2012.

To achieve the stated objectives, the following tasks have been performed:

- A review of the geological, hydrological and hydrogeological setting across the proposed site, together with public domain geo-environmental information to build up an accurate understanding of the site and surrounding environmental setting/sensitivity;
- A review of historical land uses for the site and surrounds with a particular emphasis on identifying potential ground hazards and potential on-site and off-site contamination sources;
- Preparation of a Conceptual Site Model with a view to identifying any significant source-pathway-receptor linkages followed by a qualitative risk assessment;
- A review of potential geotechnical constraints.

1.4 Sources of Information

The information and documents received for the purpose of this report are given below:

- AECOM Phase 1 Desk Study Report Rolls-Royce Derby Aerospace Campus (2015);
- British Geological Survey Solid and Drift Geological Map for Loughborough (Sheet 141) 1:50,000;
- British Geological Survey map SK33SE 1:10,000;
- BGS Memoir accompanying Sheets 141 'Geology of the country between Loughborough, Burton and Derby, Carney, Ambrose and Branden, 2001;
- British Geological Survey (BGS) website (www.bgs.ac.uk);
- Environment Agency (EA) website (<https://www.gov.uk/check-local-environmental-data>);
- Envirocheck Report, Landmark Group, 22nd January 2015, Order No. 63773255_1_1 (Appendix A);
- MAGIC website (www.magic.defra.gov.uk);
- Zetica website (http://www.zetica.com/uxb_downloads.htm);
- CL:AIRE (RB17 'A pragmatic approach to ground gas risk assessment' 2012)
- Scott Wilson Kirkpatrick & Co Ltd (2002) Geo-Environmental Site Assessment, Rolls-Royce Derby Phase 1;
- Scott Wilson Kirkpatrick & Co Ltd (2002) Geo-Environmental Site Assessment: Rolls-Royce, Derby Geo-environmental Assessment Report – Phase 2.
- URS Phase 2 Geo-Environmental Assessment Sinfin A and C Report (2013).

2. Environmental Setting and Sensitivity

2.1 General

The environmental setting of the Site is of importance because the topography, geology, hydrogeology and hydrology of the Site and the surrounding land are the main factors that influence the way in which any contaminants which may be in the soil or groundwater can be transported on or off Site, potentially impacting on identified receptors. The environmental setting of the Site has been assessed by making reference to the information sources detailed in Section 1.4.

2.2 Site Location

Rolls-Royce Sinfin A & C Site can be centred on National Grid Reference SK 35991 32503, see Drawing 60544336_DS_GE_001. The Site is located on the southern outskirts of Derby and covers a total area of approximately 21Ha. The Rolls-Royce Sinfin Aerospace Campus also contains the following areas:

- Sinfin B approximately 195,000 m²;
- Sinfin D approximately 230,000 m²;
- Moor Lane Facility approximately 178,000m²;
- PTF approximately 177,000m²;
- PCF/TBF approximately 110,000m²;
- An area of Sinfin Moor to the south and west of Wilmore Road; and
- Field South of Moor Lane, adjacent to Allotment Gardens, at approximately 22,000m².

2.3 Site Description

Located approximately 3.75km south of the centre of Derby, the Sinfin A & C area encompasses approximately 210,000m², see Drawing 60544336_DS_GE_002. Sinfin A & C is bounded by Victory Road on the north eastern and eastern flank within Sinfin B to the north east and Moor Lane Site to the east, a railway line forms the southwestern boundary with the PTF Site further west and Sinfin D to the north west, the LCDC is present to the south east.

The Site contains over 50 buildings and a fuel farm. The facilities in the area are used predominantly for the testing and development of jet engines. Buildings are fairly densely packed in the western part of the Site with more open spaces in central and eastern parts. In the west, tarmac covers much of the Site not occupied by buildings. Elsewhere there is a mixture of hardstanding and open ground. The southern area of the Site contains fill material, consisting of various wastes from the Site over the years, including coal slag, waste oils

The Site has been used as an engine experimental- and build- test facility since its inception. The Site is currently less utilised than previously, with some of the buildings being redundant. A fuel farm is located adjacent to the western boundary of the Sinfin A & C Site. There are several test beds where engines and components of engines are tested. Prototypes are built here, stripped down and re-assembled.

2.4 Site Walkover

A Site walkover was undertaken on 5th February 2015, a description of the Site during the visit is summarised below:

A Fuel Farm is present in the centre of the western boundary, holding containers for Jet Fuel which is piped around the Site. These tanks are filled via transporters from the railway line. Opposite the Fuel Farm is the Gas Plant Combustion Rig and in the foreground are the concrete foundations of the former "H" Hanger Test Bed. In front of the Fuel Farm tanks and the foundations of 'H' hanger there is an elevated platform where there is a diesel station with a tank below the platform.

Moving south along the perimeter following the railway line there are 'old test beds'. Two of the 'old test beds' are now disused but one is still in use. The two disused test beds are now used for storage. There was evidence of

fuel spills and waste oil contained in tanks underneath the test beds. There is an oil extraction unit alongside the test bed which cleans the oil from the test bed still in use. Alongside each building there are CO₂ stores which feed into the test beds as a safety precaution in case of fires. These are considered to be redundant on the two beds and are no longer in use. During the Site walkover litter was identified behind these buildings which included roofing felt and unknown items. There are four disused tanks and an old fuel pump house behind the test beds which it is understood to have held water. The pump house is currently being used for storage of CO₂ bottles.

In the south eastern corner there is a Waste Disposal Unit where all the Site waste is sorted for recycling and disposal.

Moving north along the eastern perimeter of the Site there is a macadam car park along the boundary and to the west a substation. To the north of the substation is the CVC Control and Data Services Office block, asbestos may be present within this building due to its age.

To the north of the Fuel Farm is the Advanced Seal Endurance Rig building, at the entrance to the building there is a redundant test rig with a water pump and possibly fuel bund below. At the time of the Site walkover there was evidence of oil spills on the floor in the gate entrance to the Mechanical Test Rig No. 3. At the rear of this building at the time of the Site walkover there was evidence of asbestos exposed around a pipe which protrudes out of the wall. Also in this vicinity, there is an alcove with sprinklers, flame retardant valves and apparatus. It is understood that this area may have been utilised for flame testing as the apparatus and dials are flame retardant and there are sprinkler valves in the roof space. Rubbish, including broken macadam, possibly tar based surfacing, is present inside the eastern side of the building.

To the west of the Mechanical Test Rig No.3 unit there are Chiller Units; next to these units is the Hazardous Waste Store. At the time of the Site walkover there was evidence of oil spills on the road outside the Waste Store which extends westwards and bends around the north. Moving north along this road there is the C4 Fitting Shop. The northern boundary of Sinfin A is comprised a concrete wall and macadam ground surface.

To the south of the Fitting Shop there is the Mechanical Rig Building. The Mechanical Rig Building has cladding around external pipes. These pipes lead down into the drains, and there was steam rising from the drain. At the time of the Site visit a smell of fuel fumes was noted when passing the flow meter calibration area. Adjacent to the Calibration area is the Emergency Response Unit. There is a storage area containing Jet Fuel pipes within the Emergency Response Unit yard and there is storage for CO₂ fire extinguishers. Heading north from the Emergency Response Unit there are derelict 'catacombs'. There are also 'catacombs' which are still in use on the eastern side. It is understood that inside the derelict 'catacombs' is redundant pipework. The catacombs still in use also contain pipework.

There is a macadam surfaced car park in the centre of Sinfin A, there is also a macadam surfaced car park and several modular buildings that form the Site canteen. At the time of the Site walkover in the north-west corner of the central area there were piles of rock salt covered with a tarpaulin

2.5 Topography

Contours shown on the 1:10,000 scale Site sensitivity maps included in the Envirocheck Report indicate that the Site is on relatively flat ground with a gradual fall in ground level to the south and south west. A spot height to the east of the Site notes 47m AOD and a spot height to the west notes 42m AOD.

2.6 Geology

Geological information on the Site was sourced from the British Geological Survey (BGS) Solid and Drift Maps for Loughborough, (Sheet 141) 1:50,000 scale; the 1:10,000 scale BGS map SK33SE and the BGS memoir accompanying Sheet 141, 'Geology of the country between Loughborough, Burton and Derby'.

2.6.1 Made Ground

The BGS Solid and Drift Map 1:10,000 SK33SE indicates that there is no Made Ground present on Site, although immediately north-west, west and south west of the Site Made Ground is noted on the BGS Geoindex database 1:50,000 scale map. However, previous Ground Investigations have recorded Made Ground with depths ranging between 0.10m to 2.40 meters below ground level (m bgl), see Section 5.

2.6.2 Superficial Deposits

The BGS Map for Loughborough Solid & Drift (Sheet 141) 1:50,000, indicates that Glacio-lacustrine Deposits of boulder clay (Thrussington Member) are present across the majority of the Site described by the BGS as *Diamicton, brown to reddish-brown with stones and matrix derived primarily from Upper Carboniferous and Triassic rocks; subordinate sand, gravel and stoneless clay and silt. Red pebbly clay and silty clay with rock fragments.* Offsite beyond the northern and western boundaries of the Site are deposits of Alluvium described by the BGS as *normally soft to firm consolidated, compressible silty clay, but can contain layers of silt, sand, peat and basal gravel. A stronger, desiccated surface zone may be present.*

Previous ground investigations identified natural soils underlying the Made Ground proven to a depth of approximately 7.00m bgl in the southern part of the Site, which is discussed further in Section 5.

2.6.3 Bedrock

The BGS Solid Map for Derby Solid & Drift (Sheet 125) 1:50,000 and the 1:10,000 scale BGS map SK33SE indicated that the underlying solid geology is comprised of Mercia Mudstone Group – Edwalton Formation. The Edwalton Formation is described by the BGS as *Mudstone and siltstone, red-brown and greenish grey, with beds of indurated, variably dolomitic siltstone and very fine-grained sandstone common in the lower half; finely disseminated gypsum common in upper half.*

Previous ground investigations identified weathered Siltstone (Mercia Mudstone Group) at 7.30m bgl and proved to a depth of 8.80m bgl. This is discussed further in Section 5.

2.6.4 Geological Faults

No geological faults have been noted within the Site. However, the Site lies between two faults, the Mackworth fault approximately 710m to the East with a down throw towards the north east and an unnamed fault 540m to the south west which has a down throw to the south east.

2.6.5 Mining

There are no BGS Recorded Mineral Sites within 1km of the Site. The Site is not within a Coal Mining area.

2.6.6 BGS Boreholes

There are three borehole records located on Site (Ref. SK33SE262 to 264), Made Ground was identified between ground level and 1.10m bgl and comprised concrete overlying grey gravel with slag, refractory brick and foundry sand an oily sheen was recorded within Made Ground in SK33SE262. Boulder Clay was identified between 0.50 m bgl and 8.50m bgl where the borehole was terminated. The Boulder Clay is described as firm to very stiff silty clay with gravel, cobbles and occasional coal and chalk fragments and sandstone boulders.

2.6.7 Potential for Natural Ground Hazards

The following potential for Natural Ground Hazards was identified for the Sinfin A & C Site and the adjacent Aerospace Campus in the Phase I Desk Study Report by AECOM (2015):

- Ground Dissolution Stability Hazards – no hazard
- Collapsible Ground Stability Hazards – very low potential
- Landslide Ground Stability Hazards – very low potential
- Shrinking or Swelling Clay Ground Stability Hazards – low potential
- Running Sand Ground Stability Hazards – low potential
- Compressible Ground Stability Hazards – moderate potential

2.7 Hydrogeology

2.7.1 General

The predominant superficial deposit is the Thrussington Till (boulder clay including underlying and overlying sand and gravel), which is designated by the Environment Agency (EA) as a Secondary undifferentiated aquifer. This designation has been assigned in cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.

South west of Sinfin C, underlying the PCF Site, there are superficial deposits of lacustrine deposits which are designated as unproductive by the EA. Unproductive strata are defined by EA as rock layers, or (as in this case) drift deposits, with low permeability that have negligible significance for water supply or river base flow.

The underlying bedrock across the Site is the Edwalton Formation, which is designated by the EA as a Secondary B aquifer. Secondary B aquifers are defined by the EA as *predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering*. These are noted by the EA as *generally the water bearing parts of the former non aquifers*.

2.7.2 Groundwater Vulnerability

The Environment Agency website [accessed 06/06/2017] indicates that the soils at the Site are of 'High Leaching Potential' (Minor Aquifer). A 'High' classification relates to soils able to easily transmit pollution to groundwater.

They are characterised by high leaching soils and the absence of low permeability drift deposits. A High Leaching Potential (U) classification relates to deep, permeable, coarse textured soils which readily transmit a wide range of pollutants because of their rapid drainage and low attenuation potential. A 'U' classification also relates to soil information for restored mineral workings and urban areas based on fewer observations that elsewhere. A worst case vulnerability classification (H) is assumed until proved otherwise.

2.7.3 Groundwater Source Protection Zones (SPZ)

There are no Source Protection Zones located within 1km of the Site.

2.8 Hydrology

There is one surface water feature within the Site boundary, a drain on the south western Site boundary which may be culverted beneath the southern tip of the Site heading westwards. There are drains present on the western side of the railway line at the PTF and PCF Sites. Cuttle Brook is located some 200m south-west and is a tributary of the River Trent. The drains identified may eventually flow into Cuttle Brook.

The site falls within the Lower Trent and Erewash Management Catchment and within the Trent River Operational catchment and the Cuttle Brook Catchment (trib of Trent). The EA states Cuttle Brook has an ecological quality of *Moderate* and a chemical quality classification of *Good*.

2.9 Sensitive Sites

According to the Envirocheck Report, Elm Wood (Local Nature Reserve) is located 210m to the east. Sinfin Moor Local Nature Reserve is located 870m to the south west of the Site.

2.10 Unexploded Ordnance (UXO)

The Site is within a Low to Moderate Risk region, according to Zetica Regional Unexploded Bomb (UXB) Risk Maps for Derbyshire [accessed 06/06/2017].

2.11 Radon

The Envirocheck report (63773255_1_1) indicates that the Site is 'in a lower probability radon area, as less than 1% of homes are above the action level'. This data is supplied by the British Geological Survey.

It is also noted in the Envirocheck report that “No radon protection measures are necessary in the construction of new dwellings or extensions” anywhere within the Site boundary. This is based on data supplied by the British Geological Survey.

This is for information and relevant, only, if the use of the Site changes to residential in future.

3. Historical Land Use

3.1 General

Historical mapping has been reviewed to assess the potential for past activities, both on and adjacent to the Site, to have impacted upon the Sites environmental and land quality. Historical Ordnance Survey (OS) maps of the Site were obtained as part of the Envirocheck report.

3.2 Summary of Potential Historical Sources of Contamination

A summary of historical land uses are presented in Table 1. This table describes significant changes in industry and land development within the Site boundary from 1883 to the present day and significant offsite development within 500m of the Site boundary. This overview of historical land use has an emphasis on land uses which could have contributed to land contamination. The table describes the main features present onsite and in the vicinity of the Site. Where dates are given, these refer to dates of maps on which the features appear, and do not necessarily refer to the exact date of operation of any particular facility.

Table 1. Summary of Historical Ordnance Survey Maps

Date	Scale	Description	
		Within Site Boundary	Outside of Site Boundary (<500m)
1883 – 1886	1:2,500 1:10,560	Site appears to be agricultural. <i>Merril Farm</i> is located to the east of the Site with a road running north to south.	A single railway line, <i>Derby & Melbourne Branch</i> , runs along the southern boundary of the Site running south-east to north-west and connects to another railway line to the north-east of the Site heading in a north-east direction. <i>Crank Wood</i> is located some 200m north of the site; <i>Ashtree Wood</i> is some 600m north of the Site. <i>Brick Yard</i> is located approximately 500m north-west. A small settlement called <i>Allenton</i> is located some 500m north-east. An unnamed water course is present some 250m south of the Site running south and bending around to the east. <i>Oak Wood</i> and <i>Elm Wood</i> are present some 250m north-east of the Site. <i>Cotton Farm</i> is present approximately 300m south-west of the Site.
1901	1:2,500 1:10,560	No significant changes.	<i>Normanton Brick Works</i> , <i>Sinfín Road Farm</i> and <i>Windmill (Pumping)</i> are present some 500m north-west. <i>Allotment Gardens</i> to the north-west. The Railway is now called <i>Derby and Ashby</i> .
1914	1:2,500	No significant changes.	No significant changes.
1919 - 1924	1:2500 1:10,560	No significant changes.	No significant changes.
1938	1:10,560	No significant changes.	There has been large expansion of the town of <i>Normanton</i> to the west. Immediately adjacent to the north-west of the Site is a <i>Laundry</i> , <i>Engineering Works</i> and <i>Shoe Factory</i> . A <i>Chemical Factory</i> is present some 500m to the west. A <i>Belt Works</i> is present some 500m north-west of the Site. <i>Allenton</i> has grown in size to <i>Alvaston</i> and <i>Boulton</i> . There is the addition of a residential street and network with a school some 500m to the west. The <i>Brick Works</i> is now shown with a pit on Site which is understood to be used for landfill or factory waste.
1949	1:2,500	<i>Engineering Works</i> are now present across the majority of the Site comprising of <i>Tramway</i> , <i>Tanks</i> , <i>Gantry</i> and <i>Platforms</i> . A <i>Silo</i> is present of <i>Merrill Farm</i> . A <i>Pond</i> is present in the far north-western corner of the Site.	<i>Normanton Brick Works</i> is no longer indicated, a <i>Tannery</i> is now in its location. <i>Engineering Works</i> some 100m south-west. A <i>Sports Ground</i> , <i>Allotments</i> and <i>Pavilion</i> are present immediately north-east of the Site.
1951 - 1955	1:2,500 1:10,560	No significant changes.	Residential expansion towards to the east of the Site.
1960 - 1972	1:2,500 1:10,560	Industrial expansion now referred to as <i>Works</i> . <i>Tanks</i> , <i>Gantry</i> , <i>Cooling Towers</i> , <i>Sub Stations</i> , and <i>Fire Station</i> are present.	Expansion of <i>Engineering Works</i> . <i>Victory Road</i> now runs along the north to east boundary of the Site. <i>Moor Lane</i> Present running north-south on far eastern edge of Site.

Date	Scale	Description	
		Within Site Boundary	Outside of Site Boundary (<500m)
1972 - 1975	1:2,500 1:10,560	No significant changes.	<i>Municipal Golf Course</i> present some 250m south west of the Site. A <i>Works</i> is present to the north, south and north west of the Site.
1990 - 1993	1:2,500 1:10,560	No significant changes.	No significant changes.
2006	1:10,560	No significant changes.	<i>Foundry</i> present some 250m south of the Sites most southern point.
2014	1:10,560	No significant changes.	No significant changes.

3.3 Anecdotal Evidence

There is anecdotal evidence which suggests that an area in the southern part of Sinfin C was used to deposit materials/waste from the works within Sinfin A & C. However, this area is not recorded on landfill maps on the Environment Agency website or within the Envirocheck Report.

3.4 Potential Contaminative Activities

A review has been made of the current and historic potentially contaminative uses that have taken place at the Site and the results have been recorded on risk assessment plans and tables within the Scott Wilson (2002) Geo-environmental Assessment Report – Phase 2. A simplified overview of the most important potentially contaminative uses is given in Table 2.

Table 2. On-site contamination Issues (Scott Wilson, 2002)

Uses of High Importance Reason	Reason
Main fuel farm	Very large quantities of oil have been stored here over the years. Spillages and leaks are expected to have occurred from time to time.
Coal yard and dumping ground in south-eastern corner.	Potential contamination uncertain but anecdotal information indicates that the area was used as a general dumping ground and so is likely to have some contamination.
Uses of Medium importance	Reason
Most of the test beds and rigs buildings.	Many of these buildings have used oils and kerosene over the years. Anecdotal information suggests that leaks could have occurred during testing work in many of these buildings. Also a proportion of these buildings used mercury manometers. Oils have been reported in the ground and mercury has been found in a number of buildings. The risk of extensive contamination is mitigated by the expected impermeable nature of the underlying ground.
Fuel storage areas, pump houses and fuel line routes: 38, 42, 57, 62, 74	Bulk fuel tanks, some underground. Leaks and spillages could have led to ground contamination.
Process lines: in 21, 23 and 25	Bulk tanks with various chemicals, including oils, solvents, plating chemicals, cyanides. One known leak from the process line in the Machine Shop (23 building) is known to have occurred.
Metal store, hazardous waste store and historical swarf yard: near 4 7 building	Potential for various chemicals, metals and emulsified oils to have leaked into the ground.

4. Summary of Environmental Information

4.1 General

The environmental information and sensitivity for the Site has been obtained from the Envirocheck Report 63773255_1_1 dated 22nd January 2015 obtained by AECOM, which is presented in Appendix A.

4.2 Water Abstractions

The Envirocheck Report (63773255_1_1) indicates that there are no water abstraction licenses within 1km of the Site.

4.3 Discharge Consents

The Envirocheck Report (63773255_1_1) indicates that there are no discharge consents on Site and 11 discharge consents within 500m see Table 3.

Table 3. Discharge Consents

Approximate Distance	Operator	Location	Discharge Type/Reference	Receiving Water	Status
0	Derby Specialist Fabrications	Sinfin Lane, Derby	Cooling Water / T/36/45336/T	Trib. of Cuttle Brook	Revoked
100(SW)	International Combustion Ltd	Sinfin Lane, Derby	Cooling Water / T/36/45141/T/	Cuttle Brook	N/A
100(SE)	QDF Castings Ltd	Qualcast Foundry Victory Rd, Derby	Process Water / T/36/10678/T	Trib. of Cuttle Brook	Revoked
150(NW)	International Combustion Ltd	Sinfin Lane, Derby	Cooling Water / T/36/22873/T/1	Cuttle Brook	N/A
200(NE)	Severn Trent Water	Wilmore Rd, Derby	Storm Sewage overflow / T/36/45055/O	Cuttle Brook	N/A
200(NW)	International Combustion Ltd	Sinfin Lane, Derby	Cooling Water / T/36/22873/T/3	Cuttle Brook	N/A
200(NW)	International Combustion Ltd	Sinfin Lane, Derby	Cooling Water / T/36/45141/T/	Cuttle Brook	N/A
200(NE)	Severn Trent Water	Wilmore Rd, Derby	Storm Sewage overflow / T/36/45055/O	Cuttle Brook	N/A
250(NW)	Derby Specialist Fabrications	Sinfin Lane, Derby	Cooling Water / T/36/45336/T	Trib. of Cuttle Brook	Revoked
250(NW)	International Combustion Ltd	Sinfin Lane, Derby	Cooling Water / T/36/45141/T	Cuttle Brook	N/A
400(SW)	Severn Trent Water	Thackerey St, East End, Derby	Storm Effluent / CT/36/45095/O1	Cuttle Brook(River Trent)	N/A
500(NW)	International Combustion Ltd	Sinfin Lane, Derby	Cooling Water / T/36/22873/T/2	Cuttle Brook	N/A

4.4 Pollution Incidents to Controlled Waters

There are nineteen (19) pollution incidents to controlled waters that have been reported within a radius of 250m from the Site, according to the Envirocheck Report. The details for these pollution incidents are given in Table 4.

Table 4. Pollution Incidents to Controlled Waters

Approximate Distance (m)	Date	Pollutant	Receiving Water	Severity
10(E)	10/12/97	Oil	Not given	Cat 3 Minor incident
250(SW)	03/06/98	Storm Sewage	Watercourse	Cat 3 Minor incident
250(SW)	13/03/98	Inert suspended solids	Watercourse	Cat 3 Minor incident
250(SW)	30/06/97	Sewage debris/litter	Watercourse	Cat 3 Minor incident
270(SW)	01/09/98	Crude sewage	Watercourse	Cat 3 Minor incident
270(SW)	28/01/97	Storm sewage	Watercourse	Cat 3 Minor incident
270(SW)	23/02/98	Oils – diesels	Watercourse	Cat 3 Minor incident
280(SW)	26/03/96	Inert suspended solids	Watercourse	Cat 3 Minor incident
280(SW)	18/12/96	Crude sewage	Watercourse	Cat 3 Minor incident
300(SW)	08/02/96	Crude Sewage	Watercourse	Cat 3 Minor incident
300(SW)	16/12/97	Inert suspended solids	Watercourse	Cat 3 Minor incident
300(SW)	03/01/97	Inert suspended solids	Watercourse	Cat 3 Minor incident
300(SW)	11/11/98	Unknown	Watercourse	Cat 3 Minor incident
300(SW)	01/01/98	Inert suspended solids	Watercourse	Cat 3 Minor incident
300(SW)	10/02/98	Inert suspended solids	Watercourse	Cat 3 Minor incident
300(SW)	30/01/97	Inert suspended solids	Watercourse	Cat 3 Minor incident
300(SW)	01/07/89	Unknown	Watercourse	Cat 3 Minor incident
500(NW)	29/05/96	Pesticides	Watercourse	Cat 3 Minor incident
500(NW)	28/09/98	Acid	Watercourse	Cat 3 Minor incident

4.5 Local Authority Pollution Prevention and Controls

The Envirocheck Report (63773255_1_1) identifies nineteen (19) sites with Integrated Pollution Control, ten (10) sites with Integrated Pollution Prevention and Control, two (2) sites with Local Authority Integrated Pollution Prevention and Control, nineteen (19) sites with Local Authority Pollution Prevention and Control and two (2) sites with Local Authority Pollution Prevention and Control Enforcements, all within 1km of the sites.

4.6 Potentially Hazardous Sites

The Envirocheck Report (63773255_1_1) identifies one site within 250m of the Site, under the heading of Control of Major Accident Hazard Sites (COMAH) which is on the eastern boundary. There are two (2) sites of Notification of Installations Handling Hazardous Substances (NIHHS) some 500m north-west of the site, and two (2) sites with Planning Hazardous Substance Consents all within 500m of the site. There are no Explosive Sites, or Planning Hazardous Substances Enforcements.

4.7 Environmental Prosecutions

There are no Prosecutions Relating to Authorised Processes within 1km of the site from the Envirocheck Report (63773255_1_1).

4.8 Contemporary Trade Land Use

There are six (6) Contemporary Trade Directory Entries listed within the Envirocheck report (63773255_1_1) located within 500m of the Site. Three of which are noted as active. These encompass the following classifications:

- Airports;
- Testing, Inspection and Calibration Equipment Manufacturers;
- Engineers – General;
- Aviation Engineers;
- Foundries; and
- Paper & Cardboard Products & Packaging – Manufacturers.

In addition, there are six (2) Fuel station entries listed in the Envirocheck report (63773255_1_1), situated within 1km of the Site. Table 5 identifies the Fuel Stations.

Table 5. Fuel Stations within 1km of the Site

Distance	Name	Location	Status
500m (N)	Sainsbury	Osmaston Park Road, Derby	Open
1km (W)	Sinfin Express	Wordsworth Avenue, Sinfin, Derby	Open

4.9 Local Authority Recorded Landfill Sites

There are no Local Authority Recorded Landfill sites within 1km of the Site presented within the Envirocheck report (63773255_1_1).

4.10 Registered Landfill Sites

There are three (3) Registered Landfills sites within 1km of the Site presented within the Envirocheck report (63773255_1_1), at distances of 500m (NE), 250m (W) and 721m (SW).

4.11 Historic Landfill Sites

There are two (2) Historic Landfills sites within 500m of the Site presented within the Envirocheck report (63773255_1_1). The first is approximately 500m north-west, W J Richardson was the licence holder, and has a last input date of 30th November 1986. The second is located some 250m west of the site; NEI International Combustion Limited was the licence holder and has a last input date of 31st December 1982.

4.12 Licensed Waste Management Facilities

There is one Licensed Waste Management Facilities within 500m of the Site presented within the Envirocheck report (63773255_1_1) some 300m north-west.

4.13 Registered Waste Treatment or Disposal Sites

There are two (2) Registered Waste Treatment or Disposal Sites within 1km of the Site presented in the Envirocheck report (63773255_1_1). These are W & J Richardson, located to the north of the Site whose license has lapsed, which accepted effluent treatment sludge, and Associated Heat Services plc, Victory Road.

5. Previous Ground Investigations

5.1 General

This section presents a summary of the results of existing ground investigation data obtained by AECOM, and its legacy partners at the Site.

Ground investigations have been conducted within the Rolls-Royce Sinfin Aerospace Campus between 2002 and 2013. Ground investigation (GI) works included a range of exploratory techniques including boreholes, dynamic sampling, trial pits and windowless sampling.

Information available for the Sinfin A & C area includes:

- Scott Wilson Kirkpatrick & Co Ltd (2002) Geo-Environmental Site Assessment, Rolls-Royce Derby Phase 1;
- Scott Wilson Kirkpatrick & Co Ltd (2002) Geo-Environmental Site Assessment: Rolls-Royce, Derby Geo-environmental Assessment Report – Phase 2; and
- URS (2013) Phase 2 Geo-environmental Assessment: Sinfin A & C.

The reports of the above ground investigations were reviewed to assess ground conditions and contamination. The locations of the previous exploratory holes are presented in Drawing 60544336_DS_GE_003. Table 6 summarises the ground investigation works undertaken at Sinfin A & C.

Table 6. Sinfin A and C Exploratory Works

The ground investigations were generally targeted at providing information on contaminative uses of medium or high importance. The following ground investigation work was undertaken by Scott Wilson in 2002 and URS in 2013.

Area and Date	Purpose	Scope	Hole Reference
Sinfin A - 2002	Fuel Farm	2 Borehole (BH), 6 Dynamic Sample(DS)	8106, 8107, 8328, 8326, 8329, 8250, 8327, 8325
	South-eastern dumping ground	2DS	8315, 8316
	Selection of three of the test bed/ rigs buildings, most likely to have caused ground contamination	9DS	8317, 8319, 8329,8321, 8320, 8322, 8334, 8335, 8332
	Selection of further five test beds/ rigs, next most likely to have caused ground contamination.	7DS	8337, 8313, 8311, 8314, 8336, 8339, 8338
	Former fuel tanks: 38, 42, 62, 57 and 74	3 BH, 7DS	8102, 8103, 8101, 8201, 8303, 8302, 8305, 8304, 8343, 8342
	Former and existing process lines, and swarf yard in northwest of Site: 21, 23, 25 and near 47. Including one hole outside to south of the Machine Shop's process line.	1BH, 7DS	8310, 8311, 8308, 8330, 8331, 8306, 8307, 8104
	Investigate potential for contamination to be seeping onto Site from neighbouring land	1 DS	8340
	Old chromate line	2DS	8324, 8341
	Oils and fuels have been discovered in this area in the past, in the drainage system.	1 DS	8333
	Area of Test Beds 39 - 46 Asbestos potential in ground from former buildings here	5 DS, 1 TP	BH09, BH09A, BH10, BH11, BH12 TP01
Sinfin A & C 2013	Occupational Health Department Area where chrome plating has occurred	1 DS	BH02
	Combustion Rig Area where mercury was uncovered and possible oils also	1 DS	BH08

Area and Date	Purpose	Scope	Hole Reference
	Turbine Test Rig Area Excavations filled with oil here	1 DS	BH01
	Workshop and Lab Solvents in use	1 DS	BH07
	Area south of fuel farm Near culvert where oil formerly identified	1 DS, 1 TP	BH06, TP02
	Near Pre Rig Shop Interceptor here	1 DS	BH03
	Fuel Pump House Significant fuel contamination previously identified here by staff		BH04, TP04
	Test Cells Ammonia/fuel storage	2 DS, 1 TP	BH05, BH13, TP03
	Former Coal and Slag Dumping Ground Near culvert where oil formerly identified	1 DS	BH14

5.2 Ground Profile

Ground conditions encountered during the ground investigations comprised a layer of made ground which consists of predominantly sandy gravel, locally clayey at the base. Made Ground extended to depths ranging from 0.10m to 2.40 meters below ground level (m bgl), with a typical thickness of less than 1m. The obstructions encountered during the 2013 URS ground investigation are noted in Table 7.

The natural soils that underlie the made ground consist of clay which is variably gravelly, sandy or silty. These clays were proved to approximately 7.00m bgl in the southern part of area.

Siltstone (Edwalton Formation of the Mercia Mudstone Group) was encountered at 7.30m bgl and proved to a depth of 8.80m during 2002 GI works. The Mercia Mudstones were not encountered during the 2013 GI as all exploratory holes terminated in the overlying clay. Across Site, clays locally contain a larger sand fraction in the east, and a larger gravel fraction in the north.

Table 7. Encountered concrete obstructions (URS, 2013)

Position	Depth (m bgl)	Remarks
BH04	1.45	Concrete – unable to penetrate
BH05	1.25	Concrete – unable to penetrate
BH09	0.10	Reinforced concrete surfacing – unable to penetrate
BH09A	0.12	Reinforced concrete surfacing – unable to penetrate
BH11	0.70 – 0.85	Concrete – broken through
BH13	0.65 – 0.80	Concrete – broken through
BH14	1.30 – 1.40	Concrete – unable to penetrate
TP03	3.20	Heavily reinforced slab – unable to penetrate

Groundwater was encountered at between 0.40m and 5.20m bgl during the 2002 exploration, with a typical depth of 1m. Groundwater levels were observed to be lower in the south and west of the Site. Monitoring in standpipes installed during the 2013 investigation, recorded groundwater levels at between 0.38m and 2.90m bgl.

5.3 Fieldwork Contaminant Observations

Photo Ionisation detection revealed low readings (0.5ppm to 20ppm) in half the boreholes and moderate to high readings (20ppm to >100ppm) in the remainder.

The moderate to high results were located in boreholes around:

- the fuel farm;

- test beds 39–42 and 45-46 and the nearby fuel tanks;
- from the underground fuel tanks at Gate No. 3; and
- the fuel tanks and pump house in the south of the Site.

High readings were recorded at 1m and 2m in the natural soils down to 3m. A reading at 7m depth of low values confirmed evidence of deeper depth oil penetration around the fuel pump house. Table 8 presents the records of where hydrocarbon/solvent odours were noted in 2013.

Table 8. Recorded hydrocarbon/solvent odours (URS, 2013)

Position	Depth (m bgl)	Remarks
BH01	0.40-1.40	Hydrocarbon odour
BH07	0.15-1.50	Slight solvent odour
BH11	1.10-2.30	Slight hydrocarbon odour
BH12	1.00-2.50	Hydrocarbon odour
BH13	1.50-4.00	Hydrocarbon odour
BH14	2.10-4.00	Slight hydrocarbon odour
TP04	0.80-2.30	Slight hydrocarbon odour

5.4 Soil Contaminant Concentrations

The screening values of the contaminations were measured against guidance values current at the time of reporting. The following terminology was used to describe the contaminant concentrations:

- High concentrations: where results fall on or above guideline values for a commercial/industrial end use.
- Elevated concentrations: where results fall on or above guideline values for a residential with garden end use, but below guideline values for a commercial/industrial end use.

Report details from 2002 indicate that high concentrations of oil, indicative of the likely presence of free-phase hydrocarbons in soils, were identified beneath the Fuel Rig Shop in made ground and natural soil at a depth of 1.5m. The results showed mineral oil at 14,534 mg/kg at 0.5m in Borehole 8313 and TPH between 15,000 mg/kg and 21,000 mg/kg at 1.5m in Borehole 8336. The 2013 investigation found no TPH concentrations exceeding Human Health GAC/SGV elevated concentrations. The maximum total TPH concentration reported was 5,700 mg/kg in the superficial deposits at 1.5mbgl in Borehole 13. Borehole 13 is located in the area of the test cells to the south of the Site.

High concentrations of chromium at 11,480 mg/kg at 0.5m in borehole 8324, and hexavalent chromium of between 66 and 367mg/kg at between 0.5 and 1.5m in the same borehole were detected. This borehole is situated beneath Millwrights Workshop which is where the old chromate line was present. In the 2013 ground investigations, chromium was recorded at <0.5mg/kg in all samples which is below the corresponding GAC/SGV.

In 2002, elevated concentrations of oils were reported at a number of locations which included:

- the fuel farm;
- test beds 29-32 and test beds 39–46;
- the nearby fuel tank to these test beds;
- the car park in the south east of the Site;
- the swarf yard; and,
- the fitting shop.

Out of seventy two (72) tests, twenty seven (27) were found to contain elevated PAH concentrations ranging from 50mg/kg to 888mg/kg; six of these samples were above 500 mg/kg. In 2013 PAHs were not reported to exceed GAC/SGVs, for instance, naphthalene was detected with the maximum concentration from a borehole located in the fuel farm of 1.3 mg/kg.

The former swarf yard, the fuel farm, Millwrights workshop and areas where clinker and ash were recorded showed elevated concentrations of metals hazardous to human health during the 2002 ground investigation. The most significant being from the swarf yard where arsenic of 69mg/kg and cadmium of 8mg/kg were reported. However, samples obtained in 2013 recorded concentrations of these metals below the corresponding GAC/SGV current at the time of reporting.

5.5 Groundwater Contaminant Concentrations

Groundwater testing, in 2002, revealed elevated oil and PAH concentrations in samples obtained from near the fuel pump house at a depth of 5.2m. In 2013, exceedance of TPH guideline value concentrations occurred across the Site as follows:

- Three (3) boreholes located in the centre of the Site next to the fuel aviation tanks, which could be a possible contamination source;
- A trial pit and borehole near the test cells located in the south of the Site in the area storing ammonia fuel and oils;
- Along the south west boundary, TPH concentrations exceeded the corresponding Environmental Quality Standard, although there are no tanks in this area. Therefore, the exceedance could be due to migration of TPH from other sources on Site;
- On the western boundary at the Pump House, where fuel tanks were present;
- Within the tank farm, where fuel tanks are present and possible source of contamination;
- At the northern boundary where past investigations noted oil contamination; and
- Where solvent operations existed on the northern boundary.

PAH compounds exceeded the controlled waters Environmental Quality Standard (EQS) at the same locations where TPH exceedances were recorded, see above.

Elevated concentrations of hexachloroethane and 2-methylnaphthalene (VOCs) were recorded where oil contamination was observed, in the area where former ammonia fuel/oil tanks were stored, in the 2013 ground investigation.

As a result of the 2002 and 2013 GIs, the following areas of localised soils/groundwater contamination were identified within the 2013 report:

- Tank Fuel Farm;
- Test Beds;
- Test Cells;
- Purchase Millwright Workshop;
- Turbine Test Rig.

5.6 Ground Gas Monitoring

Within the 2013 Ground Investigation, four (4) standpipes underwent ground gas monitoring with no methane being detected at any locations. The peak CO₂ concentration was recorded as 0.4 % v/v within BH12 and peak O₂ concentration at 20.3% v/v within BH02. Based on the monitoring data available (1 round), the calculated GSV values for carbon dioxide or methane place the Site within Characteristic Situation 1 (CIRIA C665, 2007).

5.7 High Level Assessment of Remediation Requirements for Sinfin Estate (URS 2012)

In 2012 URS undertook a high level assessment of the remediation requirements for the whole Rolls-Royce Sinfin Estate, which included the Sinfin A & C Site. The Sinfin A & C Site was split into 4 sub-areas A1 (CHP Plant area; 0.70Ha), A2 (Office/storage areas; 1.62 Ha), A3 (Rest of Site (SE); 14.60 Ha) and A4 (Rest of Site (NE); 5.37 Ha).

The potential contaminants noted for:

- A1 were PAHs;
- A2 was chromium;
- A3 were oils, fuels, PAHs and Chromium;
- A4 were oils, fuels, PAHs and, Chromium.

The sub-areas were categorized as follows:

- A1 – Industrial low risk (2a);
- A2 – Industrial low risk (2a);
- A3 – Industrial high risk (1);
- A4 – Industrial high risk (1).

5.8 Other Sub-Sites

5.8.1 Sinfin B

Sinfin B is located across Victory Road to the northeast of Sinfin A and encompasses an area of approximately 19.5 Ha. The majority of the site is occupied by offices, workshop buildings and a car park.

Hydrocarbon odours were observed in a number of exploratory holes during previous ground investigations and potential contaminants were detected in the soils, including TPH, PAH, lead, arsenic, cadmium and nickel.

5.8.2 Sinfin D

Sinfin D is located across railway line to the northwest Sinfin A. The site encompasses approximately 23Ha and is occupied by a variety of buildings and areas of open space, with a main use for heavy fabrication work. A licenced landfill is located in the southeast of the site, as noted in Section 4.

Field observations noted the presence of ash, clinker and burnt waste in the made ground encountered across the site during site works. Potential contaminants detected in the soils include PAH and metals / semi-metals (including arsenic, mercury, nickel and lead). Within the licenced landfill, leachate sampling and testing indicated that samples did not exceed leaching limit values for landfills of inert waste.

The main potential contaminants identified in groundwater were chlorinated solvents, in particular trichloroethene (TCE) and vinyl chloride, and PAH. TCE concentrations were indicative of possible free phase contamination being present (maximum 2,052µg/l). Other potential contaminants identified include nickel, arsenic and sulphate.

5.8.3 Learning and Career Development Centre (LCDC)

The LCDC site is located to the south west of Sinfin C, and encompasses an area of approximately 3 Ha. The site contains a mixture of office buildings, including the LCDC and an Apprentice Academy.

During site works, observations of pockets of ash and metal fragments were made in all exploratory holes. However, no contaminants of concern were identified in the soils in relation to a commercial / industrial end use.

5.8.4 Moor Lane Facility

The Moor Lane Facility is located across Victory Road to the east of Sinfin A & C, and encompasses approximately 17.8Ha. The site contains a three story office building with car parking facilities and areas of grass and woodland.

No contamination testing was carried out as part of the ground investigations reviewed. In the past, there have been significant quantities of asbestos removed from the site (buildings) with the southern area remaining as recreational fields suggesting that this area has not been used for any industrial purpose.

5.8.5 Production Testing Facility (PTF)

The Production Testing Facility (PTF) is located across the railway line to the west of Sinfin A & C, and encompasses an area of approximately 17.7 Ha. The site includes a mixture of testing facilities, office buildings and heavily vegetated land.

Fieldwork observations noted a hydrocarbon odour at a depth of 9m at the location of Test Bed 58. Potential contaminants identified in the soils include zinc at Test Bed 58. Soluble sulphate was also found to be elevated (most likely due to natural gypsum). The presence of chrysotile (white) asbestos was identified in one location at the Customer Delivery Centre.

Potential contaminants identified in groundwater included TPH and phenol at Test Bed 58.

6. Conceptual Site Model

6.1 General

Current legislation relating to contaminated land in the UK is contained within Part 2A of the Environmental Protection Act 1990, which was inserted by Section 57 of the Environment Act 1995 and by Section 86 of the Water Act 2003, and elaborated within the Contaminated Land (England) Regulations 2006 [S.I. 2006/1380] (amended 2012 [S.I. 2012/263]).

The “suitable for use” approach is adopted for the assessment of contaminated land where remedial measures are only undertaken where unacceptable risks to human health or the environment are realised taking into account the use, or proposed use, of the land in question and the environmental setting.

Current best practice recommends that the determination of health hazards due to contaminated land is based on the principle of risk assessment, as outlined in Part 2A of the Environmental Protection Act 1990.

The risk assessment process for the environmental contaminants is based on a source-pathway-receptor analysis. These terms can be defined as follows:

- **Source:** Hazardous substance that has the potential to cause adverse impacts;
- **Pathway:** Route whereby a hazardous substance may come into contact with the receptor: examples include ingestion of contaminated soil and leaching of contaminants from soil into watercourses;
- **Receptor:** Target that may be affected by contamination: examples include human occupants/users of Site, water resources (surface waters or groundwater), or structures.

For a risk to be present, there must be a viable contaminant linkage; i.e. a mechanism whereby a source impacts on a sensitive receptor via a pathway.

The following sections detail the conceptual site model, which has been developed for the Site with the view to assessing the potential risks during construction and upon completion of the proposed new development. The potential sources of contamination, potential receptors and potential pollutant pathways are identified and presented in Sections 6.2 to 6.5. The associated contaminant linkages between these sources, pathways and receptors are presented in Table 12.

6.2 Sources of Potential Contamination

Table 9 lists sources of potential contamination at the site of the proposed development.

Table 9. Sources of Potential Contamination

Potential Sources	Description
Made Ground (Onsite)	Made Ground has been recorded across the whole of the Site. The previous ground investigations at the Site have shown the presence of Made Ground within their exploratory hole logs, identified as variable constituents including clays, sand and gravels with depths ranging from 0.10m to 2.4m bgl. Concrete and brick layers were encountered towards the base ground in one borehole. Testing on the Made Ground identified clinker and burnt waste evident. Lead, mercury and mineral oil / TPH, elevated concentrations of arsenic, cadmium and nickel were also observed across the Site. Elevated concentrations of hexachloroethane and 2-methylnaphthalene (VOCs) were recorded where oil contamination occurred near to the ammonia fuel/oil tanks. Asbestos may be present within the Made Ground from rubble which has been deposited within the Made Ground. Coal Tar has also been identified previously within surfacing materials on some of the Site roads.
Soil Leachate	Potential contaminants may be leached from Made Ground sources at the Site.
Groundwater	Perched water and shallow groundwater is present within the made ground and the underlying natural ground. Elevated concentrations of PAH exceeding EQS were recorded in 2002 and in 2013. The TPH concentrations exceeded EQS values.

Potential Sources	Description
Ground Gas	Concentrations of ground gases (methane and carbon dioxide) could originate both from Made Ground and naturally from organic content within the underlying Periglacial Head deposits, Lacustrine deposits, Alluvium, and Glacio-lacustrine deposits. Results of limited gas monitoring from Sinfin A and C and sub site LCDC indicated that the sites were classed as Characteristic Situation 1 (CIRIA C665, 2007).
Offsite Sources	Leaks, spills and emissions may have occurred at locations of surrounding potential contamination sources e.g. surrounding industry around the whole of the Site including CoGen Plant situated to the south of Sinfin C and the former landfill on the north side of sub-site Sinfin D. Investigations offsite within the Rolls-Royce Sinfin Aerospace Campus have confirmed elevated concentrations of contaminants in soil and groundwater.

6.3 Potential Pathways

This section provides a summary of the potential pathways by which the identified sources may come into contact with receptors.

Table 10. Potential Pathways

Potential Pathways	Description	
Soil Pathways Including the following sources: - Made Ground sources on and offsite - Soil Derived Leachate	Dermal Contact	Dermal contact with contaminated soils, soil derived dust, soil leachate and perched groundwater.
	Direct Contact	Direct contact of building materials with contaminated soils, soil leachate and perched groundwater.
	Ingestion	Direct or indirect ingestion of soil and soil derived dust.
	Inhalation	Inhalation of soil derived dust, organic vapours or ground generated gas. Since most process wastes from Asphalt Works are in the form of dust, potential migration of contamination may be significant.
Groundwater Pathways Including the following sources: - Soil Leachate from Made Ground sources on and offsite - Perched Groundwater within the Made Ground	Rainfall Infiltration & Vertical / Lateral migration via permeable strata	Rainfall infiltration can generate and mobilise soil-derived leachate impacting on surface waters and groundwater.
	Lateral Migration through offsite Aquifer	As well as being a receptor, aquifers allow transportation of contaminants through the permeable strata.
Gas Pathways Including the following sources: Ground gas generation from Made Ground sources on and offsite	Vertical / Lateral Migration via permeable strata.	Permeable strata and areas of Made Ground may allow transportation of ground gases.

6.4 Potential Receptors

A number of potential receptors have been identified as associated with the proposed developments. Table 11 lists the potential receptors at the Site.

Table 11. Potential Receptors

Potential Receptor	Description
Future Site Users	Includes employees at the Rolls-Royce facilities and facilities/offices of other companies and Site visitors.
Controlled Waters	Cuttle Brook (a tributary of the River Trent) located adjacent to the western boundary of the Site. The underlying Secondary A and B aquifers.
Development Infrastructure	Concrete is a receptor of chemical aggressivity in contaminated soils with a low pH and high

Potential Receptor	Description
	sulfate concentrations. Gypsum (calcium sulfate dihydrate) veins are understood to be present within the underlying bedrock of the Edwalton Formation Plastic piped services can be adversely affected by the presence of hydrocarbons, including phenolic compounds, where the integrity of the pipes can be compromised. This can lead to penetration of the pipes by mobile contaminants.
Construction workers	Exposures experienced by construction workers are much less than for future Site users due to the limited period of exposure. Construction workers are therefore not considered as sensitive receptors.
Off-site receptors	This includes visitors to and workers of the Rolls-Royce Sinfín Aerospace Campus and nearby commercial / industrial properties to the north. Residents of properties to the south east at Allenton and to the west at Thackeray Street adjacent to Wilmore Road. Visitors to Elm Wood north of Moor Lane and residents to the east of the Moor Lane Facility. Visitors to Sinfín Golf Club adjacent to Wilmore Road in the south west. Visitors and users of the Allotments to the east of the field along Merrill Way, south of the Moor Lane Facility. Licensed water abstractions from between 1km and 2km.
Flora and Fauna	On Site flora and fauna, including landscaped areas in the proposed redevelopment may be affected by the presence of elevated concentrations of certain determinands.

6.5 Potential Contaminant Linkages

The potential contaminant linkages and associated risks identified for the Site are summarised in Table 12 below.

Table 12. Potential Contamination Linkages

Source		Pathway		Receptor
Diffuse metal, Inorganic and organic contamination within the Made Ground/soils	Â	- Ingestion of contaminated soil - Inhalation/ingestion of soil derived dust - Inhalation of organic vapours - Direct contact with soils/dusts	Â	- Future Site Users - Construction Workers - Offsite Receptors - Development Infrastructure - Groundwater - Secondary 'A' and 'B' aquifers
Generated leachate from contamination within Made Ground	Â	Rainfall Infiltration and Vertical / Lateral migration via permeable strata	Â	- Groundwater - Secondary 'A' and 'B' aquifers - Future Site Users - Construction Workers - Offsite receptors - Development Infrastructure
Contaminants in groundwater (perched or otherwise)	Â	Vertical and lateral migration via permeable strata	Â	- Groundwater - Secondary 'A' and 'B' aquifers - Future Site Users - Construction Workers - Development Infrastructure
Ground Gases	Â	- Vertical and lateral migration of gas through permeable strata - Migration of gasses in the dissolved phase (within perched water)	Â	- Future Site Users - Construction Workers - Offsite Receptors - Development Infrastructure
Offsite sources; Made Ground relating to quarry backfill, onsite and offsite historical and operational landfills	Â	- Rainfall Infiltration and Vertical and lateral migration of contamination through permeable strata - Vertical and lateral migration of gas through permeable strata - Migration of gasses in the dissolved phase (within the groundwater)	Â	- Future Site Users - Offsite Receptors - Groundwater - Secondary 'A' and 'B' aquifers - Development Infrastructure

7. Environmental Risk Assessment Framework

7.1 Risk Assessment Principles

Current best practice recommends that the determination of hazards due to contaminated land is based on the principle of risk assessment, as outlined in Part 2a of the Environmental Protection Act 1990. For a risk to be present, there must be a viable contaminant linkage; i.e. a mechanism whereby a source impacts on a sensitive receptor via a pathway. The potential contaminant linkages that have been identified for this Site are presented in Section 6.

Assessments of risks associated with each of these pollutant linkages, following review of available information for the Site is discussed in the following sections.

Using criteria broadly based on those presented in Section 6.3 of the CIRIA Report "Contaminated Land Risk Assessment: A Guide to Good Practice" (CIRIA Report C552) the magnitude of the risk associated with potential contamination at the Site has been assessed.

To do this an estimate is made of:

- the potential severity of the risk; and
- the likelihood of the risk occurring.

The severity of the risk is classified according to the criteria in Table 13.

Table 13. Severity of Risk

Severity	Examples
High	• Acute risks to human health likely to result in "significant harm" (e.g. very high concentrations of contaminants/ground gases). • Catastrophic damage to buildings/property (e.g. by explosion, sites with high gassing potential, extensive VOC contamination). • Major pollution of controlled waters (e.g. surface watercourses or principal aquifers/source protection zones) • Short term risk to a particular ecosystem.
Medium	• Chronic (long-term) risk to human health likely to result in "significant harm" (e.g. elevated concentration of contaminants/ground gases). • Pollution of sensitive controlled waters (e.g. surface watercourses or principal/secondary A aquifers). • Significant effects on sensitive ecosystems or species.
Mild	• Pollution of non-sensitive waters (e.g. smaller surface watercourses or secondary B aquifers or unproductive strata). • Significant damage to crops, buildings, structures or services (e.g. by explosion, sites with medium gassing potential, elevated concentrations of contaminants).
Minor	• Non-permanent human health effects (requirement for protective equipment during site works to mitigate health effects). • Damage to non-sensitive ecosystems or species. • Minor (easily repairable) damage to buildings, structures or services (e.g. by explosion, sites with low gassing potential).

Source: CIRIA Report C552

From information obtained for the desk study, a conceptual site model was developed for the site. Based on the subsequent risk assessment, the various components of the model are discussed in the following sections and take into account the site in its current condition and potential future use as a business/general industrial development.

The probability of risk occurring is classified according to the criteria in Table 14.

Table 14. Probability of Risk Occurring

Probability	Explanation
High	Pollutant linkage may be present that appears very likely in the short-term and risk is almost certain to

Probability	Explanation
	occur in the long term, or there is evidence of harm to the receptor.
Likely	Pollutant linkage may be present, and it is probable that the risk will occur over the long term.
Low	Pollutant linkage may be present and there is a possibility of the risk occurring, although there is no certainty that it will do so.
Unlikely	Pollutant linkage may be present but the circumstances under which harm would occur even in the long-term are improbable.

Source: CIRIA Report C552

An overall evaluation of the level of risk is gained from a comparison of the severity and probability, as shown in Table 15.

Table 15. Risk Based on Comparison of Probability and Severity

	Severity			
	Severe	Medium	Mild	Minor
High Likelihood	Very High	High	Moderate	Moderate Low
Likely	High	Moderate	Moderate/Low	Low
Low Likelihood	Moderate	Moderate/Low	Low	Very Low
Unlikely	Moderate/Low	Low	Very Low	Very Low

7.2 Preliminary Risk Evaluation

In accordance with the risk assessment principles, a preliminary evaluation of the potential risks associated with the identified sources at the Site to the various potential receptors is discussed and presented in this section. The level of risk is determined based on the current condition of the Site (i.e. the effects of mitigation measures are not included) and takes into account the outline development proposals. The evaluation includes an assessment of the significance of the potential pollutant linkages. Where it is considered that a particular pollutant linkage is not plausible in the context of the Site and the proposed development, the overall risk is determined as very low. The risk evaluation of potential pollutant linkages is presented in Table 16.

Table 16. Risk Evaluation of Potential Contaminant Linkages

Source	Pathway	Receptor	Potential Pollutant Linkage	Risk Evaluation		
				Severity	Probability	Risk Rating
Contaminants in Made Ground on Site	Direct contact/ ingestion / inhalation	Future Site Users	Y	Mild	Likely	Moderate/Low
	Direct contact/ ingestion / inhalation	Construction Workers	Y	Mild	Likely	Low
	Infiltration/ Migration	Controlled Waters	Y	Medium	Likely	Moderate
	Direct contact	Development Infrastructure	Y	Medium	Likely	Moderate
	Direct contact/ ingestion / inhalation	Off-Site Receptors	Y	Mild	Low	Low
	Direct Contact/uptake	Flora and Fauna	Y	Minor	Likely	Low
Contaminants in Leachate & Contaminants in groundwater (perched or otherwise) on Site	Direct contact/ ingestion / inhalation	Future Site Users	Y	Mild	Likely	Moderate
	Direct contact/ ingestion / inhalation	Construction Workers	Y	Mild	Low	Very Low
	Rainfall Infiltration & Vertical / Lateral migration of contaminants via permeable strata	Controlled Waters	Y	Medium	Likely	Moderate

Source	Pathway	Receptor	Potential Pollutant Linkage	Risk Evaluation		
				Severity	Probability	Risk Rating
Ground Gases on Site	Infiltration/ Off-site migration	Off-Site Receptors	Y	Medium	Likely	Moderate
	Direct contact/uptake	Flora and Fauna	Y	Minor	Likely	Low
	Direct contact	Development Infrastructure	Y	Medium	Likely	Moderate/Low
	Migration & Inhalation / Explosion	Future Site Users	Y	Mild	Likely	Moderate/Low
	Migration & Inhalation / Explosion	Construction Workers	Y	Minor	Likely	Low
	Migration & Explosion	Development Infrastructure	Y	Minor	Likely	Low
	Direct Contact/Uptake	Flora and Fauna	Y	Minor	Likely	Low
	Migration & Inhalation / Explosion	Offsite receptors	Y	Minor	Low	Very Low
	Rainfall Infiltration & Vertical / Lateral migration of contaminants via permeable strata	Controlled Waters	Y	Medium	Likely	Moderate
	Migration & Inhalation / Explosion (gases originating from made ground sources- historic landfill)	Future Site Users	Y	Mild	Unlikely	Very Low
Offsite Sources (Made Ground)	Migration & Inhalation / Explosion (gases originating from made ground sources- historic landfill)	Construction Workers	Y	Minor	Unlikely	Very Low
	Migration & Inhalation / Explosion (gases originating from made ground sources - historic landfill)	Development Infrastructure	Y	Minor	Unlikely	Very Low
	Rainfall Infiltration & Vertical / Lateral migration of contaminants via permeable strata / Inhalation of dust	Off-Site Receptors	Y	Medium	Unlikely	Low

7.3 Evaluation of Risks to Future Site Users

The risk to future site users is considered to be *Moderate* to *Low*. The future site users could come into direct contact with the underlying soils in the areas of landscaping around the development.

There is potential for ground gas to be sourced from the made ground materials around the site. Pathways for gas migration are likely to be present as the overburden backfill is likely to contain a variety of cohesive and granular materials, which will have a variable permeability. This could introduce a considerable variation across the site as to where ground gas could migrate to the surface.

Hydrocarbons and VOCs have been recorded within soil and groundwater samples obtained from various locations across the site. The VOCs are present as lighter PAHs, TPHs and trichloroethene and vinyl chloride. Any future assessment should include the potential for vapour migration into buildings.

It is considered that the risk to maintenance workers accessing underground utilities will also be low as it is assumed they will be wearing appropriate PPE and monitoring the atmospheric conditions, and that entry into underground structures should comply with confined space legislation and assessed prior to entry.

7.4 Evaluation of Risks to Construction Workers

The assessment has identified a *Low* risk to construction workers at the Site. This takes into consideration that whilst construction/site workers might be expected to come into contact with soils, the use of personal protective equipment will be a pre-requisite to them being on Site.

Prior to work commencing, a health and safety risk assessment should be carried out in accordance with current health and safety regulations. This assessment should cover potential risks to both construction staff and the local population. Based on the findings of this risk assessment, appropriate mitigation measures should be implemented during the course of the earthworks.

It is considered prudent that entry into excavations should comply with confined space legislation and assessed prior to entry.

7.5 Evaluation of Risks to Controlled Waters

The risks to controlled waters are considered to be *Moderate*. This is due to the potential for areas of soft-standing such as landscaped areas that could allow the migration of surface water into made ground deposits producing leachates. Therefore, migration of contaminants, through leachate migration and/or soil erosion, into these water bodies could potentially impact other surface waters in the area.

In terms of groundwater, the risk is considered to be *Moderate* as TPH and PAHs have been recorded at elevated concentrations within groundwater samples. There is also the potential for contaminated leachate from made ground to further infiltrate the groundwater or perched groundwater and migrate to surface watercourses and / or deeper groundwater.

7.6 Evaluation of Risks to Development Infrastructure

The risks to the development infrastructure from soil, leachate and groundwater contaminants have been classed as *Very Low* to *Moderate*. It is assumed that any potential risks would be mitigated by using concrete and service pipes appropriate for aggressive ground conditions, where identified, at the Site. The local potable water supplier should be contacted to identify their requirements for laying potable water supply pipes within brownfield sites.

The risks to the development from ground gases are considered to be low based on the underlying Edwalton formation solid geology and overburden. Gas monitoring at the Site revealed that current readings identify the area as Characteristic Situation 1 (CIRIA C665, 2007).

7.7 Evaluation of Risks to Off-Site Receptors

The potential risk to off-site receptors is considered to be *Low* to *Moderate*.

Any risks to local off-site receptors would be associated with off-site migration of contamination, for instance, in the form of wind-blown dust and organic vapours. Exposure via inhalation of dust is considered to be negligible for off-site receptors following development works, and as such there is not considered to be plausible pollutant linkage. The greatest potential for generation will be during the construction phase. Dust generation should be kept to a minimum in accordance with general best practice, as outlined in, for example, "Environmental Good Practice on Site", 3rd Edition, CIRIA Publication C692. Overall the risks to off-site receptors from on-site soil derived dusts are considered to be *Low*.

The potential risk to off-site receptors by contaminants within leachates and/or groundwater including the presence of free phase and dissolved phase organic pollutants is considered to be a moderate risk due to the presence of nearby minor watercourses and water bodies that could carry contaminants to sensitive receptors, such as Cuttle Brook which is a tributary of the River Trent in the south and the water wells located beyond 1km of the Site boundary.

7.8 Evaluation of Risks to On-site Flora and Fauna

The risks to flora and fauna on the site have been classified as *Low*. There is existing on-site flora and fauna that could be affected. Future on-site flora will be dominated by planting introduced during landscaping and it is assumed that the species chosen will be suited to the Site environment. Suitably designed landscaping with

sufficient depth of cover above any remaining contaminated deposits, possibly in conjunction with a separator layer, should be possible to mitigate any adverse effects that are identified through investigation.

8. Preliminary Geotechnical Appraisal

8.1 General

This section provides a preliminary appraisal of geotechnical items to provide consideration of ground conditions to support discharge of planning conditions only.

The history of the Rolls-Royce Sinfin Site is such that it has been developed for engineering by Rolls-Royce plc since approximately 1938. During the 1950s/60s to approximately 1972 the Site expanded to its present capacity. Today, the Site is still in use as an engineering foundry, but there are areas that are now not used and will be demolished in preparation for the proposed new development.

8.2 Depth to Weathered Mudstone Bedrock

Ground investigations undertaken between 2002 and 2013 by Scott Wilson and URS encountered Made Ground was encountered across the Sinfin A and Sinfin C sites with depths ranging from 0.10m to 2.40m bgl, with a typical thickness of less than 1m. Natural Soils underlying the Made Ground consisted of clay, which was variably gravelly, sandy or silty and were proven to approximately 7.00m bgl in the southern section of the site.

Siltstone (Mercia Mudstone) was encountered at 7.30m bgl and proven to a depth of 8.80m bgl.

8.3 Weak and Compressible Ground

The Site has been in continual use as an engineering foundry since it was first developed in the 1940s. Prior to development the Site consisted of agricultural fields. Made Ground is present across the whole of the Site.

The main sources of geotechnical hazards are:

- Various Made Ground deposits predominantly sand and gravel but also include clay in some areas. The made ground may have been engineered or compacted when placed, or may be unconsolidated and loosely placed.
- Potentially compressible natural ground materials (Glacio-lacustrine and Alluvial deposits) are present across the Site.
- Variable strengths of natural ground materials.

Relatively heavily loaded structures, and / or structures subject to machine vibrations, and / or structures sensitive to settlement which may be constructed as part of new development are likely to require piled foundations taken below the made ground and natural superficial strata into the mudstones of the Edwalton Formation. The main load bearing columns and walls will likely require support on groups or lines of piles. Heavily loaded floors designed for industrial use may also require piled foundations depending upon the loads imposed and the tolerance to differential settlement.

8.4 Buried Foundations

The likelihood of unknown buried foundations being present is relatively high as the Site has undergone multiple phases of redevelopment. Foundations and floor/base slabs of buildings are still in-situ but would be expected to be removed during redevelopment of the site.

Buried foundations can represent hard spots within the ground. This can cause delays where they are encountered/unforeseen, in initial foundation ground works as they need to be broken out. When left in place, buried foundations can also promote differential settlement in new structures, leading to cracking and damage to the new construction.

8.5 Aggressive Ground Conditions

There are two types of aggressive ground conditions that may be present at the Site.

The first relates to natural sulphates that, in sufficient quantities, may be aggressive to concrete and steel causing degradation and damage. This can be overcome through the specification of more resistant concrete

and anti-corrosion measures on steel, but requires testing and assessment of the soils beneath the Site in order to determine the level of risk. Gypsum, a sulphate mineral, is known to be present within the underlying Edwalton Formation bedrock. It is also noted that gypsum is a dissolution mineral which can result in the presence of voids within the bedrock.

The second area of potential for aggressive ground condition relates to contamination. This can affect several areas of construction but a common example is where hydrocarbons are present in soil that can cause damage to plastic utility pipes. These issues have been considered in more detail in the Environmental Risk Assessment presented in Section 7.

9. Conclusions and Recommendations

9.1 Conclusions

From the historical maps it can be seen that the area has had significant industrial use by Rolls-Royce, since the 1940s. A railway runs parallel along the western boundary of the Sinfin A & C Site, which is still in use today for refilling of fuel tanks.

Previous ground investigations have identified Made Ground between 0.10m and 2.40m across the Sinfin A and Sinfin C Site. Natural deposits were identified to 7.0m bgl. Siltstone was encountered in one exploratory hole at 7.30m bgl. The previous ground investigations noted moderate to high PID readings in boreholes located near the fuel farm, tests beds and nearby fuel tanks, underground fuel tanks and pump house in the south of the Site. High concentrations of TPH, PAH, clinker, ash, hexachloroethane and 2-methylnaphthalene were recorded in soils and/or groundwater in the results of the previous ground investigation reports. Based on 1 round of ground gas monitoring; the results indicated a Characteristic Situation 1 (CIRIA C665, 2007).

It is considered based on the information obtained, that the geo-environmental risks range from *Very Low* to *Moderate*. The Made Ground could be a potential source of ground gas at the Site. Cuttle Brook, a tributary of the River Trent is located approximately 200m south-west of the Site and is a potential offsite receptor. Sources of potential contamination within the boundaries of the Site will be associated with the Made Ground materials, and the potential for spillages and leaks from stores, equipment and vehicles used at the Site.

The majority of the Site is currently covered by hard standing of either macadam, or by building structures and foundations. Buildings will be demolished as part of the enabling works for the Project Genesis development. There are small areas within the Site which are currently landscaped. An area of the Site within Sinfin C has been identified anecdotally as a location where materials from the Site have been deposited in the past.

The main geotechnical issues at the Site are considered to be the potential compressibility of the Made Ground materials; the variation in strength of the superficial deposits through its depth, the depth to rockhead, and potentially shallow groundwater circa 0.38m to 5.2m bgl. The Made Ground materials may contain sulphates and sulphides. Piled foundations taken into the mudstones of the Edwalton Formation are likely to be required for heavily loaded and / or settlement – sensitive structures. The underlying Edwalton Formation is known to contain veins of gypsum, and has been recorded in exploratory hole logs from other parts of the Sinfin Site.

Although an additional ground investigation was undertaken by URS in 2013 within Sinfin A and C to supplement the 2002 Scott Wilson ground investigation, there remain areas of the Site which have not been accessible for investigation due to the presence of buildings or other significant structures.

9.2 Recommendations

It is assumed that the ground investigation will only be undertaken in accessible places, therefore additional supplementary ground investigation works would be required to investigate ground conditions beneath each area demolished as they become available.

It is recommended that combined geo-environmental and geotechnical ground investigation works are undertaken within the Sinfin A and Sinfin C Site. The ground investigations would be required to determine the presence and evaluate the significance of any geo-environmental and/or geotechnical factors that require mitigation, to allow the proposed redevelopment to proceed and to assist in discharging Planning Condition 20 that has been set by the LPA.

The ground investigations of the areas or sites that are to be redeveloped would include the following:

- Investigate the nature and extent of Made Ground across the Site;
- Investigate the nature of the underlying natural strata, where present, including determination of in-situ soil properties;
- Investigate depths to rockhead;
- Investigate the condition of the Edwalton Formation mudstones to determine the potential contamination status of deeper groundwater. The investigation can also be used to provide data for foundation option appraisals undertaken by others;

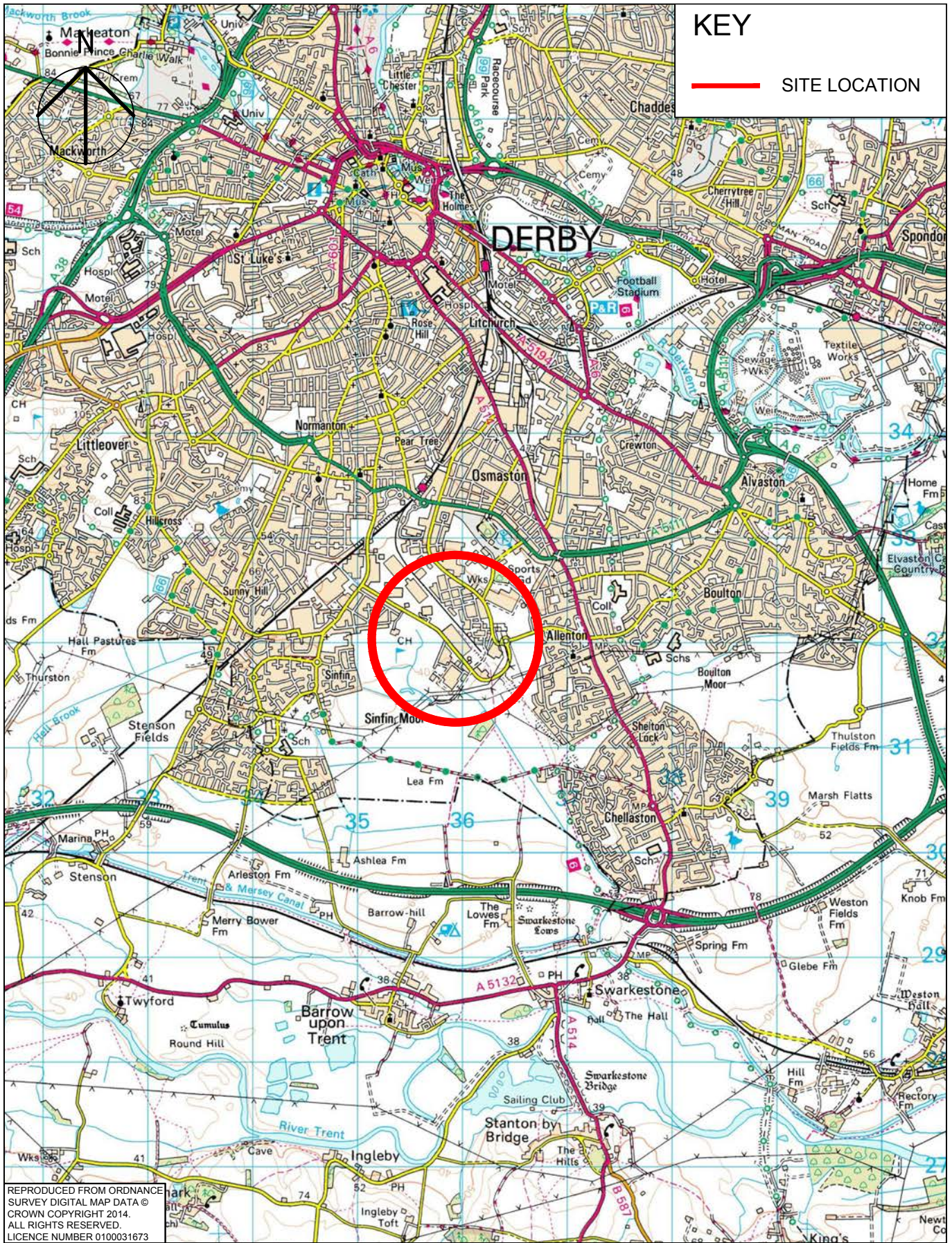
- Obtain soil and groundwater samples for chemical testing and geotechnical testing;
- Install gas and groundwater monitoring wells and undertake monitoring of ground gas concentrations and groundwater levels;
- Undertake a range of suitable soil, leachate and groundwater chemical tests, including BRE sulphate tests.

The ground investigation is expected to comprise cable percussion boreholes with rotary core follow on, to investigate the mudstone bedrock and to allow monitoring of the deeper groundwater body; and machine-dug trial pits.

Following the ground investigations, an interpretative report for the area investigated comprising human health, controlled waters and ground gas risk assessments should be undertaken to fully assess the levels of contamination across the Site, to identify mitigation measures where required and make recommendations to allow the redevelopment of the Site. This report would also review the geotechnical conditions based on the ground investigation results and provide outline guidance on the need for ground improvement.

The main interpretative report will include recommendations for mitigation, which will be expanded upon within the Remediation Strategy.

The site investigation and interpretive report can be used to assist in the discharging of relevant planning conditions stipulated by the Local Authority.



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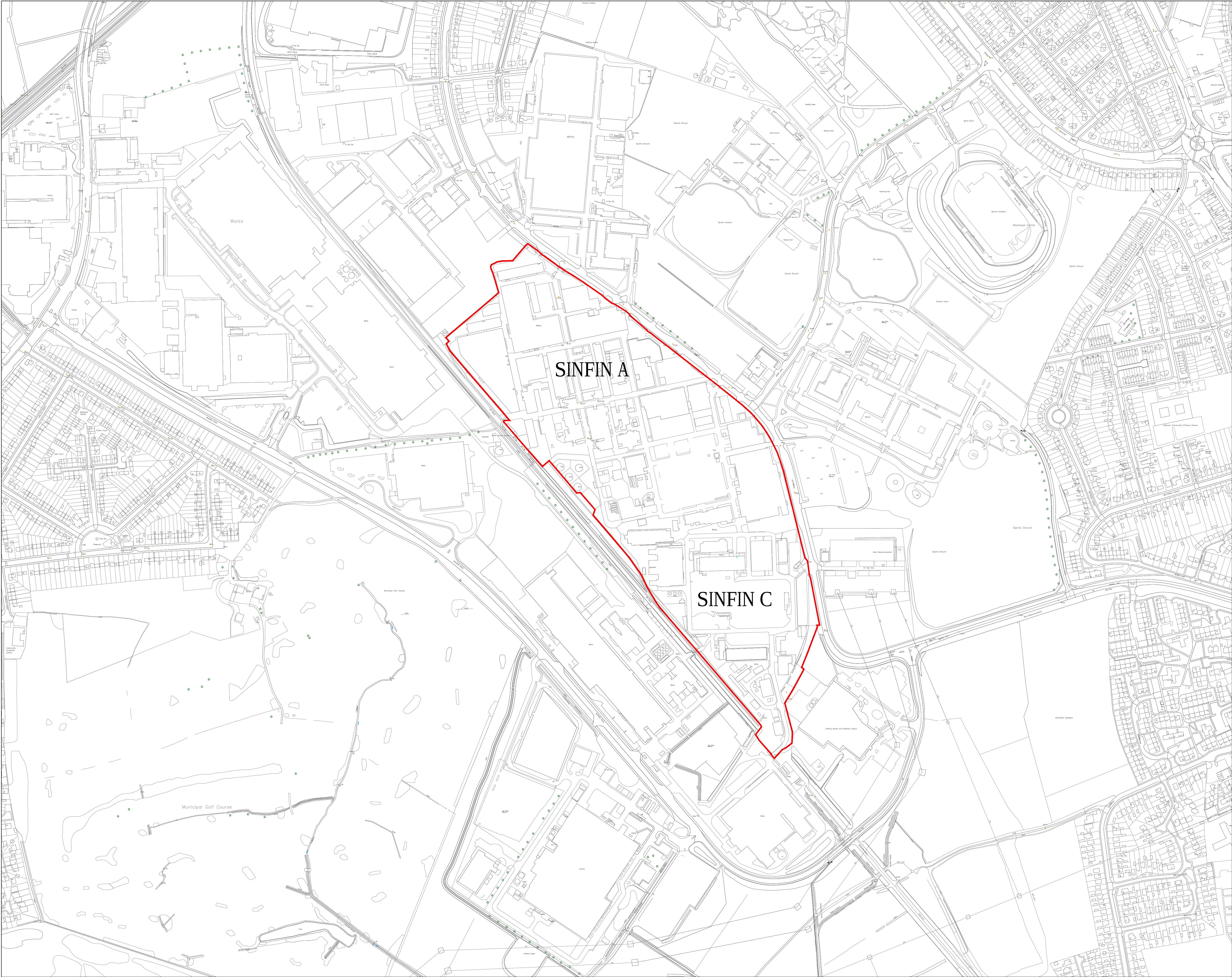
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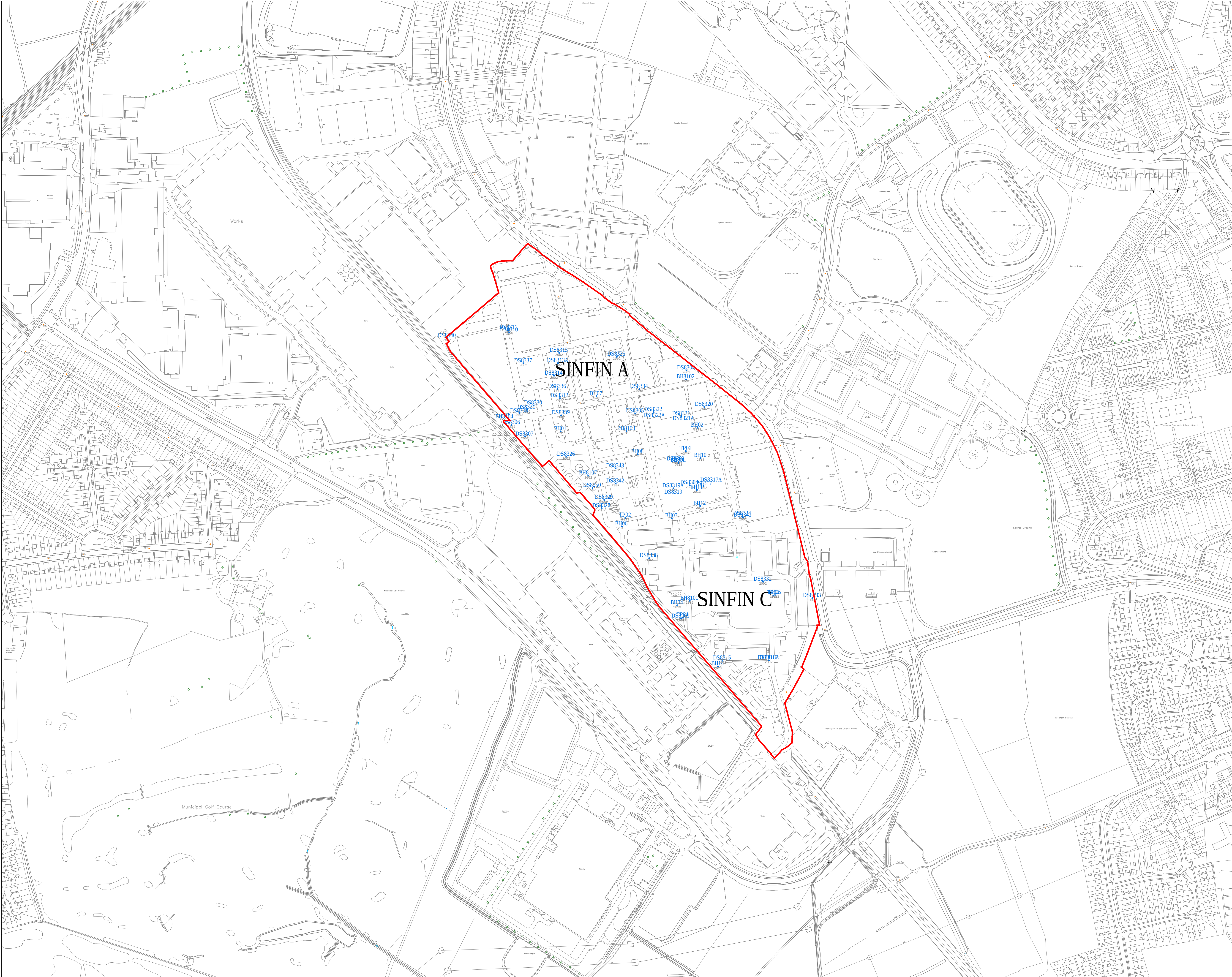
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SITE BOUNDARY					
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ROLLS-ROYCE				
Project Title				
SINFIN A & C AEROSPACE CAMPUS ROLLS-ROYCE DERBY				
Drawing Title				
EXPLORATORY HOLE LOCATIONS FROM PREVIOUS GROUND GROUND INVESTIGATION AT ROLLS-ROYCE SINFIN A & C				
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