Luton Rising
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February 2023

London Luton Airport Expansion

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Volume 5 Environmental Statement and Related Documents

5.02 Appendix 17.2 Generic Quantitative Risk Assessment - Part A

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5.02 ENVIRONMENTAL STATEMENT APPENDIX 17.2 GENERIC QUANTITATIVE RISK ASSESSMENT - PART A

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Contents

Page

1	**Introduction**	**1**
1.1	Scope	1
1.2	Objectives	1
1.3	Information sources	2
2	**Site Details**	**3**
2.1	Site location	3
2.2	The scheme	3
2.3	Current land use	3
2.4	Proposed Development	5
3	**Summary of preliminary risk assessment**	**10**
3.1	Desk based information	10
3.2	Previous ground investigations	12
3.3	Preliminary conceptual site model	12
3.4	Other risks identified in the PRA	19
4	**Ground Investigation Work**	**20**
4.1	Ground investigation strategy	20
4.2	Fieldwork	21
4.3	Groundwater/gas monitoring and sampling	23
4.4	Logging of landfill material	24
4.5	Ground investigation results	27
5	**Ground Conditions**	**36**
5.1	General	36
5.2	Stratigraphic sequence	36
5.3	Superficial deposits	39
5.4	Chalk	40
5.5	Solution features	41
6	**Hydrogeological conditions**	**43**
6.2	Regional	43
6.3	Groundwater levels and flow	44
6.4	Aquifer properties	46
6.5	Background groundwater quality	48
6.6	Kings Walden abstraction groundwater quality	50
7	**Ground Model**	**51**

8 Area A- Landfill Waste Characteristics 53
8.1 Methodology 53
8.2 Results 58
8.3 Landfill leachate 68
8.1 Comparison with other landfills 70
8.2 Interaction of earthworks with landfill 71
8.3 Summary of waste characteristics 71

9 Generic Quantitative Risk Assessment 73
9.1 Risk assessment process 73
9.2 Overall approach 73
9.3 Data used in assessment 74
9.4 Adequacy of data 74

10 Human Health Generic Quantitative Risk Assessment 76
10.1 Methodology 76
10.2 Results 81
10.3 Asbestos 90
10.4 Area A- PCBs 95

11 Ground Gas Risk Assessment 97
11.1 Introduction 97
11.2 Methodology 98
11.3 Results 100

12 Controlled Waters Generic Quantitative Risk Assessment 107
12.1 Methodology 107
12.2 Results 111

13 Revised Conceptual site model 129
13.1 Introduction 129

14 Conclusions of Generic Quantitative Risk Assessment 154
14.2 Airport Access Road 154
14.3 Area A- landfill 155
14.4 Human health 156
14.5 Ground gas 158
14.6 Controlled waters 159

Glossary/abbreviations 161

References 168

Figures 171
Figure 1 Proposed Development Location Plan

Figure 2a Proposed Masterplan – Phase 1
Figure 2b Proposed Masterplan – Phase 2a
Figure 2c Proposed Masterplan – Phase 2b
Figure 3 Site Areas
Figure 4 Current Land Use
Figure 5 Superficial Geology
Figure 6 Bedrock Geology
Figure 7 Hydrology and Hydrogeology
Figure 8 Existing Water Features within the Proposed Development
Figure 9 Previous Ground Investigations
Figure 10 Ground Investigation Landfill Specific
Figure 11 PID levels and Visual Olfactory Observations of Contamination
Figure 12 Earthworks Stage 2 Design
Figure 13 Earthworks Stage 2 Design
Figure 14 Periods of Landfill Filling
Figure 15 Minimum and Maximum Groundwater Levels
Figure 16 Human Health Exceedances
Figure 17 Ground Gas Assessment
Figure 18 Controlled Water Risk Assessment Contamination Review
Figure 19 Conceptual Site Model

APPENDICES

Appendix A - Former Landfill Ground Investigation Strategy
Appendix B -
Appendix C - Nuvia Radionuclide Survey
Appendix D - Landfill Waste Characterisation
Appendix E - Human Health Generic Quantitative Risk Assessment
Appendix F - Ground Gas Generic Quantitative Risk Assessment
Appendix G – Controlled Waters Generic Quantitative Risk Assessment

Tables

Table 2.1: Current land use of each area.
Table 2.2: Summary of Proposed Development and associated earthworks.
Table 3.1: Summary of Environmental Setting.
Table 3.2: Summary of PRA Conceptual Site Model.
Table 4.1: Ground Investigation locations and purpose.
Table 4.2 Waste component categories (adapted from ASTM D5231-92)(Ref. 16)
Table 4.3 Splitting of waste components according to the methodology adopted by the external laboratory and the methodology used in the field.
Table 4.4 PID readings above 50 ppm recorded during the GI.
Table 4.5 Visual and Olfactory observations of contamination encountered during the GI.
Table 4.6 Groundwater levels within the Chalk during monitoring.
Table 4.7 Summary of leachate measurements.
Table 4.8 Summary of the range of gas concentrations and flow rates from the post fieldwork monitoring.

Table 4.9 Summary of soil vapour sample results.

Table 5.1 General geology of the site.

Table 5.2 Volumes deposited during waste filling periods

Table 6.1 Hydraulic conductivity with depth from top of Chalk.

Table 6.2 Comparison of typical background concentrations of determinants in groundwater in the aquifer in the Luton area to site monitoring data for the Lee and Mimram catchments.

Table 8.1 Categorisation of waste types

Table 8.2 Total percentage and estimated volumes of different waste types within the landfill.

Table 8.3 Asbestos detections and quantities in waste types.

Table 8.4 Degradability of different types of waste taken from LQM (2003).

Table 8.5 Summary of the range of DOCs value of the landfill material within each era of filling

Table 8.6 Comparison of literature values of typical composition of leachate from recent and aged domestic wastes at various stages of decomposition compared to leachate measurements from the site.

Table 8.7 Average (wt.%) waste composition and comparison with literature values.

Table 8.8 Approximate volumes of landfill material proposed to be excavated in each phase

Table 10.1 Number of samples obtained for chemical analysis from within the landfill by depth

Table 10.2 Summary of proposed infrastructure in the development

Table 10.3 Exceedance of soils saturation limits for TPH and PAHs for the Airport Access Road.

Table 10.4 Exceedances of contaminants in soil when compared to generic assessment criteria (GAC) for Area A.

Table 10.5 Comparison of maximum soil concentrations to AGAC.

Table 10.6 Exceedances of contaminants in groundwater when compared to generic assessment criteria (GACgwvap).

Table 10.7 Asbestos detections and fibre content by era of waste.

Table 10.8 Locations where asbestos was detected during the Hangar 24 GI (Ref. 47).

Table 10.9 Locations where asbestos detected along the route of Airport access Road.

Table 10.10 Derived Hazard Index (HI) for PCDD, PCDF and dioxin like compounds in soils.

Table 11.1 Characteristic situations used in ground gas assessment (Ref. 49)

Table 11.2 Ground gas assessment summary within landfill waste.

Table 11.3 Ground gas assessment summary outside landfill waste.

Table 12.1 Data used in GQRA to assess contaminants in groundwater in the chalk (see **Figure 9 and 10** of this document for locations).

Table 12.2 Data and approach used in soil, soil leachate and landfill leachate assessment.

Table 12.3 Criteria to determine whether further controlled water assessment is required for contaminants.

Table 12.4 Summary of groundwater concentrations of metal and organotin contaminants which exceed the screening criteria.

Table 12.5 Summary of groundwater concentrations of inorganic contaminants which exceed the screening criteria.

Table 12.6 Summary of groundwater concentrations of petroleum hydrocarbon contaminants which exceed the screening criteria.

Table 12.7 Summary of groundwater concentrations of PAH, phenol, VOC and SVOC contaminants which exceed the screening criteria.

Table 12.8 Summary of groundwater concentrations of pesticides/herbicides and PFAS contaminants which exceed the screening criteria.

Table 12.9 Summary of contaminants of concern within groundwater requiring further assessment.

Table 12.10 Contaminants in the soil (landfill matrix) for which the maximum value exceeded the RTM Level 1 values by at least 100 times.

Table 12.11 Summary of soil leachate, leachate and perched groundwater concentrations of metal contaminants which exceed the screening criteria.

Table 12.12 Summary of soil leachate, leachate and perched groundwater concentrations of inorganic contaminants which exceed the screening criteria.

Table 12.13 Summary of leachate and perched groundwater concentrations of petroleum hydrocarbon contaminants which exceed the screening criteria.

Table 12.14 Summary of leachate and perched groundwater concentrations of PAH, phenol, VOC and SVOC contaminants which exceed the screening criteria.

Table 12.15 Summary of leachate and perched groundwater concentrations of pesticides/herbicides and PFAS contaminants which exceed the screening criteria.

Table 12.16 Summary of contaminants of concern within landfill requiring further assessment.

Table 13.1 Revised Conceptual Site Model (CSM) updated following GQRA for Area A.

Table 13.2 Revised Conceptual Site Model (CSM) updated following GQRA for Airport Access Road.

Table 14.1 Key contaminants of concern in the groundwater and landfill requiring further detailed controlled waters assessment.

1 INTRODUCTION

1.1 Scope

1.1.1 This Generic Quantitative Risk Assessment (GQRA) has been undertaken by Luton Rising (a trading name for London Luton Airport Limited) (the applicant) to support the application for a Development Consent Order (DCO) for the expansion of the airport.

1.1.2 The aim of this GQRA is to quantitatively assess the risks in relation to land contamination identified within the Preliminary Risk Assessment (PRA) in **Appendix 17.1** of the ES **[TR020001/APP/5.02]** (Ref. 1). It presents a quantitative assessment by comparing measured concentrations of contaminants of concern against criteria applicable for the protection of human health, ground gas and controlled waters. It is intended that this report is read in conjunction with the PRA.

Area covered by report

1.1.3 The extent of the Application Site is shown in **Figure 1** of this document and is described in detail in **Section 2**. The Proposed Development (shown on **Figures 2a, 2b and 2c** of this document, is split into four distinct geographical components:

a. Main Application Site;
b. Off-site Car Parks;
c. Off-site Highways Interventions; and
d. Off-site Planting

1.1.4 The findings of the PRA are discussed in detail in **Section 3**. Due to the size of the Application Site, it was subdivided in the PRA (Ref. 1), **Appendix 17.1** of the ES **[TR020001/APP/5.02]**, into smaller areas for ease of description. These areas are shown on **Figure 3** of this document**.** The report identified that the main area of concern with respect to potential contamination is a former landfill site (Area A) and required additional quantitative risk assessment. In addition, the Airport Access Road was identified as requiring additional quantitative risk assessment. Ground investigation (GI) work had been undertaken previously but no assessment of the chemical analysis results had been undertaken to identify potential contamination issues

1.1.5 No other areas within the Main Application Site, or off-site areas were identified as requiring quantitative risk assessment at this stage. Background information on the other areas is presented in **Section 3.3**, including justification for not progressing to GQRA.

1.2 Objectives

1.2.1 The objectives of this report are to meet the requirements of a GQRA as defined by the Environment Agency's Land Contamination Risk Management (LCRM) Guidance (Ref. 2) and includes the following:

a. Detailed understanding of the spatial distribution of Contaminants of Concern (CoC) in soil and groundwater within the context of current site conditions and during redevelopment (i.e. how the distribution alters with bulk earthworks);
b. Quantitative assessment of Potential Contaminant Linkages (PCLs) for soil, groundwater and gas risks identified in the PRA;
c. Refinement and development of a robust Conceptual Site Model (CSM) that considers the source-pathway-receptor linkages both on current conditions and upon completion of redevelopment;
d. Identification of relevant PCLs which require further detailed assessment through Detailed Quantitative Risk Assessment (DQRA); and
e. Identification of Relevant Contaminant Linkages (RCLs) that require additional remedial work or management to allow the proposed development to proceed safely.

1.3 Information sources

1.3.1 Several ground investigations (GIs) and other reports were made available for the assessed areas. These were reviewed in detail in **Appendix 17.1** of the ES (Ref. 1) **[TR020001/APP/5.02]**. Data from these reports have been used to support this assessment.

2 SITE DETAILS

2.1 Site location

2.1.1 The application for development consent area is located approximately 3.5km east of Luton town centre and is located around the airport centred at National Grid Reference (NGR) 513400, 221800. **Figure 1** of this document shows the location and extent of the Application Site.

2.2 The scheme

2.2.1 The Application Site covers approximately 474 hectares (ha). The majority of this land lies to the east of the existing airport, but also included are areas of the existing airport, runway and isolated land parcels north and west of the airport where road infrastructure will be upgraded.

2.2.2 The Proposed Development builds on the current operational airport with the construction of a new passenger terminal and additional aircraft stands on land owned by the applicant located to the northeast of the runway. This will take the overall passenger capacity from 18 million passengers per annum (mppa) to 32 mppa. In addition to the above and to support the initial increase in demand, the existing infrastructure and supporting facilities will be improved in line with the phased growth in capacity of the airport.

2.2.3 For the purpose of assessment there are three assessment phases, Phase 1, Phase 2a and Phase 2b, which are referred to throughout the ES. The proposed masterplans for the assessment phases are presented in **Figures 2a, 2b and 2c** of this document and present the works which are assumed to be brought forward for each phase.

2.2.4 A detailed description of the Proposed Development is provided at **Chapter 4** of the Environmental Statement **[TR020001/APP/5.01].**

2.3 Current land use

2.3.1 The current land uses of each of the areas of the Proposed Development are provided in **Table 2.1** and shown on **Figure 4** of this document.

Table 2.1: Current land use of each area.

Development Area (see Figure 4 of this document)	Current Land Use
Main Application Site	
Existing airport land	The airport infrastructure consists of a terminal building, runway with associated taxiways, stands, aprons and hangars, maintenance facilities and airport related offices. A fire station is located in the southwest of the terminal building. The associated business park to the north and west of

Development Area (see Figure 4 of this document)	Current Land Use
	the main airport area also accommodates a range of aircraft and airport production and maintenance businesses, including two fuel depots and a number of car parks for short-, mid- and long-term stay are provided for airport users.
LLAOL Contractor's Compound	The south eastern area of the airport (see **Figure 4** of this document) is a compound used by the operator's contractors for storage of various items including construction arisings from Terminal 1 improvements. In the east is the fire training ground. South of this are two existing airport soakaways (known as the central soakaway). The north east balancing pond is on the boundary with Area B.
Airport Access Road	Parts of the eastern section is existing carriageways; President's Way and Percival Way, the remainder is on the landfill and is part of Wigmore Valley Park (WVP), see Area A below. Industrial /commercial land use are located on the central section of proposed carriageway and undeveloped land along the western section along Dairyborn escarpment.
A – Former Landfill	This area comprises public open space, known as WVP. Sports pitches are present in the north eastern part of the area. The long-term car park for the airport is present in the west of the area. In the north west is another car park (operated by TUI). The central and southern part of the site are a County Wildlife Site (CWS).
B – Land West of Winch Hill	The northwest part of this area forms part of WVP. Within this area is a community centre, skateboard park, children's playground and allotment gardens as well as public open space, scrub and woodland areas. The rest of the area comprises agricultural land with a coppice and small woodland in the south, designated as ancient woodland. Winch Hill Fam and New Winch Hill Cottages are located on the eastern boundary on Winch Hill Lane.
C – Land East of Winch Hill	Predominately arable land with some hedgerows/trees. There is a woodland area present which bisects the site. Two agricultural barns are located at the western boundary and a

Development Area (see Figure 4 of this document)	Current Land Use
	large residential property 'Winch Hill House' to the south of these.
Off-site Areas	
D – Off-site Car Park North	Currently partly occupied by a trailer park for storage of heavy goods vehicle (HGV) trailers on the central and south eastern areas and an area of car parking and vehicle servicing area along the north western area.
E – Off-site Car Park South	The site is currently vacant, most recent land use was as a compound by the contractor working on the Luton Direct Air to Rail Transit (DART)[1]. Part of the site is covered with hardstanding and two unidentified structures are also present.
Off-site Highway Interventions	Asphalt carriage-way and landscaping to road verges, see **Appendix 17.1** of the ES (Ref. 1) for further details **[TR020001/APP/5.02]**.

2.4 Proposed Development

2.4.1 This section presents a description of the Proposed Development and the likely associated earthworks within each of the areas described in **Table 2.1.** The extent of earthworks within each of the areas is important in assessing the potential risk to receptors from contamination. As discussed in **Section 1.1.4**, the scope of this report is a GQRA for Area A (see **Figure 3** of this document) and the Airport Access Road. However, the assessment needs to consider works to be undertaken in the vicinity which could impact on Area A and cause potential preferential pathways for any potential contaminants. A description of the Proposed Development is described below in **Table 2.2** and shown in **Figure 2** of this document. The Off-site Highway Intervention works and work on existing airport land are excluded as detailed in **Section 1.1.5.**

Table 2.2: Summary of Proposed Development and associated earthworks.

Development Area	Proposed Development	Likely earthworks work required
Existing airport land	**Terminal 1** Improvement of existing terminal area including refurbishment of Terminal 1, small extensions to the north	Earthworks include piling for the new pier and excavation Made Ground and natural soils for the section of Luton DART. Construction of decked car park.

[1] a new cable-hauled fast passenger transit connecting Luton Airport Parkway station to the airport (the announcement of an official opening date will be made in early 2023).

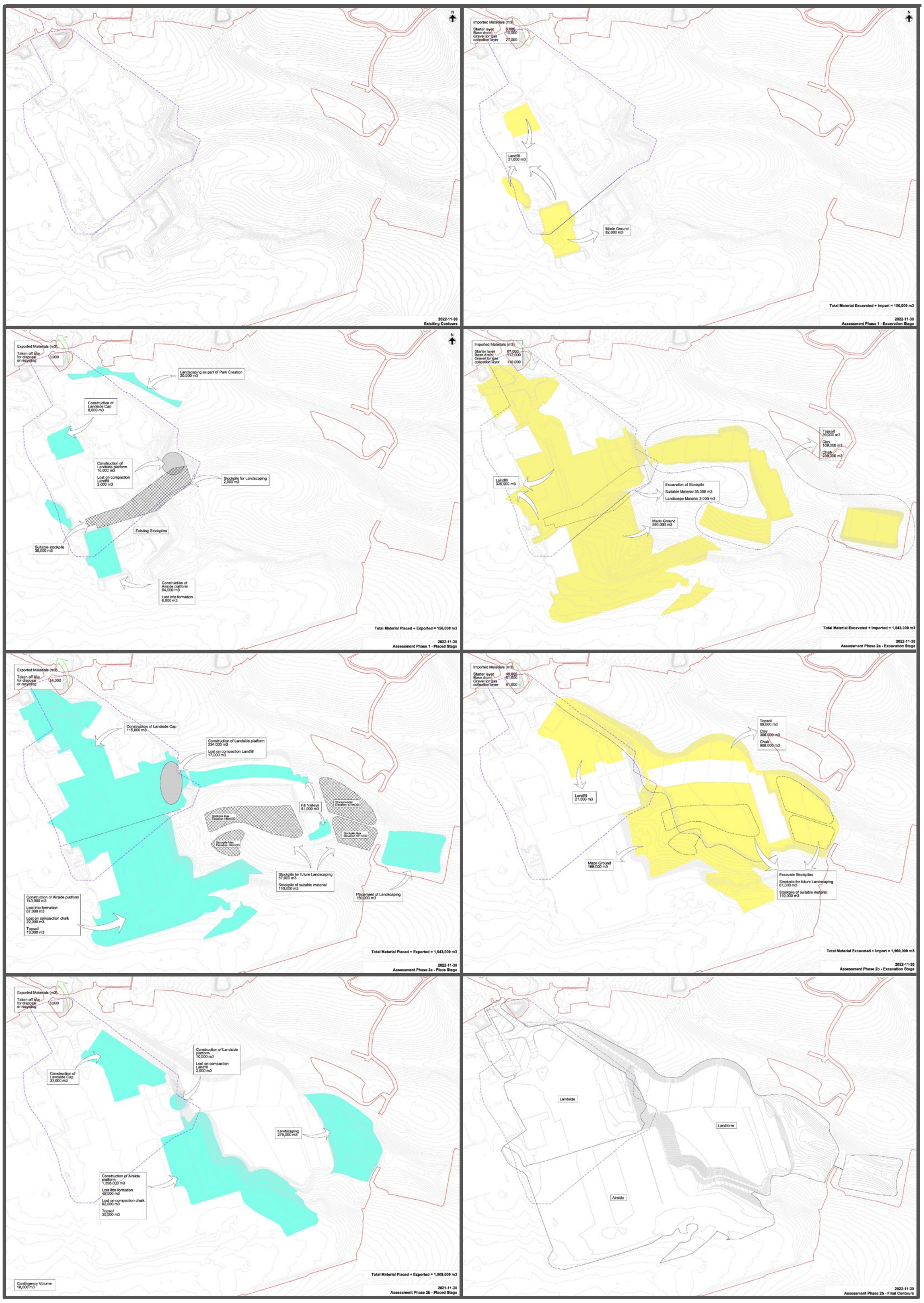
Development Area	Proposed Development	Likely earthworks work required
	east and south east corners, and a new apron and stands. A section of the Luton DART extension (the announcement of an official opening date will be made in early 2023) will also be constructed by cut and cover. Relocation of the fire training ground with its associated facilities to the south of the runway. Relocation of staff car park. New 33kV substation SMR tower	Relocation of the fire training ground is likely to require minor earthworks for construction of the soakaway and associated drainage.
LLAOL Contractor's Compound:	Apron, piers, stands taxiways and attenuation tank.	Earthworks will be required to create an aviation platform to tie-in with the existing airport levels. Made Ground and natural soils to be excavated and relocated to the southern end of Area A to surcharge the landfill prior to development. Construction of the airside platform with engineering fill (chalk) excavated from Area B for the platform.
Airport Access Road	Construction of new carriageway / duelling of existing carriageway to create a new link road from Airport Way to Terminal 2 (T2) with connections to a series of new access and on-airport distributor roads for T2 and Green Horizons Park (formerly New Century Park).	Earthworks will be required to create the new link road including excavation to create cuttings and construction of reinforced earth embankment. Excavation of landfill material where road is located in Area A.
A – Former Landfill	**North** Green Horizons Park developments; offices, hotels, warehouses and car parking. Airport infrastructure car parking, new road infrastructure including eastern section of	Excavation of landfill material for provision of Airport Access Road and minor access roads and to create development platform. Piling through the landfill into underlying chalk for foundations

Development Area	Proposed Development	Likely earthworks work required
	Airport Access Road and landscaping. Attenuation tank.	to proposed buildings and structures.
	South New terminal building. Piers, apron, stands and taxiways. Extension to the Luton DART to the new terminal and new station. Energy centre, coach station and car parking	Major earthworks to create a development platform to tie-in with the existing airport levels – excavation, processing and relocation of landfill material/ Made Ground to extend landside platform east of landfill and for the Luton DART tunnel and station. Import of engineering fill (chalk) from Area B for development platform. Surcharging of landfill with stockpiled soils excavated from LLAOL Contractor's compound. Piling through the landfill into underlying chalk for foundations.
B – Land West of Winch Hill Lane	Ancillary airport buildings. Aprons and stands. Fuel Storage Area and pipeline. Car parking. Water treatment plant Attenuation tank for drainage. WVP community centre, allotment gardens and parkland will be retained. Relocated public parkland.	Major excavation of clay and chalk to provide site-won engineering materials for the airside development platform. Piling into underlying chalk for foundations. Excavation of natural ground for provision of access road and car parks. Some landscaping works will be required for preparing the land to be suitable for re-provision of public parkland. Creation of temporary stockpiles of materials suitable for reuse in construction and landscaping.
C – Land East of Winch Hill Lane	Creation of infiltration basin (below ground infiltration tank).	Excavation for infiltration basin. Excavation and connection to National fuel delivery pipeline. Creation of temporary stockpiles of materials suitable for reuse in construction and landscaping.
Off-site Areas		

Development Area	Proposed Development	Likely earthworks work required
D – Off-site Car Park North	Car park.	Potential for resurfacing, re-levelling.
E – Off-site Car Park South	Car park.	Construction of a multi-storey car park.
Off-site Highway Interventions	Junction improvements.	Low potential for minor level change, widening of carriageway, signalisation at junctions. Further details are provided in **Appendix 17.1** of the ES (Ref. 1) **[TR020001/APP/5.02]**.

2.4.2 A simplified schematic of the earthworks required to create the development platform for the expansion work is shown in **Drawing 1** below.

Drawing 1 Simplified sequencing of the earthworks required to create the development platform for the expansion work.



3 SUMMARY OF PRELIMINARY RISK ASSESSMENT

3.1 Desk based information

3.1.1 **Appendix 17.1** of the ES (Ref. 1) **[TR020001/APP/5.02]** involved a desk-based assessment of the potential risks associated with the Proposed Development using a range of data sources including historical information, regulatory databases and findings of previous GIs and quantitative risk assessments.

3.1.2 This section provides a summary description of the physical and environmental setting of the Proposed Development, provided in **Table 3.1**. This is based on the study area described in **Section 3.1** of **Appendix 17.1** (Ref. 1) and the identified information sources. **Appendix 17.1** of the ES (Ref. 1) should also be referred to for further details **[TR020001/APP/5.02]**.

Table 3.1: Summary of Environmental Setting.

Environmental Feature	Details
Geology (**Figures 5** and **6** of this document)	**Made Ground** is confirmed or anticipated across the Main Application Site, but likely to be absent from agricultural land in Areas B and C and Off-site planting.
	Superficial deposits are present across all areas apart from Areas D and E and generally comprise Head deposits and Clay with Flints. Glaciofluvial deposits are present beneath the Off-site Highway Interventions at Hitchin.
	Bedrock is generally recorded as Lewes Nodular and Seaford Chalk Formation across the Proposed Development.
Mining/Ground workings	The Proposed Development is in an area which has been the location of chalk extraction. The whole of Area A is also identified as an unspecified workings/location of a refuse heap, a small unspecified quarry is recorded in the centre of Area B.
Natural cavities	Solution pipes are recorded as located 15m north of Area A and in Area D.
Radon	The site is not within a radon affected area (less than 1% above action level), and therefore radon protection measures are not required.
Hydrogeology (**Figure 7** of this document)	Across the Proposed Development the Chalk groups (Lewes Nodular, Seaford, Holywell Nodular and New Pit Chalk formations) are all Principal Aquifers.

Environmental Feature	Details
	A groundwater divide is located between the existing airport land and Area A, see **Section 6** for further detail on regional hydrogeology and groundwater conditions beneath the site.
Source Protection Zones (SPZ) (**Figure 7** of this document)	The Main Application Site and Off-site Highway Interventions generally lie within an SPZ3 (Total catchment) with the following exceptions: Areas D and E and Gipsy Lane/Airport Way Off-site Highway Intervention are not within an SPZ, and the Off-site Highway Interventions Windmill Road/Crawley Green Road and Windmill Road/Kimpton Road are in SPZ1 (Inner zone) and SPZ2 (Outer zone), respectively.
Abstraction (**Figure 7** of this document)	**Groundwater**- two active abstraction licenses are recorded within 2km of the Main Application site Order Limits; 1.5km west for general use and 1.5km north east a potable water supply operated by Affinity Water Limited. Further private water supplies are located within 2km, see **Figure 7** of this document. **Surface water –** no abstractions recorded.
Hydrology (**Figure 7** and **Figure 8** of this document)	No surface watercourses are located within the Main Application Site, the River Lea is approximately 300m south of Area E. Other surface water features on site include Thames Water Compound storage pond and Thames Valley Drain (TVD) (also referred to as the Thames Water overflow pipe) , numerous soakaways are located around the existing airport land.
Environmental permits	Three are recorded to operations on the Main Application Site for operation of combustion plant, coating processes and dry cleaning.
Dangerous or hazardous sites	A lower tier Control of Major Accident Hazards (COMAH) site for storage of Jet A-1 fuel and a site licensed under the Manufacture and Storage of Explosive Regulations 2005 (MSER) are located on the existing airport land.
Waste disposal	Area A was formerly the Eaton Green Landfill, in use between 1937 and early 1990s, wastes disposed included: inert, industrial, commercial, household and liquid sludge, see **Appendix 17.1** of the ES (Ref. 1) **[TR020001/APP/5.02]** and previous studies (Ref. 3) for further detail. An active, waste site is the Tidy Tip (formally called the Eaton Green Civic Amenity Site), a Local Authority recycling centre located in the north west of Area A, this is currently permitted.

Environmental Feature	Details
Ecological designations	The following ecological designations are located on the Main Application Site; Area A – County Wildlife Site (CWS) is located within the south east area of WVP and Area B – a designated ancient and semi-natural woodland in the south east.
Unexploded Ordnance	Several UXO reports have been obtained and identify the airport, LLAOL Contractor's Compound and Area A as Very High risk for UXO. However, where works are to be undertaken within post war fill material/Made Ground this is considered Low Risk. All other areas of the Proposed Development are Low to Moderate Risk.

3.2 Previous ground investigations

3.2.1 A number of previous GIs were reviewed and summarised in the PRA which covered the existing airport land, LLAOL Contractor's Compound and Areas A and B, see **Figure 9** of this document for GI locations. This identified Area A – Former Landfill as the significant potential source of contamination within the Proposed Development, and further risk assessment of soils, groundwater and gas results would be required to refine the CSM and PCLs. The report also identified that assessment was required of GI data for the Airport Access Road, further detail is provided in **Table 3.2.**

3.3 Preliminary conceptual site model

3.3.1 To complete the PRA a CSM was developed based on the desk study information which identified a number of PCLs as moderate to high risk. A summary of these PCLs is provided in **Table 3.2**. The PRA is provided as **Appendix 17.1** of the ES **[TR020001/APP/5.02]** (Ref. 4) and should be consulted for a full list of PCLs and qualitative assessment of the risks.

3.3.2 As detailed in **Sections 1.1.4 and 1.1.5**, Area A and the Airport Access Road have been considered further in this GQRA report. A summary of justification of exclusion of other areas from further assessment is provided in **Table 3.2**, further details is provided in the PRA **Appendix 17.1** (Ref. 1) of the ES **[TR020001/APP/5.02]** and the ES (Ref. 4) **[TR020001/APP/5.01]**.

Table 3.2: Summary of PRA Conceptual Site Model.

Area	Receptor	PCLs	Qualitative Assessment of Risk	Additional Assessment /GI required?
Existing airport land (including LLAOL contractors compound)	Human health	Inhalation of airborne contaminants by construction workers from Made Ground during construction works.	Moderate	**No** The PRA identified a potential moderate risk associated with excavation of materials during construction works to human health and a risk to foundations/infrastructure from aggressive ground conditions. A high risk from UXO was identified in the LLAOL Contractor's Compound. All of which can be addressed at detailed design stage with additional testing of materials and employment of mitigation and control measures during construction including adherence to a Construction Code of Practice (CoCP), see **Appendix 4.2** of the ES **[TR020001/APP/5.02]** and measures to ensure that preferential pathways for gases from the landfill are not created.
		Driving of piles impact UXO with risk to construction workers/public/airport operatives.		
	Buildings/ Infrastructure	Direct contact with contaminated soils/groundwater.	High	
Airport Access Road	Human health	Inhalation of airborne contaminants by construction workers from Made Ground during construction works.	Moderate	**Yes** The PRA noted that the areas of the proposed new road (off the landfill) has been subject to GI but no formal assessment of the data had been undertaken. It was therefore recommended that GQRA is undertaken to identify whether there is any contamination issues which require further consideration.
		Direct contact with Made Ground e.g. dermal, and/or		

Area	Receptor	PCLs	Qualitative Assessment of Risk	Additional Assessment /GI required?
		accidental ingestion by construction workers.		
	Buildings/ Infrastructure	Direct contact with contaminated soils/groundwater.		
A- Former Landfill	Human health	Migration of ground gases from former landfill into future development.	Very High	**Yes** The PRA noted Area A was the main area of potential contamination within the Proposed Development. A significant part of the Proposed Development will be within this area including the new terminal building and as such a number of very high, high and moderate PCLs were noted. The PRA recommended the following further work: a. Further detailed assessment of GI results; b. Detailed assessment to understand the gassing conditions after work is undertaken to remodel the landfill; c. Complete full characterisation of the landfill waste based on the additional data gathered to inform the detailed assessment of the potential risks to groundwater and also to determine the potential for reuse of material;
		Migration offsite to adjacent residential properties/ existing airport buildings of ground gases from former landfill through preferential pathways.	Moderate	
		Inhalation of airborne contaminants by adjacent site users (e.g. residential housing, existing Luton Airport) and construction workers from Made Ground/former landfill during construction works.	High	

Area	Receptor	PCLs	Qualitative Assessment of Risk	Additional Assessment /GI required?
	Controlled waters	Driving of contaminants downwards during any future piling and via preferential pathways to principal chalk aquifer and lateral migration of contaminants in groundwater to controlled water receptors.	Moderate	d. Develop a remedial strategy for the re-engineering of the former landfill material to ensure the potential risks associated with this material are assessed and controlled as to not present a risk to controlled waters or future users of the site; e. Detailed consideration of the gas management measures for the buildings/infrastructure on the Proposed Development; and f. The geotechnical risks should be reassessed to finalise any ground improvement techniques/foundation design prior to construction and used to further develop the earthworks strategy for the Proposed Development.
	Buildings	Direct contact with aggressive ground conditions.	Moderate	
B-Land West of Winch Hill Lane	-	No moderate/high risk PCLs identified.	-	**No** This area has no history of contaminative use based on the available information assessed in the PRA. The PRA concluded no further GI or assessment is required for Area B. Construction works should include measures to ensure that preferential pathways for gases from the landfill are not created, as well as to

Area	Receptor	PCLs	Qualitative Assessment of Risk	Additional Assessment /GI required?
				detect, and if necessary treat, any existing features such as drains and other utilities that might be providing a preferential pathway for gases from the former landfill in Area A.
C- Land East of Winch Hill Lane	-	No moderate/high risk PCLs identified.	-	**No** The PRA concluded this area is greenfield and has only ever been agricultural land. On this basis it was considered unlikely there would be any potential sources of contamination and therefore, no GI for geoenvironmental purposes or further risk assessment is considered necessary
D – Off-site Car Park North	Human health	Inhalation of airborne contaminants by construction workers from Made Ground during construction works.	Moderate	**No Further assessment or GI for geoenvironmental purposes is not required at this stage.** The PRA indicated there is no GI data available for this area and concluded that based on the desk study information there may be occasional areas of localised contamination from the historical uses and its current use as a trailer park, car parking and garage. The overall risk of contamination was considered low, detailed assessment of contamination risks is not required at this stage in the application for development consent. GI will be required to obtain geotechnical information for the Proposed Development in these areas, prior to construction, this would be
	Controlled waters	Leaching of contaminants in soil to principal chalk aquifer.	Moderate	
		Driving of contaminants downwards to principal chalk aquifer during any future piling.	Moderate	

Area	Receptor	PCLs	Qualitative Assessment of Risk	Additional Assessment /GI required?
				coupled with a geoenvironmental investigation to verify existing mitigation requirements and design measures.
E - Off-site Car Park South	Human health	Inhalation of airborne contaminants from Made Ground by construction workers from Made Ground during construction works.	Moderate	**No further assessment or GI required at present**. The PRA indicated there is no GI data available for this area and concluded that based on the desk study information no major contamination sources are likely to be present within these areas however an earthworks platform was constructed during the 1940s from material of unknown origin or quality, therefore, there is the potential for this material to be a source of contamination. The overall risk of contamination is considered to be low, detailed assessment of contamination risks is not required at this stage in the application for development consent. GI will be required to obtain geotechnical information for the Proposed Development in these areas, prior to construction, this would be coupled with a geoenvironmental investigation to verify existing mitigation requirements and design measures.
	Controlled waters	Leaching of contaminants in soil to principal chalk aquifer.	Moderate	
		Driving of contaminants downwards to principal chalk aquifer during any future piling.	Moderate	
Off-site Highway Interventions		No moderate/high risk PCLs identified.		**No** **Further assessment or GI for geoenvironmental purposes is not required at present.** The PRA identified that no GI has

Area	Receptor	PCLs	Qualitative Assessment of Risk	Additional Assessment /GI required?
				been completed within the areas of proposed Off-site Highway Interventions. However the overall risk was been determined as very low to low to future site users/infrastructure as the majority of the sites have shown little potential contaminative historical uses. In addition the proposed works in these areas will not involve substantial earthworks and as such there will be limited interaction with soils and groundwater. Any risks associated with contamination can be mitigated during construction by use of site management procedures and personal protective equipment (PPE). Further GI will be undertaken prior to construction, post DCO consent, to inform detailed design and verify mitigation requirements.

3.4 Other risks identified in the PRA

Unexploded ordnance

3.4.1 Areas A and LLOAL Contractor's Compound have 'Very High' risk from UXOs and the risk will need to be addressed further when considering design and construction (Ref. 5). Areas D and E will require further UXO assessment since current assessments do not cover these areas. The other areas of the Proposed Development; Existing Airport Land and Off-site Highway Interventions do not require further consideration as these areas have been previously developed and most the earthworks are anticipated to be relatively shallow.

Ecological risks

3.4.2 Invasive species have been identified in Area A, including Japanese Knotweed. Further ecological surveys may be required in other undeveloped areas of the Proposed Development as part of the detailed design stage to determine presence/absence of invasive species.

4 GROUND INVESTIGATION WORK

4.1 Ground investigation strategy

4.1.1 Preliminary GIs were undertaken in 2016/17 (Ref. 6)(Ref. 7)(Ref. 8)(Ref. 9) which provided coverage for the Airport Access Road, Area A and Area B. These GIs were reviewed as part of the PRA in **Appendix 17.1** of the ES (Ref. 1) **[TR020001/APP/5.02]**. Following the findings of the PRA a detailed GI was developed to focus on any data gaps and relevant PCLs within Area A, which was identified as the main area of potential contamination within the Proposed Development. The GI Strategy (Ref. 10) was presented to the Environment Agency (EA) on 25 March 2018. The EA provided comments which indicated that the GI strategy was comprehensive and would obtain the expected level of data for a detailed assessment. The sampling strategy and minutes from the meeting are included in **Appendix A.**

4.1.2 The GI within Area A was intended to inform the following:

a. Confirm the depth of waste in the landfill;
b. Confirm the geological conditions, including presence/absence of Clay-with-Flints and potential presence of solution features;
c. Characterise in detail the type, age and condition of waste in the landfill;
d. Provide detailed information on leachate and gas conditions both on and off the former landfill.;
e. Investigate potential contaminative sources within the landfill including asbestos;
f. Inform on landfill composition for preliminary geotechnical and earthworks design;
g. Confirm the groundwater elevations and condition beneath the landfill; and
h. Build on the existing network of groundwater monitoring boreholes across the DCO area.

4.1.3 The GI was designed to generate sufficient information for a detailed assessment. The detailed GI in conjunction with the previous preliminary GI has generated datapoints at approximately 50m intervals across the landfill for ground gas monitoring locations and 150m intervals for groundwater monitoring locations. This is consistent with recommended sampling grids for a main site investigation (Ref. 11).

4.1.4 The locations of previous ground investigation and the 2018 exploratory holes are shown in **Figures 9** and **10** of this document. The investigation was split in two phases due to access restrictions. The first phase was conducted between 5 June to 2 July 2018 in WVP and the CWS. The second phase was conducted between 26 November to 14 December 2018 in the Long-Term Car Park (LTCP).

4.1.5 The scope of the GI for the Airport Access Road was developed by Pell Frischmann based on a Preliminary Sources Study Report (PSSR) (Ref. 12). The GI was completed over 2 phases.

4.2 Fieldwork

Overview

4.2.1 A summary of the 2018 GI locations on the former landfill and their purpose, including installation details is provided in **Table 4.1.** The GI locations are shown on **Figure 9** of this document.

Table 4.1: Ground Investigation locations and purpose.

Exploratory Hole Type	Purpose of hole	Number of holes	Maximum Depth (m)	Purpose of installation
Cable percussion	Boundary hole	3	20.9	Groundwater monitoring
Roto-sonic	Determine depth of Made Ground, characterise landfill waste and underlying natural ground	17	20.0	Gas monitoring
		4	18	Leachate monitoring
Dynamic sampling (Window sample)		24	5	Gas monitoring
		1	6	Leachate monitoring
	Boundary hole	15	5.45	Gas monitoring
Rotary cored/ Dynamic sampling with rotary follow-on/Sonic with rotary follow-on/ Cable percussion with rotary follow-on	Penetrate landfill and at least 10 m into chalk	5	36.2	Gas monitoring
	Deep boreholes for hydrogeological characterisation – within landfill boundary	5	64.5	Groundwater monitoring
	Deep boreholes for hydrogeological characterisation– not within landfill boundary	2	54	
	Determine depth of Made Ground, characterise landfill waste and underlying natural ground	8	14	Gas monitoring
Trial pits	General characterisation of ground/landfill waste	51	4.5	N/A

Exploratory Hole Type	Purpose of hole	Number of holes	Maximum Depth (m)	Purpose of installation
Cone Penetrometer Test	Penetrate chalk	5	26.2	N/A
	Penetration of landfill	62	22.8	
Dynamic probing		29	18.8	N/A
		15	6	

Note: These exploratory hole quantities are based on number of exploratory hole locations and do not include re-drills, locations that were cancelled, nor where CPT/DP refused early and was re-attempted.

Testing and monitoring

4.2.2 A number of in-situ tests and monitoring were undertaken during the fieldwork, full details are provided in the Factual GI report (Ref. 13) and summarised below:

During fieldwork

a. Forensic analysis of the waste- in an on site laboratory (details below in **Section 4.4).**
b. Single Packer permeability testing- packer testing was undertaken at regular intervals in the Chalk strata in seven boreholes (GW201-GW206 inclusive and GW207a).
c. Environmental monitoring- as there was limited information regarding waste content, environmental monitoring was conducted during the course of the works. This included monitoring for vapour and gases at each work site, background dust and specialist monitoring for radionuclides.
d. UXO mitigation- prior to works commencing a detailed UXO survey was obtained, which identified parts of Area A which required specific measures during the works. These measures included the use of a magnetometer equipped with a cone penetration test (CPT). Further details are provided in the Factual GI report (Ref 13)**.**
e. Ecological surveys- species of ecological importance were identified by an ecologist including orchid, badgers, birds and reptiles. In addition, the invasive plan species Japanese Knotweed was identified in several areas of the site. Exploratory locations near site of ecological interest were surveyed by an ecologist and a watching brief undertaken by an ecologist during the works.

Post Fieldwork

a. Continuous gas monitoring- Five Ambisense GasfluX units were also installed to BH202, BH206, BH208, BH224, & BWS202. The GasfluX units were installed in August 2018 and decommissioned at the end of October/start of November 2018. Purge and recovery tests were also undertaken on the locations installed with the Ambisense GasfluX to inform gas emissions.

b. Spot gas measurements- gas readings for methane, carbon dioxide, oxygen, hydrogen sulphide and carbon monoxide were taken from standpipes using a GFM 435 gas analyser.

c. Bulk gas and vapour sampling- samples of soil gases and bulk landfill gases were taken from specific wells using either gas cannisters or vacuum bottles. Samples were analysed for semi-volatile and volatile compounds.

d. Data loggers for groundwater- data loggers were installed in three groundwater boreholes (GW201, GW204 and GW207A) which measured the groundwater level at five-minute intervals. The data was collected between October 2018 to March 2019.

e. Groundwater samples- were obtained using low flow micro-purging and sampling techniques to obtain samples representative of the chalk aquifer and minimise disturbance to the water column. The samples were tested for a range of analytes including metals, semi and volatile organic compounds (SVOCs and VOCs), total petroleum hydrocarbons (TPHs), polyaromatic hydrocarbons (PAHs), pesticides, phenols, polychlorinated biphenyls (PCBs) and volatile fatty acids (VFAs).

f. Leachate samples- five boreholes (LW201 – LW205) were installed for the monitoring of leachate collected from the landfill waste. These boreholes were installed with slotted pipe through the thickness of the landfill waste with a 1 m plain pipe installed at the base to act as a sump to collect leachate for monitoring and testing samples of leachate. Where present, leachate samples were obtained from wells. The samples were tested for a range of contaminants including metals, volatile organic compounds (VOCs), total petroleum hydrocarbons (TPHs), polyaromatic hydrocarbons (PAHs), pesticides, phenols, polychlorinated biphenyls (PCBs) and volatile fatty acids (VFAs).

g. Radionuclide survey- a survey was undertaken post GI works to follow up on locations where readings has been encountered above background levels. The further survey **(Appendix C**) indicated that the levels of radionuclides detected were consistent with expected natural background levels.

4.3 Groundwater/gas monitoring and sampling

4.3.1 In parallel to the GI a 12-month period of monthly groundwater and gas monitoring was undertaken across the network of boreholes established during the preliminary GIs, between 6 August 2018 and 22 March 2019. These locations were predominately within Area A and Area B, see **Figure 10** of this document. The objectives of this monitoring were:

a. to establish whether there is any migration of contaminants from the landfill site and characterise their spatial extent;

b. determine the direction, rate and variability of groundwater flow and contaminant migration;

c. determine the baseline groundwater level, including variability and trends;
d. determine baseline groundwater quality including variability and trends;
e. determine baseline gas concentrations including variability and trends;
f. monitoring, sampling and testing undertaken were as follows:
g. monthly monitoring for groundwater levels and samples taken at 17 groundwater quality monitoring points (GQMP);
h. monthly monitoring at 9 gas monitoring points and bulk gas/ SVOC and VOCs samples taken every two months;
i. monitoring of leachate thicknesses and sampling every 2 months at 4 leachate monitoring wells; and
j. obtaining samples of non-aqueous phase liquids (NAPLs), where present.

4.4 Logging of landfill material

4.4.1 Accurate and consistent description of landfill materials was a priority for this investigation, as it provided a vital indication of the material's likely geotechnical behaviour, the potential for contamination and/or the potential for ground gas generation. However, BS 5930:2015 (Ref. 14) and BS EN ISO 14688-1 (Ref. 15) provide only limited guidance on the description of anthropogenic "soils" and there is no published approach for logging former landfill materials.

4.4.2 An approach was developed for use during the GI to ensure consistent description of the landfill waste. The protocol for logging is included in **Appendix D.**

Forensic analysis of landfill material

4.4.3 Samples of landfill material were collected from either borehole core runs or trial pit bulk samples and transported to the field laboratory for forensic assessment (see **Photograph 1**).

4.4.4 The assessment comprised testing of the samples in accordance with Standard Test Method D5231-92 (Ref. 16). An initial assessment of the sample included weighing and sample description for the following parameters:

a. colour;
b. dampness: dry, damp and wet;
c. degradation: undegraded (materials fresh, predominantly in original state), moderately degraded (materials stained, some breakdown of material, some of original components unrecognisable) and highly degraded (materials falling apart, majority of original components unrecognisable);

d. odour: described in accordance with **Table 19** in BS5930-2015 (Ref. 14) (camphor, musk, floral, peppermint, ether, vinegar, putrid and hydrocarbon);
e. odour rating: 0 (no odour), 1 (faint odour), 2 (distinct but not strong), 3 (strong odour), 4 (strong odour discernible in ambient air) and 5 (very strong odour very discernible in ambient air);
f. sample texture; and
g. presence of leachate.

4.4.5 Face protection was used at all times by the logging engineers and therefore, weaker odours may not have been detected.

Photograph 1 Sample forensic logging in the field laboratory.

4.4.6 Following this initial assessment, a detailed assessment comprised splitting the sample into 14 categories of waste components as specified on the landfill waste logging sheet **(Appendix D)** and each individual component weighed. Observations regarding the presence of potential asbestos containing material were carried out at this stage. The individual waste components would then be recombined, the sample re-weighed and re-bagged for storage on site before final disposal at completion of the ground investigation works. **Appendix D** further details the methodology for forensic waste logging and waste category methodology. The 14 waste categories used to characterise the samples are described in **Table 4.2.**

Table 4.2 Waste component categories (adapted from ASTM D5231-92)(Ref. 16)

Waste Component Categories	Description
Mixed paper	Office paper, computer paper, magazines, glossy paper, waxed paper and other paper not fitting the categories of newsprint and corrugated.
Newsprint	Newspaper.
Corrugated	Corrugated medium, corrugated boxes or cartons and brown (kraft) paper bags.

Waste Component Categories	Description
Plastic	All plastics – PET bottles, HDPE bottles, film, other plastics.
Garden waste	Branches, twigs, leaves, grass and other plant material.
Food waste	All food waste except bones.
Wood	Lumber, wood products, pallets and furniture.
Biological	Clinical waste, veterinary waste.
Other organics / combustibles	Textiles, rubber, leather and other primary burnable materials not included in above categories.
Construction waste	Concrete, brick, tiles, plaster, tarmac, bitumen.
Ferrous	Iron, steel, tin cans and bi-metal cans.
Aluminium	Aluminium, aluminium cans and aluminium foil.
Glass	All glass – clear, brown, green.
Other non-organics / non-combustibles	Rock, sand, soil, ceramics, non-ferrous non-aluminium metals (copper, brass), bones, ash, clinker, slag.

4.4.7 The results of the forensic waste analysis are presented in **Section 8.**

Quality Assurance of Forensic Assessment

4.4.8 Selected samples underwent additional forensic assessment in an external laboratory and the laboratory certificates are presented in **Appendix D.**

4.4.9 The methodology followed by the external laboratory split the waste components into seven groups listed below and some waste components were re-grouped in order to allow comparison of results (see **Table 4.3**):

a. visible cloth and leather;
b. other degradable material;
c. visible wood, branches, trees;
d. visible vegetation, grass, food waste;
e. visible metal, glass, ceramics and other inert material;
f. coarse inert particles, including gravel and concrete; and
g. fine soil including gravel < 10mm.

Table 4.3 Splitting of waste components according to the methodology adopted by the external laboratory and the methodology used in the field.

Laboratory Waste Components	Field Waste Components
Sum of two fractions: Visible cloth and leather Other degradable material	Mixed Paper
	Newsprint
	Corrugated
	Plastic

Laboratory Waste Components	Field Waste Components
	Other organics / combustibles
Visible wood, branches, trees	Wood
Visible vegetation, grass, food waste	Garden waste
	Food waste
	Biological
Visible metal, glass, ceramics, other inert material	Ferrous
	Aluminium
	Glass
Sum of two fractions: Coarse inert particles, including gravel and concrete Fine soil including gravel <10 mm	Construction waste
	Other inorganics

4.5 Ground investigation results

In-situ testing

4.5.1 Photoionisation Detector (PID) readings were undertaken during the GI, most locations within the landfill recorded a positive reading with a maximum recorded measurement of 346 ppm. Notable PID detections (above 50 ppm) are detailed in **Table 4.4** below and are shown on **Figure 11** of this document**.**

Table 4.4 PID readings above 50 ppm recorded during the GI.

Exploratory location	Depth (mbgl)	PID Result (ppm)
BH209	10.8	94.3
BH225	0.7	50.9
BH226	6.0	73.6
BH231	3.8	271.1
	4.35	64.9
BH233	3.8	298.0
WS221	1.4	346.0
WS224	3.6	185.6
TP217	3.0	71.0
	4.5	52.3
TP220	2.5	67.0
	4.5	56.4
TP223	4.5	67.1
TP228	2.5	370.2
TP237	4.5	254.8
TP261	4.5	51.2
	5.5	78.9
TP262	5.7	51.2

Exploratory location	Depth (mbgl)	PID Result (ppm)
TP268A	4.5	55.8
	5.4	89.0
TP269	3.5	52.8
	4.5	98.2
	5.4	102.8
TP274	2.5	50.1
	3.5	72.9
	4.5	97.3
	5.4	101.3
TP275	4.5	50.2
	5.4	82.8

Visual and olfactory contamination

4.5.2 Visual and olfactory observations of contamination from the GI are detailed in **Table 4.5** and shown on **Figure 11** of this document, with the exception of observations associated with degradation of organic waste in the landfill, which were widespread.

Table 4.5 Visual and Olfactory observations of contamination encountered during the GI.

Hole ID	Observation Type	Depth (mbgl)	Description
BH208	Visual and olfactory	9.0 – 11.5	Oily sheen and hydrocarbon odour
BH223	Visual and olfactory	4.9 – 6.25	Oily sheen and faint putrid odour
BH224	Visual and olfactory	1.0 – 1.7	Oily sheen and strong musk and hydrocarbon odour
	Visual	6.0 – 7.0	Oily sheen
BH228	Visual and olfactory	7.0 – 7.5	Oily sheen and distinct putrid and hydrocarbon odour
BH231	Visual and olfactory	4.0 – 4.5	Oily sheen and strong ether and hydrocarbon odour
TP268	Visual	0.7	Barrel containing free product
WS224	Visual	4.0 - 5.0	Heavy black staining between 4.0 - 5.0mbgl and oily sheen on perched water surface

Groundwater Levels

4.5.3 Following the GI fieldwork, groundwater level monitoring was undertaken from July to October 2018 and from December 2018 to March 2019. Six rounds of monitoring were completed on each of the wells. Generally, the groundwater levels were recorded between 30 – 43m bgl beneath the landfill. **Table 4.6** below records the monitoring results of groundwater levels within the Chalk.

Table 4.6 Groundwater levels within the Chalk during monitoring.

Hole ID	Date	Depth (m bgl)	Level (m AOD)
GW201	07/08/2018	30.64	111.01
	23/08/2018	30.6	111.05
	04/09/2018	31.12	110.53
	18/09/2018	31.70	109.96
	01/10/2018	31.86	109.79
	16/10/2018	32.13	109.52
	14/06/2019	29.22	112.43
GW202	07/08/2018	35.36	111.44
	23/08/2018	35.18	111.62
	04/09/2018	35.68	111.12
	18/09/2018	36.31	110.49
	01/10/2018	36.44	110.37
	16/10/2018	36.9	109.90
	14/06/2019	35.3	111.50
GW203	07/08/2018	41.8	110.65
	23/08/2018	41.76	110.70
	04/09/2018	42.26	110.19
	18/09/2018	42.84	109.61
	01/10/2018	42.03	110.42
	15/10/2018	42.4	110.05
	14/06/2019	41.07	111.38
GW204	07/08/2018	41.84	112.06
	23/08/2018	41.98	111.93
	04/09/2018	42.09	111.81
	18/09/2018	42.59	111.31
	01/10/2018	42.91	110.99
	18/10/2018	43.33	110.57
	14/06/2019	43.73	110.17
GW205	07/08/2018	41.91	111.29
	23/08/2018	42.09	111.12
	04/09/2018	42.25	110.95
	18/09/2018	42.76	110.45
	01/10/2018	43.1	110.10
	16/10/2018	43.21	109.99
	14/06/2019	44.78	108.42
GW206	14/01/2019	42.25	113.41
	21/01/2019	42.92	112.74
	07/02/2019	43.71	111.94
	18/02/2019	43.11	112.55
	05/03/2019	43.6	112.05

Hole ID	Date	Depth (m bgl)	Level (m AOD)
	21/03/2019	43.18	112.47
	14/06/2019	43.46	112.19
GW207A	15/01/2019	38.28	116.57
	05/02/2019	39.99	114.86
	07/03/2019	39.81	115.04
	21/03/2019	39.19	115.66
	14/06/2019	40.97	113.88

Leachate

4.5.4 Nine leachate monitoring wells are located within the landfill as shown on **Figure 10** of this document**.** During 2018 leachate levels were monitored to assess the thickness of leachate that was being generated by the decomposition of landfill waste. The monitoring results are summarised in **Table 4.7** below.

4.5.5 Leachate is recorded to have accumulated in all installations with the exception of LF-BH07 which was dry on all monitoring visits. LW201, LW204, LF-BH06 and LF-BH12A have consistently recorded the greatest thickness of leachate (>0.9 m on average).

Table 4.7 Summary of leachate measurements.

Location	Leachate thickness (m)		
	Minimum	Maximum	Mean
LW201	1.085	2.04	1.63
LW202	0	1.91	0.66
LW203	0	0.37	0.13
LW204	0.58	1.13	0.91
LW205	0.05	1.28	0.83
LF-BH06	0.9	4.22[1]	1.53
LF-BH07	0	0	0
LF-BH09	0	0.17	0.04
LF-BH12A	0.33	2.11	1.37

Note:
[1] The maximum leachate thickness recorded in LF-BH06 in December 2018 appears to be an erroneous result, on all other occasions the leachate thickness in this well ranged between 0.9m and 2m

Gas monitoring

4.5.6 Gas spot monitoring was undertaken between August to October 2018 and January to March 2019. Monitoring periods consisted of six rounds, every fortnight. In addition to the dedicated gas installations, boreholes with groundwater standpipes were included as part of the monitoring.

4.5.7 The readings were undertaken during periods of both high and low pressure (>/<1000mb). A summary of the range of gas concentrations and flow rates detected is summarised below in **Table 4.8**.

Table 4.8 Summary of the range of gas concentrations and flow rates from the post fieldwork monitoring.

Property	Result	Location of Max Result
Within Landfill Boundary		
Peak flow rates (l/hr)	<0.1 – 0.9	BH217
Peak Methane (% v/v)	0.1 – 80.6	WS224
Peak Carbon Dioxide (%v/v)	0.1 – 60	BH223
Minimum Oxygen (% v/v)	0 – 21.3	BWS217
Peak Hydrogen sulphide (ppm)	0 – 7	WS212
Outside Landfill Boundary		
Peak flow rates (l/hr)	<0.1 - 0.2	BBH204
Peak Methane (% v/v)	0 - 54.4	BWS211
Peak Carbon Dioxide (%v/v)	0.1 - 29.7	BWS211
Minimum Oxygen (% v/v)	0.1 - 21.5	BWS218
Peak Hydrogen sulphide (ppm)	0 - 1	BWS203
Notes: Only positive flows rates are reported in this table. Negative flow rates were encountered and are discussed further in **Section 12.**		

Soil vapours

4.5.8 Soil vapour samples were obtained from a total of 28 boreholes LF-BH12A, LF-BH10G, LF-BH08G, LF-BH05G, LF-BH03G, LF-BH04G, LF-BH09, LF-BH07, LF-BH06 and LF-BH02 (long-term monitoring wells), BH201, BH203, BH204, BH207, BH213, BH219, BH220, BH226, BWS203, BWS213, BWS2016, WS206 (WVP) and BH216, BH222, BH223, BH232, BWS217, WS224 (LTCP), which were tested in the laboratory for the following:

a. bulk gases i.e. methane, carbon dioxide, oxygen;
b. speciated volatile organic compounds (VOCs);
c. odorant gas analysis (hydrogen sulphide);
d. C1-C7 hydrocarbons (alkanes & alkene);

e. total petroleum hydrocarbon (TPH) in gas samples (aliphatic and aromatic C4 to C12); and

f. dioxins and furans.

4.5.9 The limit of detection (LOD) varies for each determinand and between borehole samples due to dilutions needed to be conducted on the samples**. Table 4.9** below summarises the results where values above LOD were recorded. The total number of tests was 75 for each contaminant unless otherwise stated.

Table 4.9 Summary of soil vapour sample results.

Contaminant	CAS No.	Min.	Max.	No. above LOD/ (total number of tests)
		µg/m^3		
1,1,1-Trichloroethane	71-55-6	46.9	490	3
1,1,2,2-Tetrachloroethane	79-34-5	15.7	1300	6
1,1,2-Trichloroethane	79-00-5	46.5	1220	7
1,1-Dichloroethane	75-34-3	27.5	300	4
1,1-Dichloroethene$^+$	75-35-4	27	68.8	3 (93)
1,2,3-Trimethylbenzene$^+$	526-73-8	10.2	1020	10 (83)
1,2,4-Trichlorobenzene	120-82-1	10.5	5920	16
1,2,4-Trimethylbenzene$^+$	95-63-6	6.91	48.7	9 (93)
1,2-Dibromoethane	106-93-4	44.8	44.8	1
1,2-Dichlorobenzene	95-50-1	9.94	45	2
1,2-Dichloroethane	107-06-2	42.7	42.7	1
1,2-Dichloropropane	78-87-5	44.6	44.6	1
1,2-Dichlorotetrafluoroethane	76-14-2	16	10200	19
1,3,5-Trimethylbenzene$^+$	108-67-8	9.3	2200	18 (93)
1,3-Butadiene	106-99-0	100	100	1

Contaminant	CAS No.	Min.	Max.	No. above LOD/ (total number of tests)
		µg/m³		
1,4-Dichlorobenzene	106-46-7	26.5	588	5
1-Propanol	71-23-8	3.52	3.52	1
2-Butanone (MEK)	78-93-3	4.26	171	6
2-Pentanone	107-87-9	1010	1010	1
3-Pentanone	96-22-0	811	811	1
4-Methyl-2-pentanone	108-10-1	48.2	434	4
Acetone+	67-64-1 & 123-38-6	15.4	4000	16
Acetonitrile	75-05-8	5.5	4840	12
Acrolein	107-02-8	9.96	371	2
Benzene*	71-43-2	5.69	1040	38 (88)
Bromomethane	74-83-9	17.6	17.6	1
Carbon Disulphide	75-15-0	6.43	783	18
Carbon Tetrachloride	56-23-5	64.3	64.3	1
Chloroethane	108-90-7	31.4	1220	14
Chlorobenzene	75-00-3	34.6	34.6	1
Chloroform	67-66-3	23	134.3	3
Chloromethane	74-87-3	121	121	1
cis-1,2-Dichloroethene	156-59-2	17	571	12
cis-1,3-Dichloropropene	10061-01-5	30.4	30.4	1

Contaminant	CAS No.	Min.	Max.	No. above LOD/ (total number of tests)
		µg/m³		
Cyclohexane	110-82-7	8.2	2810	32
Dichlorodifluoromethane	75-71-8	11.5	2580	25
Difluorochloromethane	75-45-6	5.11	20100	32
Ethylbenzene*	100-41-4	5.84	5330	31 (90)
Hexachlorobutadiene+	87-68-3	15.5	107	5 (83)
Hexanal	66-25-1	5.65	116	5
Hexane	110-54-3	9.9	6320	35
Hydrogen Sulphide	7783-06-4	0	13500	79 (600)^
Isobutene	115-11-7	3.65	328000	43
m/p-Xylene*	108-38-3 & 106-42-3	8.51	101000	54 (90)
Methacrolein	78-85-3	10.9	55	3
Methylene Chloride	75-09-2	7.11	703	7
Naphthalene		9.54	15	3 (90)
o-Xylene*	95-47-6	6.02	2070	25 (90)
Pentanal	110-62-3	8.24	290	2
Pentane	109-66-0	5.67	13600	36
Styrene	100-42-5	7.7	28.4	3
Tetrachloroethene +	127-18-4	8.9	273	20 (90)
Toluene*	108-88-3	6.47	2060	34 (93)
Trans-1,2-Dichloroethene	156-60-5	7.5	18.6	2

Contaminant	CAS No.	Min.	Max.	No. above LOD/ (total number of tests)
		µg/m3		
trans-1,3-Dichloropropene	1006-02-6	26.8	26.8	1
Trichloroethene	79-01-6	9.1	1080	5
Trichlorofluoromethane	75-69-4	11.8	1420	16 (93)
Trichlorotrifluoroethane	26523-64-8	90.2	90.2	1
Vinyl Acetate	108-05-4	11.5	1180	5
Vinyl Chloride	75-01-4	11.5	1730	13
p-Isopropyltoluene+	99-87-6	28	73	2 (41)
Dimethyl sulphide+	75-18-3	140	140	1 (31)
Ethyl Mercaptan+	75-08-1	91	91	1 (31)
Isopropyl benzene+	98-82-8	33	33	1 (41)
Sec-Butylbenzene+	135-98-8	18	18	1 (41)
Acetaldehyde+	75-07-0	20	50	6 (35)
Formaldehyde+	50-00-0	30	50	3 (35)
Arsenic+	7440-38-2	200	200	1 (35)
Mercury+	7439-97-6	1.3	1.3	1 (35)

Notes:
* Dataset includes additional results from TPH in Gas Suite
+ alternative suite A, 4 sets of results for long-term monitoring wells only, concentration calculated by laboratory from ng
^ includes results from spot monitoring and odorant gas suite

5 GROUND CONDITIONS

5.1 General

5.1.1 A 3-dimensional (3D) ground model of the area to assist the understanding of the Main Application Site was developed (Ref. 3). The 3D ground model has been developed by collating information from a range of data sources, including:

a. photogrammetry data at 5 m resolution;
b. topographical survey of the site;
c. historical aerial photographs;
d. historical maps;
e. GIs undertaken at the site; and
f. forensic logging of waste material within the landfill.

5.1.2 This model has been updated to include all additional ground investigation data. The most recent version includes data from the preliminary 2016/17 investigations as well as data from the 2019 ground investigation. Cross sections showing the geology and proposed development are shown on **Figure 12** and **13** of this document.

5.1.3 The model has been used to inform the ground conditions presented in the following sections and the risk assessments presented in **Section 10**.

5.2 Stratigraphic sequence

5.2.1 The strata encountered during the ground investigation are detailed in **Table 5.1.** The ground investigation data and Arup's model broadly confirm the published geology and previously encountered conditions from historical GIs identified in the PRA.

Table 5.1 General geology of the site.

Material Name	Typical Description	Typical Thickness (m)
Topsoil	Generally stiff gravelly sandy clay. The gravel comprises flint, chalk, brick, concrete and clinker.	Average of 0.3m in 'undeveloped' areas of the Development Area.
Made Ground (General)	Typically, arisings from past airport projects, but also includes the construction of car parks.	Generally <1.0m but up to 6 m to the immediate south of the landfill and up to 20m beneath the proposed Airport Access Road along the Dairyborn Escarpment.
Made Ground (Landfill)	Mixed domestic, commercial and construction/demolition waste	Up to 20m.

Material Name	Typical Description	Typical Thickness (m)
	deposited between the 1930s and 1980s.	
Dry Valley Deposits	Silty clay and gravel.	2m within the valley bottom.
Head Deposits	Clay associated with the weathering of material in the valley sides and floor.	2m (but up to 5m in places) in the valleys.
Clay-with-Flints	Highly plastic clay containing flint gravel.	3m (but up to 7m in places) on the plateau occupied by the existing airport. Absent in the valley areas.
Chalk	Chalk – weathered near the surface.	Full thickness not proven.

5.2.2 Each stratum within the ground model and in the wider proposed development are described in more detail below:

Made Ground

5.2.3 Made Ground is generally >1m in thickness across most of the proposed development, with the exception of the following areas where significant thicknesses were encountered (see **Figure 3** of this document for location of Areas):

a. **Area A**- the former landfill covers most of Area A, with waste up to of 20+ m above the base of the valley. The nature of the landfill material is further discussed in detail in **Section 8**;

b. **Existing airport land (LLAOL Contractor Compound)**- Made Ground was observed to be up to 10m in thickness within the area to the south of the landfill. This material is understood to be the arisings from previous development across the airport and is material that is being temporarily stored in this area (Ref. 17). It is understood that this fill material was imported as part of the development of the runway and levelling of the area;

c. **Airport Access Road** - significant depth of Made Ground encountered at Airport Way up to 20.0 m associated with the Dairyborn escarpment. This lies directly onto the underlying chalk bedrock in places; and

d. **Areas D and E** - historical mapping suggests a significant amount of fill has been imported onto Area D to form an earthwork platform; the platform was built out from the existing slope. The volume of the material deposited is estimated to be 62,000 m^3, with a maximum fill depth of 15 m. Aerial photography indicates that this fill is likely to date from the mid-1950s and is predominately chalky in nature. The origin of this material is unknown, however, the aerial photography suggests excavations were occurring in a number of areas in the vicinity of the site at the time of its deposition. In Area E, historical mapping, aerial photography and current topography suggests that up to 10 m of fill has been placed in parts of the site. The age and origin of the material is unknown but aerial photography and historical mapping suggest it may have been placed during the 1940s.

Landfill

5.2.4 A detailed review of the records pertaining to the landfill was undertaken previously (Ref. 1) which indicated that the landfill is not as extensive as the Environment Agency boundary. The GI observed that the north-eastern extent of the agency boundary comprises of natural strata (see **Figure 3** of this document).

5.2.5 The landfill has filled the head of the dry chalk valley and the waste thickness reflect this, with thicker areas above the base of the valley (20+ m) and the thinner deposits towards the sides (4m – 5m).

5.2.6 The history of filling was previously estimated as part of assessment work on the landfill. The estimated filling history has been updated with the recent GI data combined with the following information:

a. Photogrammetry observations of waste deposited at different periods;
b. Dates recorded on waste material during the recent GI works;
c. Observations of the nature of material from the recent GI works; and
d. Structure of the landfill developed in the ground model.

5.2.7 The estimated order and extent of filling is shown in **Figure 14** of this document and the estimated volume placed during each era of filling is provided in **Table 5.2.**

5.2.8 Detailed discussion of the characteristics of the waste and the variation between different periods of filling is presented in **Section 8.**

Table 5.2 Volumes deposited during waste filling periods

Period of filling	Estimated volume in landfill (m^3)	Typical components of this era of filling
Pre 1947	190,000	Ash/fines, wood, metal, fabric, rubber, ceramic, brick and glass.
1947 – 1955	350,000	Ash/fines, wood, metal, fabric, rubber, ceramic, brick and glass.
1955 – 1960	580,000	Ash/fines, wood, metal, fabric, rubber, ceramic, brick and glass.
1960-1970	520,000	Ash/fines, wood, metal, fabric, rubber, ceramic, brick and glass Later 60s waste include plastic components

Period of filling	Estimated volume in landfill (m^3)	Typical components of this era of filling
1970-1980	2,500,000	Brick, tile, concrete, polystyrene, paper, plastic, cans and food waste, cardboard, metal, rubber and glass.
Post 1980	150,000	Non-landfill material. Fill material placed post closure of landfill on LTCP area to create a suitable surface for use as a car park.
Total	**4,400,000**	

5.2.9 Further detailed description of the waste types encountered within the landfill is provided in **Section 8**.

5.3 Superficial deposits

5.3.1 The distinction between Clay-with-Flints, Head and Dry Valley Deposits has been made both by examining ground investigation logs and an understanding of where each of these materials should be present. Clay-with-Flints would have covered the entire development area, however the incision of the valley into the chalk would have eroded these deposits completely from the valley floor. Weathering of the remaining Clay-with-Flints on the valley sides resulted in Head deposits with some of this material eroding and deposited at the valley floor, forming Dry Valley Deposits. Further description of the superficial deposits is provided below.

Dry Valley deposits

5.3.2 These deposits have been mapped by the BGS and are anticipated to be present in the valley floor throughout the proposed development.

5.3.3 These deposits are formed by a combination of processes including the weathering of the chalk bedrock under periglacial conditions, input of material supplied from the valley sides by solifluction and a degree of fluvial reworking by surface water.

5.3.4 The Dry Valley Deposits are typically described as firm to stiff (occasionally soft) light brown, dark brown, orangish brown, reddish brown or greyish brown slightly sandy, slightly gravelly clay. Rarely it is present as sandy, slightly gravelly, clayey silt; very clayey, very sandy gravel or slightly silty, slightly gravelly sand. The gravel is recorded as flint and occasionally chalk and subangular to subrounded cobbles of flint are frequently present.

5.3.5 The 2016 ground investigations (Ref. 6)(Ref. 7)(Ref. 8)(Ref. 9) confirmed their presence within the valley bottom in Area B, between 0.7m and 2.1m thick.

Head

5.3.6 Head is present on the valley sides of the two dry valleys present within the development area.

5.3.7 The Head is typically described as firm to very stiff (occasionally soft) light brown, dark brown, orangish brown, reddish brown or greyish brown slightly sandy, slightly gravelly clay. Rarely it is present as slightly sandy, slightly gravelly, clayey silt. The gravel is recorded as flint and chalk (occasionally chert). Subangular to subrounded cobbles of flint are frequently present.

Clay-with-flints

5.3.8 This formation overlies the chalk group and is a residual soil formed by the solution weathering of the chalk. The Clay-with-Flint Formation comprises stiff reddish brown slightly sandy gravelly clay with a medium cobble content. The gravel is angular to rounded and comprises flint gravel and occasional chalk.

5.3.9 The Clay-with-Flints varies in thickness across the development area. It is mainly present on the plateau (typically 3-5 m in thickness) and valley sides however, is absent from the base of the valley. Previous GI has indicated it is typically 3.7 m thick across the Proposed Development area but has been recorded up to 15 m thick. This reflects the irregular dissolution contact between the Clay-with-Flints and the Chalk group. The GI completed along the proposed Airport Access Road alignment recorded Clay-with-Flints beneath the Made Ground from 0.5m bgl up to 7.45m bgl beneath the industrial areas on the existing airport land but is generally absent at the western extent along the Dairyborn Escarpment where there is a greater depth of Made Ground.

5.4 Chalk

5.4.1 The bedrock beneath the proposed development consists of Cretaceous Chalk (undifferentiated Lewes Nodular and Seaford Chalk formations). These are classified as being part of the “Upper Chalk” and are composed of firm and hard chalk strata with common nodular and tabular flints and hardgrounds.

5.4.2 These in turn are underlain by the Holywell Nodular and New Pit Chalk formations, part of the “Middle Chalk” which outcrop within the dry valleys. These are generally similar in composition to the Upper Chalk formations but are generally flintless.

5.4.3 The Chalk is unusual compared to many other limestones, due to its almost entirely biogenic origin. In general, the Chalk is extremely fine grained (<10μm), soft and micritic[2]. Coccoliths and other microfossils such

[2] A rock texture characterised by a very fine-grained matrix of limestone and microfossils

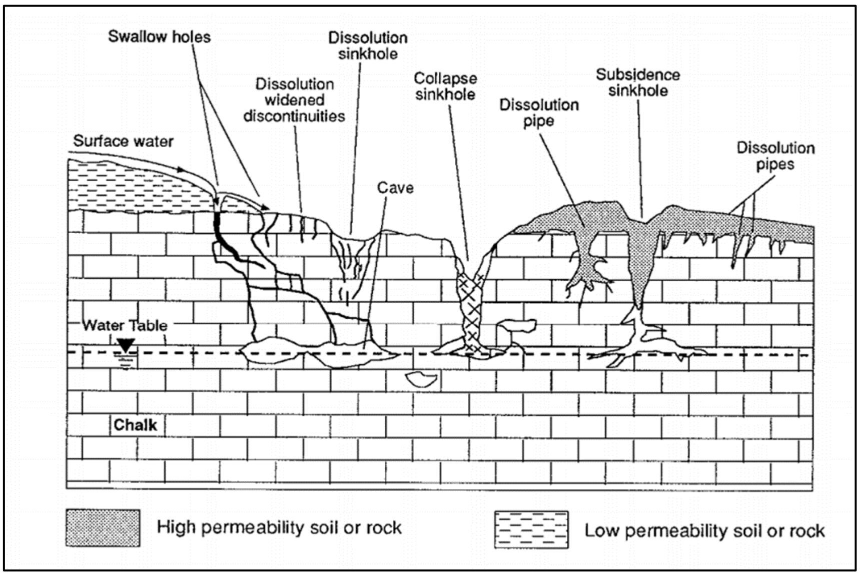
as foraminifera and calcispheres[3] make up a notable quantity of the matrix.

5.4.4 The condition of the chalk encountered during the GI beneath the Proposed Development area is variable. GI undertaken in Areas A, B and the Airport Access Road indicated that the upper levels of the chalk was heavily weathered and it was generally recovered as structureless sandy very silty gravel or sandy gravelly silt (Grade Dm) (Ref. 18). The depth of weathering is variable with different grades of chalk present up to Grade A (Ref. 18) at depth. This was generally present as very weak low or medium density white chalk.

5.5 Solution features

5.5.1 Solution features are formed by the dissolution of the Chalk as a result of chemical weathering. These features are present at the interface between the Clay-with-Flints formation and the Chalk. As such, these are predominately present where Clay-with-Flints formation is present such as the plateau and valley side but less frequent in the base of the valley. The types of solution features which can be encountered are shown in **Drawing 2**.

Drawing 2 Schematic illustration of common dissolution types (based on Applied Geology, 1993 (Ref. 19) as cited in CIRIA C574 (Ref. 20).



5.5.2 It is difficult to detect solution features via ground investigation, as they are discrete features. Site investigation and observations from local construction projects suggest that fretting is a ubiquitous feature of the top of the chalk and that pipes features, like those exposed by the Direct Air to Rail Transit (Luton DART) excavations, are frequent as shown in **Photograph 2.** The Luton DART is a new cable-hauled fast passenger

[3] Fossilised carbonate structures secreted and left behind by microscopic organisms

transit connecting Luton Airport Parkway station to the airport (to be officially announced in early 2023)

Photograph 2 Left: Irregular fretting of the top of the chalk in an excavation for Luton DART Right: Possible solution features noted during Luton DART excavation works.

5.5.3 It is also likely that sinkholes of the type illustrated in **Drawing 2** are present in the area. The GI undertaken did not find any evidence of sinkholes but solution pipes and infilled fissures were found to be present beneath Area A (former landfill) and Area B. These features are important when considering potential pathways for contaminants to the groundwater, however they are difficult to detect through ground investigation and predict in terms of both location and frequency.

6 HYDROGEOLOGICAL CONDITIONS

6.1.1 A detailed review of the hydrogeological conditions beneath the site, has been undertaken (areas within the Mimram catchment) and is provided in the following report:

- Luton Rising (2022) Hydrogeological Characterisation Report. LLADCO-3B-ARP-00-00-RP-CG-0001 (Ref. 21).

6.1.2 The following sections are a summary of the information provided within the report.

6.2 Regional

6.2.1 The main water bearing strata in the region is the Chalk which is a dual-porosity aquifer where the matrix provides the storage and the fractures provide permeable pathways (Ref. 22). Most of the flow in the Chalk in the area is likely to occur in a few dilated fractures, typically occurring at or within a few tens of metres of the water table through dissolution enhanced features. However, it is often influenced by the presence of solution features in the chalk which can lead to interlinkages between groundwater catchments (Ref. 23).

6.2.2 The regional groundwater flow within the Chalk is predominantly towards the southeast in the dip direction of the Chalk. The main area of groundwater recharge is the Chiltern Hills along the northern boundary of the area where the escarpment forms a major groundwater divide (Ref. 22). The regional flow system is likely to be locally influenced by abstraction of groundwater from the aquifer, the nearest potable water supply borehole is located at King's Walden approximately 1.5km northeast of the Main Application Site (2.8 km northeast of the landfill boundary).

6.2.3 There are two main water body catchments which cover the Luton area; the Lee and the Mimram catchments. The former landfill (Area A) lies in the Mimram catchment and there is a groundwater divide to the west, where the airport lies in the Lee catchment. Groundwater flow direction in the Lee catchment is influenced by local abstraction and flows in a westerly direction. Abstractions are identified on **Figure 7** of this document, in the Lee catchment these are generally for industrial use and clustered around the former Vauxhall Motor Works, two private water supplies are located south of the River Lee, a second potable supply operated by Affinity Water and a supply for commercial and domestic purposes. The groundwater flow in the Mimram catchment is affected by the potable abstraction near Kings Walden (Ref. 22) and a second potable water abstraction (Nine Wells) at Whitwell, east of the former landfill. Both may create a more easterly flow direction than the south easterly regional flow.

6.2.4 Two private water supplies are located east of the site. The abstractions are located approximately 1.5km northeast and 1.2km south east of the

Main Application Site (2.7km northeast and 2.6km south east of the landfill boundary) within the Mimram catchment, see **Figure 7** of this document.

6.3 Groundwater levels and flow

Observed levels

6.3.1 Groundwater levels in the chalk within the Mimram catchment (underlying Area A-Former Landfill) have been measured in the boreholes installed during the most recent GIs. Recorded groundwater elevations have been contoured and are shown in **Figure 15** of this document**.** The groundwater elevations beneath the landfill are typically 112m AOD (40m bgl) and range between 17.5m to 36m below the base of the landfill.

6.3.2 The highest groundwater level recorded beneath the site was in June 2018 at 124.46m AOD at LF-BH05 located to the southwest of the landfill. This is consistently higher than the levels recorded beneath the remainder of the landfill. It is possible that the groundwater levels in this borehole are being influenced by the presence of a nearby soakaway in the airport (the Central Soakaway) which is artificially increasing water levels in this borehole.

6.3.3 There are several soakaways present on-site within the airport, see **Figure 8** of this document for locations. These are expected to cause local increases in groundwater levels, however are unlikely to directly influence the location of the main groundwater divide in the area.

6.3.4 The groundwater surface is lower in the south east of the Main Application Site beneath the base of the valley floor, at approximately 106m AOD (14m below the level of the valley floor).

6.3.5 Groundwater levels within the Lee catchment have been recorded as part of post fieldwork monitoring for the Luton DART (Ref. 24). The monitoring data indicates groundwater levels to be around 110m AOD beneath the existing airport land, (42m bgl) and dropping to 99m AOD beneath the Parkway Station and western end of Airport Way, approximately 39m bgl and 12m bgl respectively. The groundwater is much shallower at the Parkway Station due to the fall in ground levels to the southwest of the airport.

6.3.6 Based on these groundwater levels, the groundwater flow direction, close to the former landfill, is generally east-northeast with a flow divide located to the south and west of the landfill site beyond which groundwater flows in a southwesterly direction beneath the airport toward the River Lee.

6.3.7 The observed levels and flow direction correlate with the assumption that the flow system near the site is locally modified by abstraction of groundwater from the Chalk aquifer. The nearest potable water supply borehole is located approximately 2.8km northeast from the landfill at Kings Walden. A second potable water abstraction (Nine Wells) is located at Whitwell, approximately 4.5km east of the Main Application Site and

5.3km east of the former landfill. Both appear to be influencing a more easterly flow direction than the anticipated southeasterly regional flow.

Seasonal variability

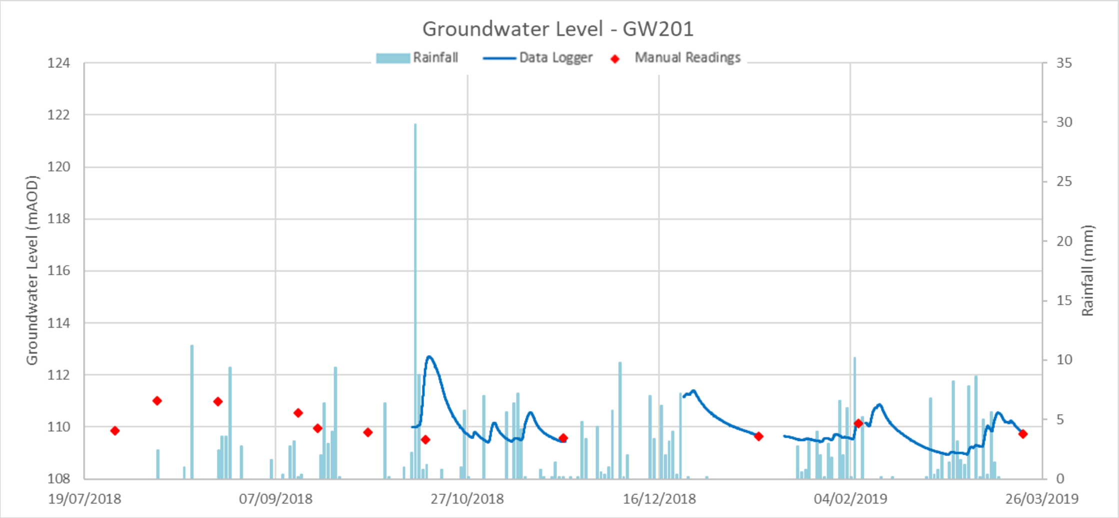
6.3.8 The groundwater levels recorded to date indicate that the valley that the former landfill lies within is dry, with no seasonal emergences. The numerous site walkovers undertaken in the area support this and no indications of any emergence of groundwater in the base of the valley have been observed e.g. marshy areas. The nearest point at which groundwater is known to emerge is at the River Mimram, northwest of Whitwell, approximately 4km to the southeast of the site.

6.3.9 As there are no surface water features in the vicinity of the site the recharge to the underlying Chalk aquifer is almost entirely from infiltration of precipitation, either naturally through soils in the undeveloped areas, or more focused through several on-site engineered infiltration basins.

6.3.10 The anticipated low permeability of the Clay-with-Flints deposit, as well as hardstanding areas associated with the airport, may limit rainfall infiltration and therefore recharge to the underlying Chalk aquifer. Recharge is likely to occur to the Chalk aquifer where there is an absence of these low permeability deposits, such as where the Chalk is exposed in the dry valleys.

6.3.11 Observed groundwater levels show a seasonal response to rainfall. Groundwater levels recorded by data loggers installed on the Main Application Site during 2018 show a relatively rapid response in groundwater levels following a high rainfall event as shown in **Drawing 3.**

Drawing 3 Groundwater levels recorded in GW201 compared to rainfall.



6.3.12 The groundwater levels recorded below the landfill from January 2018 to December 2018 show a maximum seasonal variation of 10.94 m, this was observed in borehole LF-BH04 between January and June 2018. This is due to a high groundwater level reading taken in June 2018 that is dissimilar to all other readings at this location and is considered to be anomalous. The next highest seasonal variation observed is 7.6 m within LF-BH05.

6.3.13 Larger seasonal and year-to-year variations in groundwater levels were observed beneath the landfill area than within the dry valley (part of the Century Park development ground investigation). Within the dry valley, most of the boreholes display a seasonal variation, between January and December 2018, of less than 5 m. The largest seasonal groundwater variation recorded was 5.22 m in CP-BH24. Though, due to the lower topographical elevation within the dry valley, groundwater levels are closer to surface (15 m bgl to 35 m bgl). This variation of fluctuation related to topography is common in the Chalk aquifer.

6.3.14 The variability in groundwater levels recorded during 2018 supports outputs from the Environment Agency's Hertfordshire Chalk regional groundwater model, suggesting that the likely seasonal range in groundwater levels is approximately 5m to 10m in the vicinity of the landfill, and up to a maximum 5 m variation within the dry valleys. The minimum and maximum groundwater levels recorded in May 2017 and June 2018 are contoured in **Figure 15** of this document.

6.3.15 The majority of the groundwater monitoring completed within the Main Application Site is of limited duration and provides a short-term, non-continuous dataset of the groundwater levels and as such is unlikely to recorded extreme minimum and maximum groundwater events. A detailed assessment of potential maximum groundwater levels which might be expected to occur on site has been undertaken and is reported separately (Ref. 21). The report concluded that absolute maximum groundwater levels are expected to range from 134m AOD in the centre of the groundwater divide, west of the landfill, to 112m AOD in the dry valleys.

6.4 Aquifer properties

6.4.1 The Chalk is confined in some areas of the site by low permeability deposits such as the Clay-with-Flints and Head Deposits. Rainfall infiltration and recharge into the underlying Chalk aquifer may be limited in these areas (Ref. 23). As a result, the background chemistry between areas of confined and unconfined Chalk varies. In addition, areas where the Chalk aquifer is unconfined are more susceptible to pollution, in particular diffuse pollution from agricultural or domestic sources (Ref. 23).

6.4.2 The ability of groundwater to flow (transmissivity) within chalk is complex and is heavily influenced by the presence and geometry of fractures. Literature has noted the following important features of the fractures which affect the hydraulic properties of the chalk (Ref. 25).

6.4.3 The fracture density is generally thought to peak at about 20 mbgl; productive fractures decrease with depth. It is generally accepted that productive fractures are restricted to the upper few tens of metres of the aquifer (circa 50m).

6.4.4 Fractures are both horizontal and vertical.

6.4.5 The fractures can be termed primary and secondary fissures. Primary are the ubiquitous narrow fractures which have a typical hydraulic conductivity of the order of 0.1 m/d (1.2 x10-6m/s) and contribute a transmissivity of 20m2/d to the aquifer. The secondary fractures are the solution enlarged fractures and they contribute the remaining transmissivity of the aquifer, often more than 1000m2/d. The transmissivity of the matrix is generally negligible.

6.4.6 The matrix of the chalk does not contribute directly to the permeability, but it has an important role in providing water to the fractures.

6.4.7 The areas of highest transmissivity generally tend to be beneath valleys, with the highest values in the unconfined chalk.

6.4.8 Aquifer properties are also strongly controlled by lithology, with hard bands of chalk rock having increased permeability as a result of associated fracturing.

6.4.9 It is further complicated by the weathered top of the chalk, which is often referred to as ‘putty chalk’, where the chalk is structureless and forms a clayey silt. This material can have significantly lower hydraulic conductivity reducing the transmissivity of the aquifer. The travel time within the putty chalk horizon is estimated to be between 2-15 times slower than in the main Chalk (Ref. 25).

6.4.10 Packer testing was undertaken as part of the 2018 GI to inform the permeability of the Chalk aquifer beneath the site. Packer testing was undertaken at regular intervals in the Chalk strata in seven boreholes (GW201-GW207 inclusive and GW207a). The permeability results were variable with some tests displaying behaviour characteristic of a high conductivity system. These higher values are likely to be a result of interception of low frequency but high permeability fissures.

6.4.11 The packer test data has been separated in to 20 m intervals from below the top of chalk to observe the variation in hydraulic properties with depth, the averages for each interval are shown in **Table 6.1.**

Table 6.1 Hydraulic conductivity with depth from top of Chalk.

Depth from top of Chalk (m)	Mean hydraulic conductivity (m/s)	Geometric mean hydraulic conductivity (m/s)
0 – 20	2.37×10^{-5}	1.30×10^{-6}
20 – 30	8.04×10^{-6}	3.65×10^{-6}
30 - 40	6.00×10^{-6}	7.00×10^{-7}
40 – 52	3.36×10^{-7}	2.38×10^{-7}

6.4.12 The results from this analysis fit the conceptual model of the permeability of the Chalk from regional information. The results of the packer tests indicate a decrease in hydraulic conductivity with depth, with the higher conductivities likely to be associated with the secondary fissures formed from dissolution around the water table fluctuations within the top 20 m of the Chalk.

6.5 Background groundwater quality

6.5.1 The background chemical quality of groundwater in the vicinity of Luton is known to be poor because of a "low level halo" of solvent contamination due to the long history of industrial sites in the area. Published information indicates no single source of the pollution has been identified and it was attributed to widespread diffuse pollution with some 'hotspots' of high concentrations. Clean up of the aquifer was not considered a practical option and therefore treatment of the groundwater at abstraction points was adopted instead (Ref. 26).

6.5.2 A baseline report is available for the Chalk of the Colne and Lee river catchments as well as information on the contamination of the Chalk aquifer by chlorinated solvents (Ref. 26). This report indicates that a wide variety of contaminants including nitrate, ammonia, pesticides, bromate, hydrocarbons and solvents have been detected in the Chalk between the River Colne and the River Lee. The data in the report is for the Lee catchment, however there may be interlinkages between the catchments through solution features as discussed above and as such, may also be relevant for the Mimram catchment.

6.5.3 A comparison of literature values for groundwater quality for selected determinants within the Lee catchment are summarised in **Table 6.2**. The data is compared to groundwater quality data obtained from groundwater wells installed within the Chalk across the Airport which lies within the Lee catchment, these samples were obtained during ground investigations completed in 2016 and 2017. Background groundwater quality from the Mimram catchment obtained during the 2018 GI from two wells installed up-hydraulic gradient of the landfill (GW201 and GW202) is also summarised.

Table 6.2 Comparison of typical background concentrations of determinants in groundwater in the aquifer in the Luton area to site monitoring data for the Lee and Mimram catchments.

Determinand	Units	Literature Values		Groundwater samples			
		Lee catchment		Lee catchment		Mimram catchment (up-gradient of landfill)	
		Min	Max	Min	Max	Min	Max
Calcium	mg/l	17	205	71	208	106	119
Magnesium	mg/l	1.7	113	2.2	8.7	2.42	4.07
Sodium	mg/l	6	589	7	83	40.3	51
Potassium	mg/l	0.8	28.5	<1	6	1.44	4.63

Determinand	Units	Literature Values		Groundwater samples			
		Lee catchment		Lee catchment		Mimram catchment (up-gradient of landfill)	
		Min	Max	Min	Max	Min	Max
Chloride	mg/l	14	1,250	12	122.86	62.3	108
Sulphate	mg/l	5	562	13.1	173	11.6	33.6
Nitrate	mg/l	<0.01	11.2	<0.07	21.9	<0.07	1.18
Nitrite	mg/l	<0.001	0.053	<.03	0.49	<0.02	0.27
Ammoniacal nitrogen	mg/l	<0.003	1.66	<0.015	0.3	<2	0.433
Arsenic	µg/l	<1	5	<0.15	2.52	0.586	6.68
Boron	µg/l	<100	600	<10	100	10.9	40
Barium	µg/l	25	93.6	35	100	60	89.7
Cadmium	µg/l	<0.05	0.35	<0.02	0.02	<0.08	<0.08
Chromium	µg/l	<0.5	3	<0.2	35	<1	10.8
Copper	µg/l	0.4	37.1	<1	17	<0.3	1.6
Iron	µg/l	<5	1280	5	1,900	<19	584
Mercury	µg/l	<0.1	0.7	<0.01	0.07	<0.01	0.0144
Manganese	µg/l	<2	40	0.4	300	117	641
Molybdenum	µg/l	<0.1	3.5	<0.05	1.1	<3	8.17
Nickel	µg/l	<0.2	78	<0.1	44	2.19	4.11
Lead	µg/l	<0.4	1.7	<0.2	1.1	<0.2	0.344
Antimony	µg/l	<0.05	1	0.7	15	<1	<1
Zinc	µg/l	<2	298	<1	18	1.33	23.6
Tetrachloroethene (TCE)	µg/l	1.12	631	<1	3	<1	<1
1,1,1-trichloroethane (TCA)	µg/l	5.5	1,020	<1	4	<1	<1
Tetrachloroethene (PCE)	µg/l	1.7	206	<1	4	<1	<1

6.5.4 In general, the concentrations recorded within both the Lee and Mimram catchments are similar to the literature values. Concentrations of chromium and manganese are elevated in wells within both catchments compared to literature values suggesting that there has been some impact on the aquifer from either on or off-site sources.

6.5.5 Low concentrations of solvents have been recorded in the groundwater within the Lee catchment and may be a result of the low-level halo of contamination across the wider Luton area. Solvent concentrations within the wells in the Mimram catchment were below the laboratory LOD, suggesting that there may be limited connectivity between groundwater in the two catchments, although this cannot be completely ruled out.

6.6 Kings Walden abstraction groundwater quality

6.6.1 Groundwater quality data for the Kings Walden potable water supply abstraction (approximately 2.8km northeast of the Main Application site) was obtained from the Environment Agency which covered the period from November 1992 to September 2018.

6.6.2 A limited number of determinands are routinely monitored at the abstraction (pH, conductivity, ammoniacal nitrogen, nitrate and nitrite). Concentrations of nitrate are elevated (average of 11mg/l) when compared to the background groundwater quality data obtained from the on-site monitoring wells and are likely to be reflective of agricultural land use in the area surrounding the abstraction. No ammoniacal nitrogen, which is a common indicator of landfill leachate, is present in the groundwater at Kings Walden.

6.6.3 Limited samples of groundwater from the abstraction have been analysed for other contaminants including metals, hydrocarbons and solvents. The concentrations of these contaminants indicated that they are either absent or within the normal background groundwater quality range expected in the Chalk.

7 GROUND MODEL

7.1.1 The ground model is key to understanding the overall fate and transport of potential contaminants from the landfill. A 3D ground model was developed as part of the assessment as described in **Section 5.1.** This model has been used to inform the ground and hydrogeological features pertinent to the risk assessment. Key features of the ground model are:

a. The area is characterised by a series of dry valleys. The former landfill fills part of the head of one of the dry valleys;

b. The surface of the former landfill is undulating with an elevation between 150m AOD and 155m AOD with the southern part being particularly uneven and the ground level to the south and east dropping off steeply. The elevation at the bottom of the dry valley adjacent to the landfill is approximately 130m AOD;

c. Clay-with-Flints would have originally covered the area, but when the valleys were incised into the chalk this removed these deposits from the base of the valleys. Head deposits were formed on the valley sides through weathering of the Clay-with-Flints deposits, leaving only Head present on the valley sides. Some of this material eroded and was deposited in the bottom of the valleys, forming Dry Valley Deposits in the base of the valleys;

d. The ground model suggests that there may be discontinuous clay superficial deposits present beneath the landfill site which, where present, would retard the downward migration of leachate;

e. The strata underlying the Airport Access Road (off the landfill), varies, a significant depth of Made Ground (up to 20m) has been recorded directly onto weathered chalk along the Dairyborn escarpment, a thin band of Made Ground onto Chalk with Flints up to 7.0m thickness over weathered chalk is noted beneath the sections running through the Existing Airport Land;

f. The detailed GI found no consistent basal liner or engineered cap which confirms that the site is an old ‘dilute and disperse’ landfill;

g. The waste was noted to be relatively dry during the GI and this is supported by limited amount of leachate which collected within the leachate wells. This suggests that the infiltration is percolating through and is not retained by the landfill;

h. Monitoring suggests that the groundwater flows generally to the east beneath the side and generally it lies at least 15 m below the lowest part of the landfill;

i. Solution features were noted beneath the landfill during the GI, most commonly there were an irregular fretting of the top of the chalk, and solution pipes that extend further into the chalk. These features contain a mixture of deposits from sandy to clayey material. The features may contain more permeable deposits may provide a more rapid route of transport of contaminants to the underlying groundwater;

j. The top of the chalk is weathered, which is often referred to as putty chalk, where the chalk is structureless and forms a clayey silt. This material can have significantly lower hydraulic conductivity reducing the transmissivity of the aquifer. The weathered chalk may retard the downward migration of leachate downwards;

k. Typically, hydraulic conductivity reduces with depth, with the higher conductivities likely to be associated with the secondary fissures that may have been enlarged by dissolution around the water table fluctuations within the top 20m of the Chalk;

l. The regional flow system in the Mimram catchment is likely to be locally modified by abstraction of groundwater from two potable abstractions which have modified flow direction to the east rather than south east; and

m. Groundwater flow in the Lee Catchment beneath the Airport Access Road is to the south west toward the River Lee.

8 AREA A- LANDFILL WASTE CHARACTERISTICS

8.1 Methodology

8.1.1 Following the waste forensics assessment, as detailed in **Section 4.4**. a review of the investigation location logs, site photographs and site notes, each sample was assigned a waste type in accordance with the seven main waste types summarised in **Table 8.1**. The same process was also undertaken for the exploratory logs to assign the predominate waste type to each waste strata encountered. A total of 1,239 strata description were assessed.

8.1.2 The detailed methodology for assigning waste types is presented in **Appendix D.** This process was subjective and therefore the potential for bias exists. To ensure the results were representative a number of checks were undertaken on the data, these are detailed in **Appendix D.** In addition, a proportion of the forensic samples were sent off for laboratory analysis. Good correlations were found between the fraction of each waste component measured in the samples under laboratory conditions and the results obtained in the field laboratory.

Table 8.1 Categorisation of waste types

Waste Type	Overall description	Criteria for determining waste type	Representative example of waste type
Non-Chalky Cover	Cover material with a non-chalky matrix	The Non-Chalky Cover is largely derived from superficial deposits such as Clay-with-Flints Formation or Dry Valley Deposits. Generally described as brown or orangish brown, containing flint and occasionally chalk gravel. The majority of this waste type are natural materials (other non-organics) mostly soil with some inclusions of construction waste. Small proportions of other waste constituents may also be present within these layers, generally presumed to be from tracking materials whilst being placed.	
Chalky Cover	Cover material with a chalky matrix	The Chalky Cover is largely derived from Chalk. It is generally described as white, off-white or grey in colour and containing chalk and more occasionally flint gravel. Comprises mostly of natural materials (other non-organics), mostly soil with some inclusions of construction waste. Small proportions of other waste constituents may also be present within these layers, generally presumed to be from tracking materials whilst being placed.	

Waste Type	Overall description	Criteria for determining waste type	Representative example of waste type
Old Domestic	Household waste from pre-1970	Old Domestic waste typically comprised of ashy household waste, including newspaper, leather, bones. Where dates where identified in the waste (e.g. on newspapers or food containers), this was used to separate the Old Domestic Waste from the Recent Domestic Waste. Where no dates were identified a combination of the types of items within the stratum and an assessment of the composition of the strata above and below were considered.	
Recent Domestic	Household waste from post-1970	Recent Domestic waste typically, brown to dark grey in colour and largely comprising 'black plastic bag' waste from household bins, mixed with other materials such as materials from domestic skips and characterised by the presence of plastic, newspaper and food containers. Where dates where identified in the waste (e.g. on newspapers or food containers), this was used to separate the Recent Domestic Waste from the Old Domestic Waste. Where no dates were identified a combination of the types of items within the stratum and an assessment of the composition of the strata above and below were considered.	

Waste Type	Overall description	Criteria for determining waste type	Representative example of waste type
Commercial	Office and retail waste	Commercial Waste typically comprised of office, school or retail waste from shops or the airport. Characterised by typically greater amounts of mixed paper, newsprint, corrugated, plastic and wood in the form of pallets.	
Industrial	Waste arising from factories, scrapyards	Industrial Waste largely comprised of waste from local factories, garages and the former scrapyard located in the northwest of the landfill. This waste type spans the history of waste deposition into the landfill and is therefore varied in composition. Earlier Industrial Waste typically contains more construction waste, ash, clinker and slag than the later industrial waste of the 1960s and 1970s.	

Waste Type	Overall description	Criteria for determining waste type	Representative example of waste type
Construction	Material from construction projects	Construction waste was typically encountered near surface as a ‘cover’ layer but was also present throughout the landfill including at significant depths. Largely derived from reworked natural superficial deposits and described as brown or orangish brown in colour. This waste type is defined by the presence of brick and concrete with a lesser percentage of wood, plastic, glass, ferrous and other organics. Occasionally, brick and concrete may be absent, but other typifying waste items are present	

8.2 Results

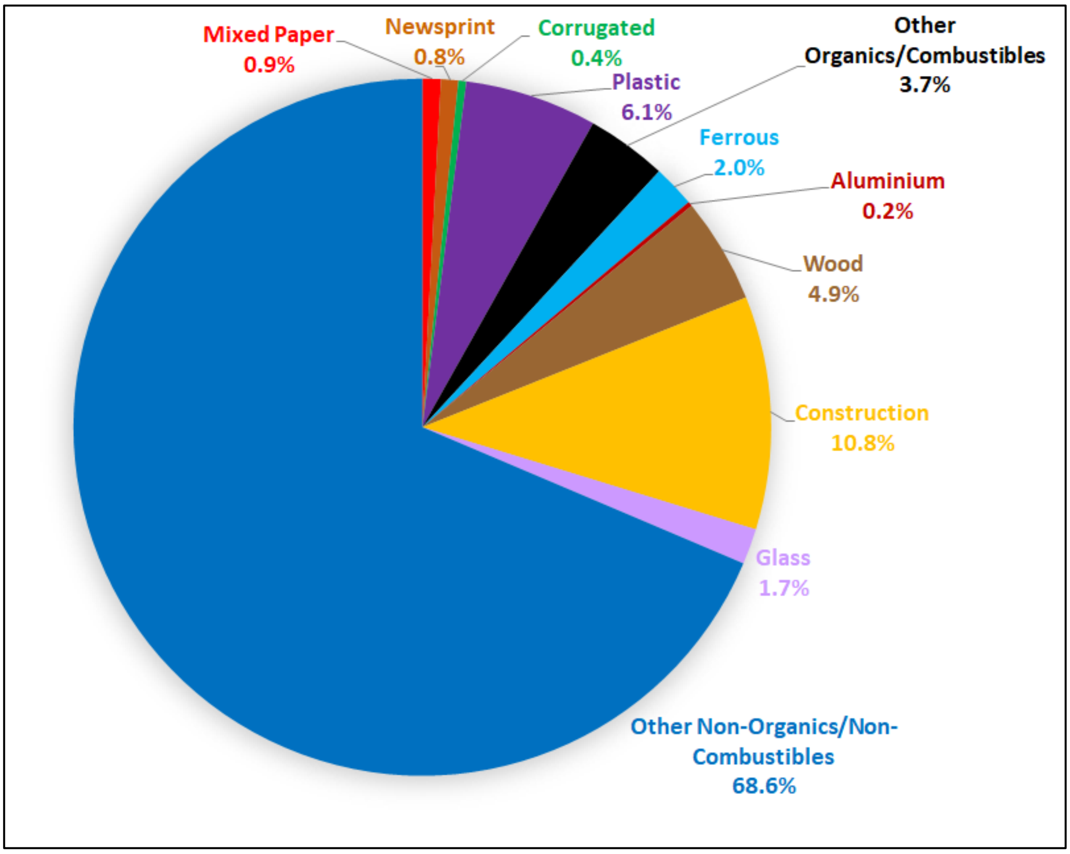
Overall waste composition

8.2.1 Understanding the overall components of the material in the landfill is important to the understanding of its current and future potential to produce leachate and landfill gas.

8.2.2 The forensic analysis of the waste provided a good estimate of the total proportions of different waste types within the landfill. As detailed in **Section 4.4** each waste component was weighed during the analysis, therefore the average percentage volume of each waste component can be calculated. **Drawing 4** shows the calculated overall percentages of the waste components.

8.2.3 The overall waste composition was found to be predominately (68%) other 'non-organics' which was defined as rock, sand, dirt, ceramics, non-ferrous metals (copper, brass), bones, ash, clinker and slag (see **Appendix D** logging protocol).

Drawing 4 Waste components presented as average volume percent in the landfill.



Age of waste

8.2.4 The age of the waste was estimated using the forensic analysis and observations of dates during GI works. These observations were incorporated into the ground model developed (see **Section 5**). The model indicated that the major period of filling was during the 1970s (see **Table 5.2).**

8.2.5 The composition of the waste has changed over time reflecting the change in societal and economic growth in the UK. These trends can also be seen in the composition of the waste at the former Eaton Green landfill. The following trends can be seen in the composition of the waste:

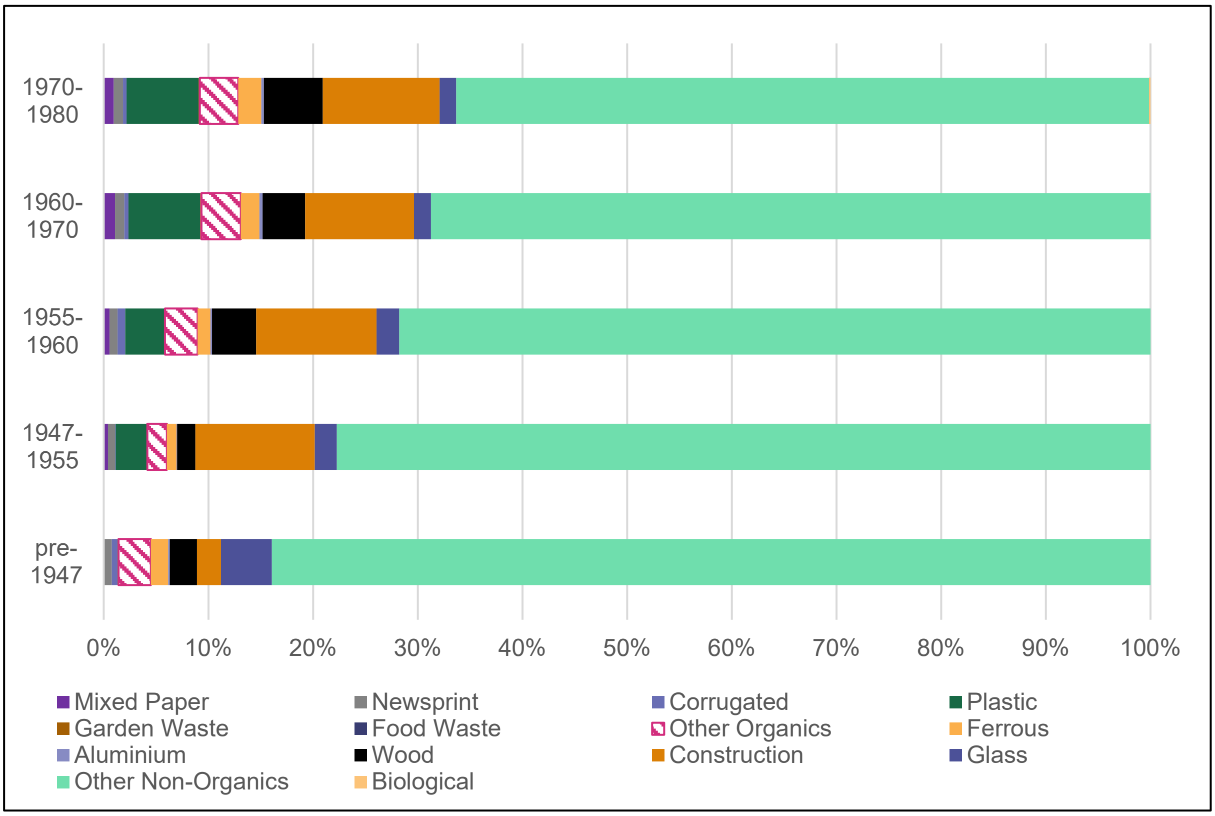
a. Prior to and during World War II very little waste was disposed of by household and industries, most by-products had a use and waste was collected for reuse and recycling i.e. rag-and-bone men (Ref. 27). This is illustrated in **Table 5.2** by the relatively low volumes of material disposed during this period.

b. There were also major changes in the composition of household waste as appliances replaced open fires for cooking, heating and water heading. Less paper and other waste was burnt on fires as appliances became more affordable (Ref. 27). The principal component of the pre-1947 waste at the former Eaton Green landfill is other non-organics material, which is likely to reflect waste of this era mainly comprising of household ash material. In addition, prior to 1950s a lot of waste was taken to ‘destructors’ by Local Authorities where waste was incinerated. The residue from these destructors also ended up in landfill (Ref. 28). The introduction of the Clean Air Act in 1957 led to a shift from incineration to disposal in landfills.

c. After World War II the 1950s were a period of economic growth and there was a big increase in carboard, plastic and glass waste which was due to a change in shopping habits towards the ‘self-service shop’ which meant every product had to be packaged. This can clearly be observed in the composition of the waste in **Drawing 5**, where there is a marked increase in the proportion of plastic, glass and paper derived materials.

d. In all ages of waste there is a high component of either cover material or non-organic material. There is likely to be a lot of cover material present as even prior to the introduction of regulations on disposal of material to landfill, there was a requirement for ‘controlled tipping’ which required a covering of all waste within 72 hours and a minimum of 9 inches of final cover material (Ref. 27).

Drawing 5 Composition of waste by era



Waste types

8.2.6 An assessment of the waste was carried out as described in **Section 8.1,** supporting information is presented in **Appendix D.**

8.2.7 The overall percentage of different waste types by average volume in the landfill is present in **Table 8.2**. A large portion of the waste is categorised as construction (36 vol.%) or cover material (27 vol.%).

Table 8.2 Total percentage and estimated volumes of different waste types within the landfill.

Waste Type	% volume	Estimated volume (m^3)
General Made Ground*	2%	85,000
Commercial	3%	130,000
Old Domestic	4%	170,000
Recent Domestic	10%	440,000
Chalky cover material	11%	485,000
Industrial	18%	790,000
Non-chalky cover material	16%	700,000
Construction	36%	1,600,000
	Total	4,400,000

Notes: Estimated total volume of material in the landfill is based on volumes calculated from the ground model (see **Section 5**).
* General Made Ground is material within the landfill not material placed post filing.

8.2.8 **Drawing 6** indicates that the distribution of waste types by era of filling. The following observations can be made:

a. There is a logical pattern demonstrated, with greatest proportion of old domestic waste in the pre-1955 waste and highest proportion of recent domestic waste in the post 1970s filling period. This supports the assessment work undertaken;

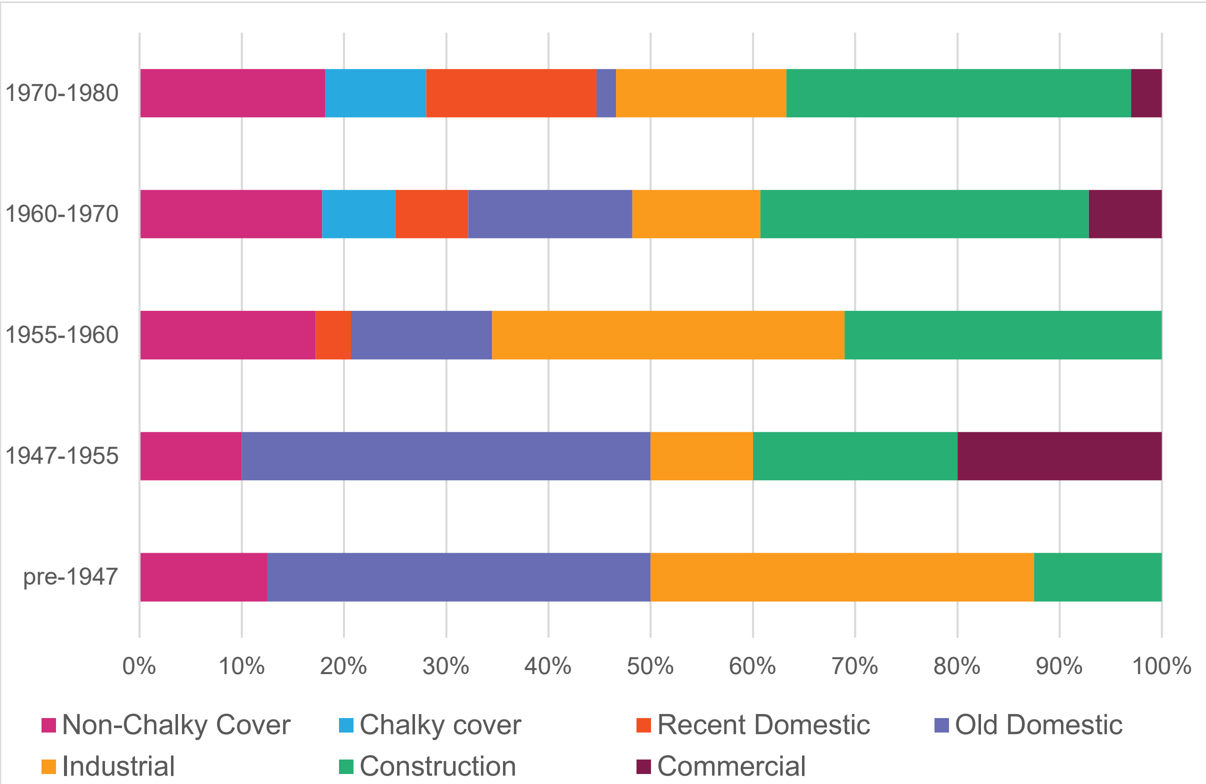
b. Chalky cover material does not appear to have been used pre-1970;

c. The proportion of construction material is highest in the most recent waste post-1970s waste;

d. Proportion of industrial waste appears to be highest in the older (pre-1960 waste). This may be due to difficulties distinguishing between ashy industrial and old domestic household ash waste; and

e. The proportion of cover material used appears to have increased from the 1960s onwards.

Drawing 6 Waste type by eras of filling.



Chemical composition

8.2.9 The chemistry of the waste types has been examined to determine whether there are any patterns. The full analysis is presented in **Appendix D.** The following general observations in chemistry were noted:

a. The old domestic waste generally had higher concentrations of heavy metals than other waste types (**Drawing 7**);

b. There was no clear trend shown with the organic contaminants. However, generally industrial, construction and recent domestic had higher concentrations than the other waste types (**Drawing 7**); and

c. Asbestos was detected most frequently and at the highest quantities in the industrial waste (see **Table 8.3**), further assessment of the asbestos encountered is provided in **Section 10.3**.

Drawing 7 Concentrations of arsenic (top left), mercury (top right), benzene (bottom left) and Naphthalene (bottom right) by waste type. Concentrations in mg/kg

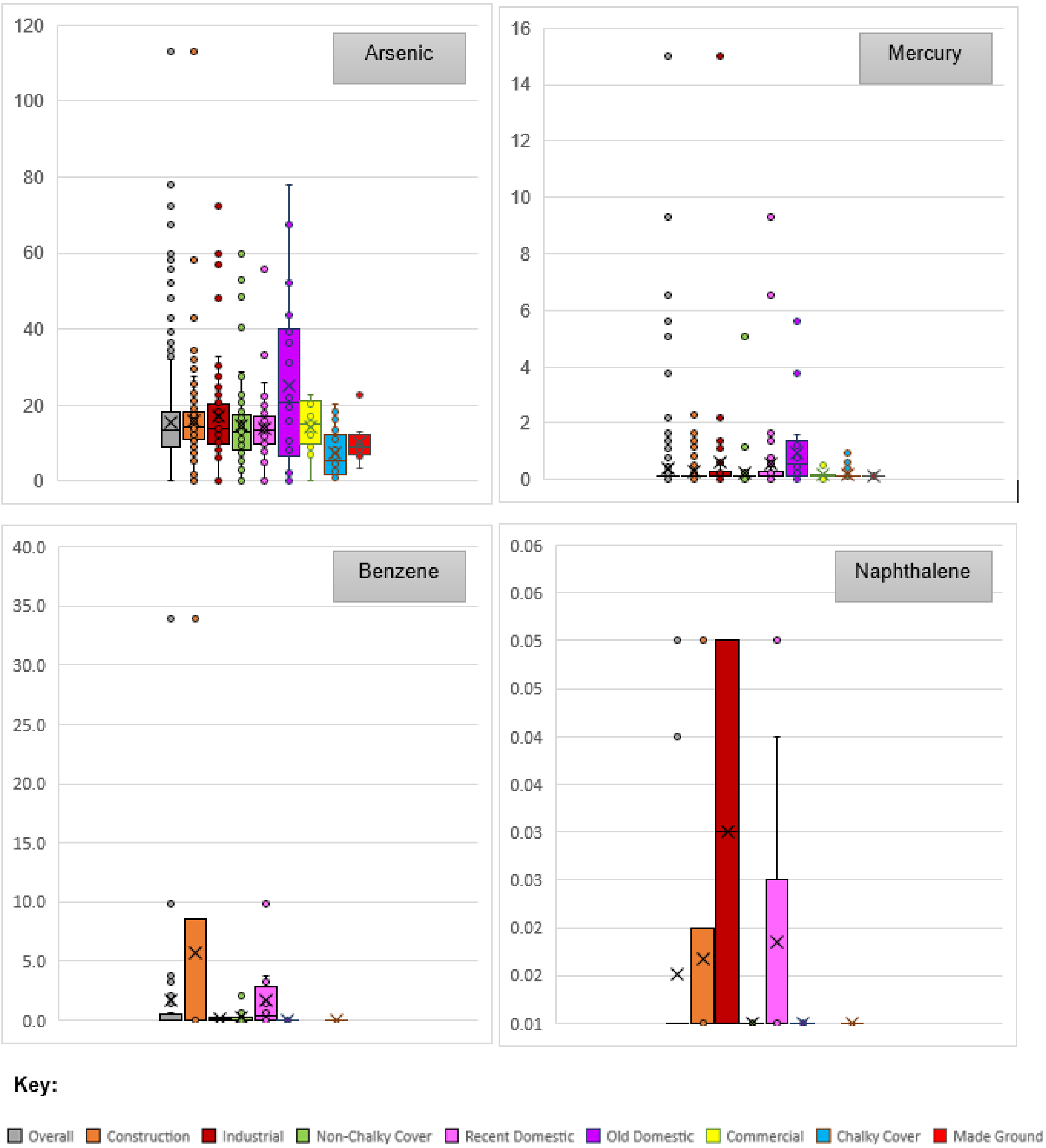


Table 8.3 Asbestos detections and quantities in waste types.

Waste Type	No of samples	No. with asbestos fibres detected	% of detections	Min %w/w	Max %w/w
General Made Ground	14	2	14%	<0.001	0.0227
Commercial	12	4	33%	<0.001	<0.001
Old Domestic	19	4	21%	<0.001	0.963
Recent Domestic	50	12	24%	<0.001	0.225
Chalky cover material	28	1	4%	-	0.0534
Industrial	52	19	36%	<0.001	6.93
Non-chalky cover material	64	9	14%	<0.001	1.08
Construction	116	22	19%	<0.001	0.112

Decompostition status

8.2.10 The ability of a landfill to produce gas and leachate depends on the decomposition status of the waste and the age of the landfill. Therefore, it is important to understand the components in the waste which are degradable and the extent of degradation.

8.2.11 Degradation of waste material is controlled by the conditions in the landfill as well as the specific biochemical consistuents of the materials (i.e. their fat, sugar, protein, cellulose, hemicelluloses, lignin content). The degradation potential of materials is a function of the amount of degradable organic carbon (DOC) they contain, with cellulose and hemicellose making up 91% of the degradable carbon fraction. The typical degradability of different waste components from literature is presented in **Table 8.4** (Ref. 29).

Table 8.4 Degradability of different types of waste taken from LQM (2003).

Waste Category	Fraction of degradable carbon (%)			
	RM	MD	SD	Inert
Paper and card	0	25	75	0
Dense plastics	0	0	0	100
Film plastics	0	0	0	100
Textiles	0	0	100	0
Miscallenous non-combustible	0	0	0	100
Putrecible	100	0	0	0
Composted putrescibles	0	50	50	0

Waste Category	Fraction of degradable carbon (%)			
	RM	MD	SD	Inert
Glass	0	0	0	100
Ferrous metal	0	0	0	100
Non-ferrous metal and aluminium cans	0	0	0	100
Non-inert fines	100	0	0	0
Inert fines	0	0	0	100

Notes: RM- readily degradable. MD- moderately degradable. SD- slowly degradable

Degradable Organic Content (DOC)

8.2.12 The readily biodegradable fraction of municipal waste which can produce landfill gas is primarily made up of cellulose and hemicellulose, although not all the cellulose in waste is available for biodegradation. Therefore, the volume of degradable material can be estimated from the degradable organic content (DOC). The DOC of material has been estimated from the measured total organic carbon content (TOC) analysis from each era of filling using a conversion factor of 1.331 (Ref. 30). The range of DOC values are presented in **Table 8.5**

Table 8.5 Summary of the range of DOCs value of the landfill material within each era of filling

Waste Era	Location	Depth (mbgl)	Waste type	Range of values for degradable organic carbon (DOC) (%)
1947	LF-BH04	13.50	Industrial	7.8- 45.4
1955	LF-GW206	7.60	Old Domestic	0.09- 14.9
1960	LF-LW204	7.80	Construction	0.7- 23.51
1970	LF-BH228	5.30	Old Domestic	0.3- 18.32
1980	LF-BH212	9.40	Commercial	0.3- 37.15

8.2.13 The DOC readings suggest that the landfill waste is generally considered to have a low to moderate amount of DOC (Ref. 30). However, there appears to be no significant correlation between the waste age/type and organic content of the landfill. Therefore, the nature of the degradable materials has been examined below to establish if any relationship exists.

Nature of degradable materials

8.2.14 Degradable materials encountered during the GI in the landfill comprised primarily of paper in its various forms (mixed paper, newsprint and corrugated) and wood. It is estimated that paper items account for 7.4 wt.% (2.1 vol.%) of the landfill mass, whilst wood waste accounts for 3.5 wt.% (4.9 vol.%) of the landfill. Newspaper print was noted from the forensic analysis to still be legible and relatively undegraded. However this should not be taken as an indicator of the overall degradation state of the landfill as newspaper does not degrade as efficiently as other paper such as white office paper, due to its complex ligin-cellulose structure (Ref. 31) making it very slow to degrade.

8.2.15 Other clearly identifiable organic waste comprised textiles, rubber and leather, as well as other primarily combustible materials, which were classed under the ‘other organics/combustible’ waste fraction. Overall, this waste fraction comprised an average 5.3 wt.% (3.7 vol.%) of the total waste (**Drawing 4**).

8.2.16 Due to the age of the landfill (last known period of infilling recorded as late 1970s), biowaste comprising of garden waste, food waste and biological waste, was found to have degraded and was generally absent from the waste samples assessed. These three fractions, were observed, accounted for less than 0.5wt.% of the total weight of samples which is in agreement with the findings of previous studies (Ref. 32) that indicate that organic waste cannot be distinguished after 15 years of landfilling. This material is likely to have decomposed to a point where degraded organic matter and mineral content are now indistinguishable. Due to the low quantities of biowaste material observed, these items are included in the ‘other organics/combustibles’ waste fraction in **Drawing 4**. In total, it is estimated that 16.2 wt.% (10.7 vol.%) of the landfill is comprised of degradable material.

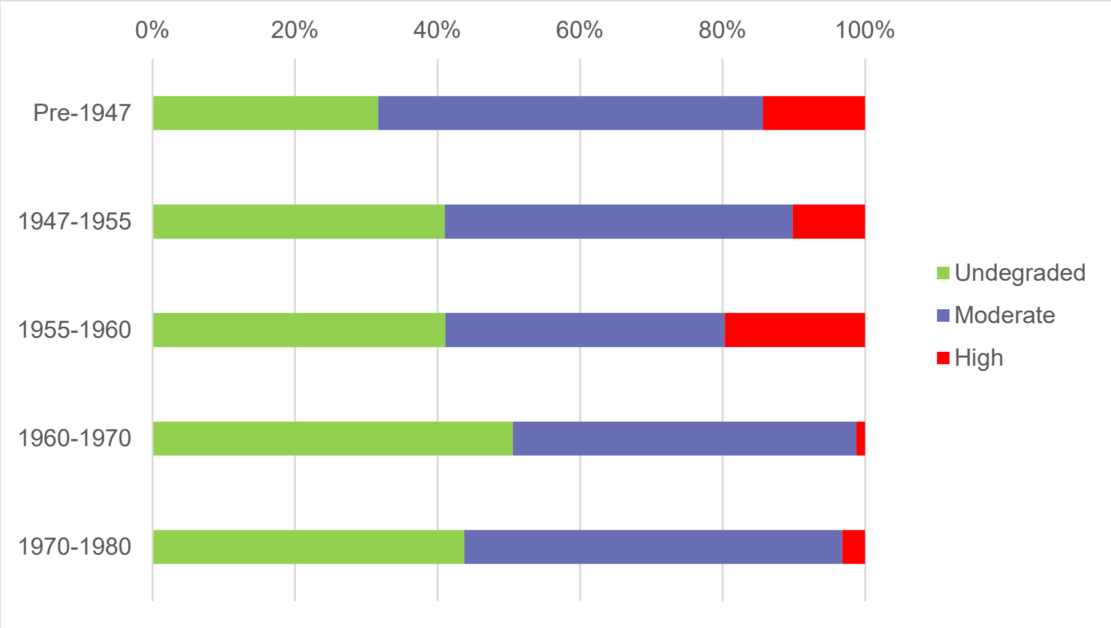
8.2.17 Field observations of the degree of degradation support this finding and with over 60% of the 189 samples assessed on site described as moderately (54%) or highly (7%) degraded.

8.2.18 Non-degradable items encountered in the landfill include waste arising from construction and demolition activities (5.9 wt%) and material classed as ‘other non-organics/non-combustibles’ (67.2 wt%) comprising mostly of rock, sand, ceramics, bones, ash, clinker or slag. It is estimated that a total of 69 vol.% of the landfill is comprised of non-degradable materials.

8.2.19 In addition to clearly degradable and non-degradable materials, a minor fraction of the landfill is composed of inert items such as glass (2.8 wt.%), plastic (4.8 wt.%) ferrous (2.3 wt.%) and aluminium (0.8 wt%) waste.

8.2.20 When examined by age of waste there is a clear relationship to age. The older, pre-1960s, waste is predominately moderately or highly degraded (up to 75% degraded). In the younger waste (1970 onwards) there is still a reasonably high component of undegraded waste (33-40%) with much less highly degraded waste. This is shown in **Drawing 8.**

Drawing 8 Observations of the degree of degradation of samples by era of landfill waste.



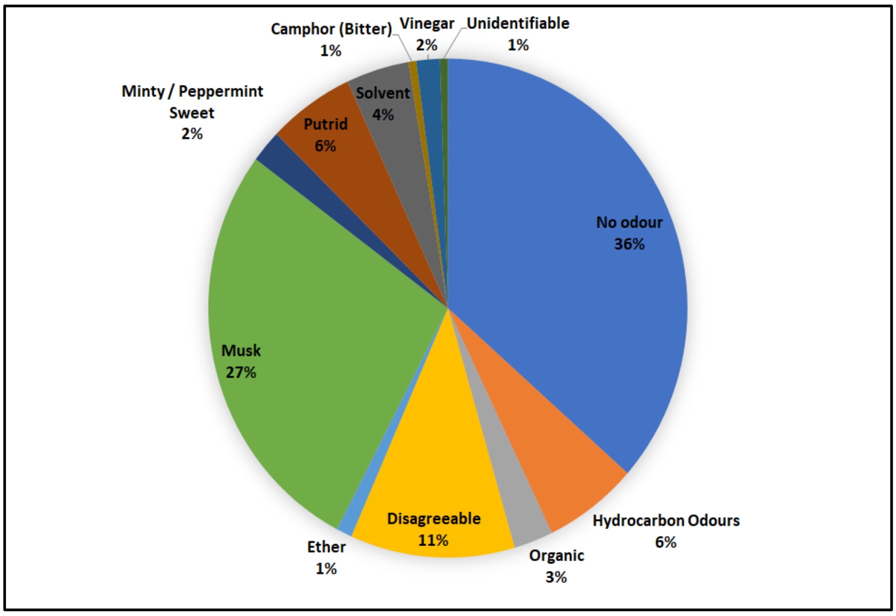
Odours

8.2.21 The assessment of odours provides qualitative information on potential contaminants within the waste and degradation state. The samples were described with an odour rating from 0 (no odour) to 5 (very strong). None of the samples analysed were described as having a strong odour. Odours are very subjective, and observations can be interpreted differently by individuals.

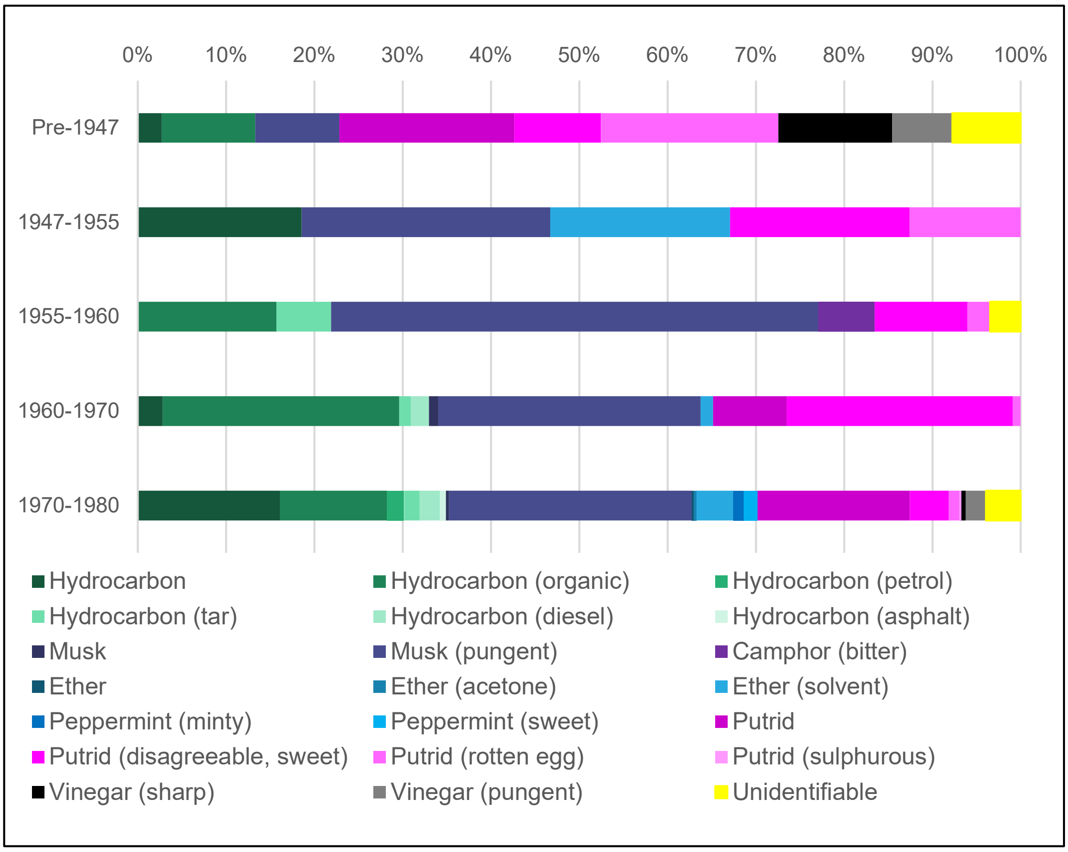
8.2.22 The odours noted during exploratory locations were described into one of 12 categories. **Drawing 9** presents a summary of the overall odour observations. Approximately one third (37%) of the samples were found to have no discernible odour, with another third (28%) presenting a mostly musk odour which was occasionally associated with organic or hydrocarbon odours. Only 6% of the samples were described primarily as having a hydrocarbon smell (organic, petrol, diesel or tar) although hydrocarbons were frequently identified as secondary odours. Disagreeable odours (11%) were occasionally associated with a musk or organic smell. The musk and putrid notes odours are likely to be associated with the degraded waste and reflect the odours associated with volatile fatty acids such as propionic acid and formic acid (Ref. 33) (Ref. 34).

8.2.23 Review of the data by period of filling, indicated that hydrocarbon odours were most prevalent in the more recent waste (post 1970s) waste. Putrid and musk odours were more common in the older (pre-1960s) waste which supports the fact that this material is more degraded than the more recent waste. This is shown in **Drawing 10.**

Drawing 9 Odour description of samples analysed by forensic analysis.



Drawing 10 Odours encountered by era of waste filling.



8.3 Landfill leachate

8.3.1 The chemical quality of a landfill leachate is determined primarily by the composition and solubility of the waste constituents. Household waste and industrial waste will give rise to leachate. The leachate quality changes over time and for landfills which received non-hazardous municipal waste there is a series of distinct stages:

a. Leachate produced in the early stages of decomposition of waste is typically generated under aerobic conditions that produce a complex solution with near neutral pH. This stage generally only lasts a few days or weeks and is relatively unimportant in terms of leachate quality. However, because aerobic degradation produces heat, leachate temperatures can rise, sometimes as high as 80–90ºC, and if this heat is retained it can enhance the later stages of leachate production.
b. As decomposition processes develop, waste becomes anaerobic. At the early anaerobic stage (the acidogenic/acetogenic phase), leachate develops high concentrations of soluble degradable organic compounds and a slightly to strongly acidic pH. Ammonium and metal concentrations also increase during this phase. Even small quantities of this high-strength leachate can cause serious damage to surface water receptors.
c. After several months or years, methanogenic conditions are established, and the leachate becomes neutral or slightly alkaline, and of lower overall concentration, but it still contains significant quantities of some pollutants (e.g. ammonium).
d. As biodegradation nears completion, aerobic conditions may return, and the leachate will eventually cease to be hazardous to the environment.

8.3.2 Published literature reports that leachate from household waste is reasonably consistent in composition, with key changes in the composition occurring over time (as per stages 1-4 described above). As indicated in **Table 8.2,** the GI observations suggest that the landfill is predominantly construction waste, with some industrial, old and recent domestic wastes.

8.3.3 The quality of leachate obtained from the landfill has been compared to published literature values for recent and aged domestic wastes in **Table 8.6** to give an understanding of the stage of decomposition and the pollution potential of the leachate being generated.

Table 8.6 Comparison of literature values of typical composition of leachate from recent and aged domestic wastes at various stages of decomposition compared to leachate measurements from the site.

Determinand	Leachate from recent wastes[1] (mg/l)	Leachate from aged wastes[1] (mg/l)	Average concentrations recorded in on-site leachate monitoring wells (mg/l)						
			LF-BH06	LF-BH12A	LW201	LW202	LW203	LW204	LW205
pH	6.2	7.5	6.9	6.7	7.3	8.06	7.9	7.4	7.1
COD	23,800	1,160	773	359	734	4,240	1,420	2,673	6,297
BOD	11,900	260	20	88	214	394	-	1,568	20
BOD/COD ratio	0.5	0.22	0.2	0.3	0.2	0.2	-	0.3	0.005
Fatty acids (as C)	5,688	5	<10[2]	13[2]	221[2]	26[2]	<10[2]	12[2]	<10[2]
Ammoniacal nitrogen	790	370	11	38	162	35	18	72	0.2
Oxidised Nitrogen	3	1	0.6	1.4	<0.1	<0.1	<0.1	0.1	2.1
Chloride	1,315	2,080	559	163	273	133	119	110	800
Sodium	960	1,300	374	195	446	254	1,250	84	313
Magnesium	252	185	11	33	60	26	21	25	4
Potassium	780	590	21	22	112	50	20	40	19
Calcium	1,820	250	233	169	213	140	36	215	201
Manganese	27	2.1	1.4	1.1	0.92	0.88	0.23	1.7	0.2
Iron	540	23	3	5	38	1.2	0.26	12	0.03
Nickel	0.6	0.1	0.31	0.008	0.043	0.021	0.03	0.022	0.014
Copper	0.12	0.3	0.43	0.002	<0.0003	<0.0003	0.0006	<0.0003	0.0031
Zinc	21.5	0.4	0.0014	0.004	0.012	0.031	0.01	0.006	0.34
Lead	8.4	0.14	0.0004	0.001	0.0004	0.0005	<0.0002	0.001	0.001

Notes:
[1] Typical composition taken from Waste Management Paper No.26 Landfilling Wastes (1986)
[2] Sum of fatty acids (C2-C7) above limit of detection; ethanoic acid, butanoic acid, hexanoic acid, propanoic acid and pentanoic acid

8.3.4 The comparison in **Table 8.6** indicates the following:

a. The levels of contaminants are broadly consistent with leachate from aged waste, with the concentrations of many contaminants lower than those typical of an aged waste e.g. ammoniacal nitrogen, magnesium, manganese, zinc and lead.

b. The BOD to COD ratio provides an indication of the amount of organic matter present, a high ratio of BOD to COD suggest a large amount of biodegradable organic matter is present in a landfill. In LF-BH12A and LW204 the BOD/COD ratio is lower than that of a typical recent waste but slightly higher than an aged waste suggesting that there may still be significant biodegradable matter in this part of the landfill. Both of these wells are located in the southern section of the landfill with LW204 towards the centre where the waste extends to approximately 11 m depth.

c. The BOD/COD ratio in the other leachate wells is similar to that of an aged waste, these wells are located across the northern and south west parts of the landfill.

d. Volatile fatty acids (VFAs) are formed via anaerobic degradation of larger organic molecules. The presence of VFAs such as acetic acid, would suggest that the landfill is continuing to break down organic matter and produce leachate. However, they are not present in very high concentrations in any of the wells, when compared to leachate from a typical recent waste, which suggests the landfill is approaching an aged state (between stages 3 and 4 outlined above).

e. The highest concentration of fatty acids was recorded in LW201 which is one of the locations where there has consistently been a greater accumulation of leachate recorded within the landfill. No VFAs were detected in leachate sampled from LF-BH06, LW203 or LW205.

8.1 Comparison with other landfills

8.1.1 There is very little available literature on the composition of waste in similar aged landfills within the UK. The most relvent information on composition of landfilled waste is a review of 60 landfill mining projects across Europe where the composition was determined (Ref. 35). **Table 8.7** indicates that the waste composition of Luton is broadly similar to other typical landfills across Europe.

Table 8.7 Average (wt.%) waste composition and comparison with literature values.

Waste Component	Typical Landfill (various countries) (wt.%)	Former Eaton Green Landfill (wt.%)
All paper fractions	5.3	7.5
Wood	3.5	3.5
Other organics / combustibles	11.1	5.3
Total Degradable Materials	***19.9***	***16.3***
Minerals / inert	5.8	-
Construction waste	9.0	5.9
Other non-organics	57.3	67.2
Total Non-Degradable Materials	***72.1***	***73.1***
Glass	1.1	2.8
Plastic	4.7	4.8
Total metals	2.0	-
Ferrous	-	2.3
Aluminium	-	0.8
Other	***7.8***	***10.7***

8.2 Interaction of earthworks with landfill

8.2.1 The proposed works have been designed to minimise the amount of landfill waste required to be excavated. The volumes of material to be excavated at each phase of the Proposed Development are shown in **Table 8.8.**

Table 8.8 Approximate volumes of landfill material proposed to be excavated in each assessment phase

Phase	1	2a	2b	Total required to achieve 32 mppa
	m^3	m^3	m^3	m^3
Landfill	31,000	335,000	21,000	387,000

8.3 Summary of waste characteristics

8.3.1 The waste forensics assessment, review of the exploratory logs, site photographs and site observations on the former landfill indicated the following:

a. Much of the waste was deposited 40-50 years ago, and initial filling started almost 80 years ago. The most recent waste, in the capping layer, was deposited 30 to 40 years ago;
b. The waste is reasonably well degraded with no discernible biowastes. The slower degradable fractions of material are remaining such as newspaper;
c. An analysis of the waste components indicates that 69% is non-organic/non-combustible material;
d. The waste contains a high proportion of cover material (both non-chalky and chalky), particularly in the more recent wastes (1970s onwards);
e. A large portion of the waste is categorised as construction (36 vol.%) or cover material (27 vol.%);
f. The old domestic waste has higher heavy metal concentrations, which may be a function of the predominate material in this waste being ashy material;
g. There was no clear trend shown with the organic contaminants. However generally industrial, construction and recent domestic had higher concentrations than the other waste types;
h. Chemical analysis of the landfill leachate indicated the levels of contaminants are broadly consistent with leachate from aged waste, with the concentrations of many contaminants lower than those typical of an aged waste e.g. ammoniacal nitrogen, magnesium, manganese, zinc and lead;

i. Asbestos was detected most frequently and at the highest quantities in the industrial waste; and

j. Overall there is no distinct spatial variation in the waste types or chemistry. The relative proportions of different waste types are defined by the era in which it was deposited. As such it is not considered necessary to sub-divide the landfill for any of the subsequent assessment detailed in the following sections.

9 GENERIC QUANTITATIVE RISK ASSESSMENT

9.1 Risk assessment process

9.1.1 The statutory guidance which accompanies Part 2A Environmental Protection Act 1990 legislation (Ref. 36) details that the significance of any contamination should be evaluated through a risk assessment. The current best practice for risk assessment methodology is detailed in Environment Agency's Land Contamination Risk Management Guidance (Ref. 2).

9.1.2 The risk assessment process is underpinned by the concept of establishing whether a contaminant linkage exists between a source and a receptor via a viable pathway. For a potential risk to exist all three elements must exist to form a contaminant linkage.

9.1.3 The risk assessment process aims to establish whether unacceptable risks exist and if so what further actions need to be taken in relation to the site. It is an iterative tiered approach which consists of three progressively detailed stages of risk assessment; PRA, GQRA and DQRA. Depending on the nature of the site and contamination present, not all stages of risk assessment may be required.

9.2 Overall approach

9.2.1 As identified in **Section 10**, the PRA identified that Area A (former landfill) and the Airport Access Road, were the only areas requiring further risk assessment. Therefore, the assessment will focus on these areas.

9.2.2 As described in **Section 9**, overall there is no distinct spatial variation in the waste types or chemistry. As such it is not considered necessary to sub-divided Area A for the risk assessment. The risk assessment considers a reasonable worst-case scenario is representative of the conditions at the landfill. This is considered conservative but allows for the heterogenous nature of the landfill in the assessments.

9.2.3 Construction related impacts have been considered, where appropriate, in the assessment. Any breaking out of surfaces along the Airport Access Road where Made Ground or landfill material will be exposed, as well as the excavation work to the landfill for the Proposed Development described in **Section 2.4** will be undertaken in a manner in such that the potential impacts are controlled and minimised. These control measures will be detailed in the CoCP (**Appendix 4.2** of the ES **[TR020001/APP/5.02]**) and Outline Remediation Strategy (ORS) (Ref. 37) (**Appendix 17.5** of the ES **[TR020001/APP/5.02]**).

9.3 Data used in assessment

Area A - Former Landfill

9.3.1 All available data from the following GIs (**see Figure 10** of this document) has been used to assess the conditions within Area A and the potential for impacts outside of the landfill boundary:

a. AECOM (2019) Luton Airport Landfill, Main Ground Investigation – Factual Report;
b. AECOM (2018) Luton Hangar 24 Ground Investigation, Factual Ground Investigation Report;
c. Structural Soils Limited (2017) Landfill Factual Report on Ground Investigation;
d. Structural Soils Limited (2017) Century Park Factual Report on Ground Investigation;
e. Structural Soils Limited (2017) Century Park Access Road, Factual Report on Ground Investigation; and
f. Concept Site Investigations (2015) Luton Airport Terminal Extension, Site Investigation Report.

Airport Access Road

9.3.2 Two GI's have been undertaken along the proposed road alignment:

a. Structural Soils Limited (2017) Century Park Access Road, Factual Report on Ground Investigation; and
b. Geotechnics Ltd (2018) Century Park Access Road Additional Works, Factual Report. Draft.

9.3.3 It is pertinent to note that the Airport access Road traverses the former Landfill towards the eastern extent and data from this area has been assessed under Area A.

9.4 Adequacy of data

Eaton Green Landfill

9.4.1 As discussed in **Section 4.1.3** preliminary and detailed GIs have been undertaken within the landfill area. The sampling locations have a good spatial, lateral and vertical distribution, encompassing all the main eras of waste deposition. A substantial number of samples have been undertaken including; soil (1219 samples), groundwater and leachate (328 tests) and gas/VOC samples (96 tests) to industry standards providing a comprehensive dataset for the area.

9.4.2 A considerable amount of gas monitoring has also been undertaken which has included:

a. twelve months' worth of spot gas monitoring (i.e. levels measured at monthly intervals from boreholes);
b. continuous gas monitoring in five boreholes across the landfill during the recent GI (which have taken continuous readings over a 3-month period); and
c. samples of bulk and trace gases to determine the constituents and volumes of gases within the landfill.

9.4.3 The investigations undertaken to date provide a good understanding of the general composition of the waste, groundwater, leachate and landfill gas conditions. Therefore, the data is considered to be adequate to inform the risk assessment. There were some areas of the former landfill which were not accessible during the GI, including parts of the landfill which were airside and the southeastern end of the landfill which had a steep slope. Further GI may be required in these areas prior to works to ensure they are consistent with the general understanding of the ground conditions.

Airport Access Road

9.4.4 Two phases of ground investigation have been undertaken for the Airport Access Road in 2017 (Ref. 8) and 2018 (Ref, 9) which were reviewed in **Appendix 17.1** of the ES (Ref. 1) **[TR020001/APP/5.02]**. The sampling locations are distributed across the route at approximately 50m spacing. Chemical testing was not undertaken at each location, so in some areas the chemical sampling density does not meet that of an exploratory investigation as set out in BS10175 (Ref. 11). Samples were tested for a range of analytes relevant to the past contaminative land uses and provides a preliminary dataset to assess the risks posed to human health.

9.4.5 No groundwater testing or leachate testing was undertaken as part of the GI works. It is not envisaged that the proposed earthworks will interact with the groundwater. However, this will need to be reviewed at the detailed design stage.

9.4.6 Ground gas monitoring collected during the GI works has been used as part of an overall assessment of the area outside of Eaton Green Landfill.

10 HUMAN HEALTH GENERIC QUANTITATIVE RISK ASSESSMENT

10.1 Methodology

Soil

10.1.1 A human health generic quantitative risk assessment (GQRA) has been undertaken in accordance with the Environment Agency's Contaminated Land Exposure Assessment (CLEA) framework (Ref. 38). The CLEA model estimates human exposure (children and adults) to soil contaminants for those potentially living, working and/or playing on contaminated sites over long time periods (chronic exposure). It does not assess risks to groundwater and does not include short-term risks, for example to construction workers. Risks to construction workers should be covered by appropriate site management plans i.e. CoCP, **Appendix 4.2** of the ES **[TR020001/APP/5.02]**. However, an initial assessment of the acute risks has been undertaken to inform management of risks during future works. The approach to the acute generic risk assessment is described below in **Section 10.1.12.**

Radionuclides

10.1.2 Percival Works, which was located immediately west of the site, was a former aircraft manufacturer, including during World War II. It is known that during this period aircraft dials were commonly painted with radium to make them luminous. The PRA identified the potential for radionuclides to be present in the waste materials in Area A, if luminous aircraft dials from the nearby Percival Works were disposed there.

10.1.3 A survey was undertaken after the GI works to follow up on locations where readings had been encountered above background levels. This further survey (**Appendix C**) indicated that the levels of radionuclides detected were consistent with expected natural background levels and do not pose a risk to health. Therefore, no further risk assessment of the radionuclide risks is required. However, a watching brief will be required during excavation works and procedures in place to ensure any suspected radionuclide containing material encountered is appropriately managed.

Statistical analysis

10.1.4 A review of the data indicated that statistical analysis is unlikely to be appropriate for assessing the human health risks from the soils/waste in Area A for two main reasons:

a. Trial pits provide good representation of the material but were not able to progress beyond 5 m in the landfill waste. Therefore, the data is skewed towards the shallower horizons of the landfill due to the depth of the waste. **Table 10.1** indicates the number of samples obtained from the various depth horizons within the landfill. As detailed within the CL:AIRE guidance (Ref. 39), it is not appropriate to apply statistical testing to biased sampling; and

b. The conditions in the landfill are extremely variable therefore it is unlikely that the contamination concentrations detected will be attributable to any underlying population.

10.1.5 The ground model developed has been used to collate all the historical, site investigation and other data to develop an understanding of the contaminant concentrations and characteristics across the site based upon a “lines of evidence” methodology.

Table 10.1 Number of samples obtained for chemical analysis from within the landfill by depth

Depth (m bgl)	No. Samples
0 – 5	358
5 – 10	86
10 – 15	34
15 – 20	9
20 – 25	1
Total	488

10.1.6 Statistical analysis was also not applied to the Airport Access Road due to the following reasons:

a. The chemical sampling density is not sufficient to allow determination of suitable averaging areas or allow robust statistics; and

b. Chemical sampling along the route was largely targeted on potential areas of contamination and as detailed within the CL:AIRE guidance (Ref. 39), it is not appropriate to apply statistical testing to biased sampling.

10.1.7 Therefore, comparison of the maximum concentration against appropriate assessment criteria is considered suitable for a preliminary assessment of the potential risks to human health receptors.

Chronic exposure risk assessment

10.1.8 In order to use the most appropriate assessment criteria for determining the potential risk to future users, it is important to consider the proposed end use in the area. The proposed development within Area A and along the Airport Access Road includes:

a. Hotel;

b. Energy centre;

c. Café;

d. Offices/light industrial premises;

e. Areas of landscaping;

f. Car parking associated with the office/industrial units;

g. Access road;

h. Luton DART extension from T1 and new Luton DART station;
i. New terminal building; and
j. Apron, stands and taxiways.

10.1.9 **Table 10.2** below provides justification for the Generic Assessment Criteria (GACs) selected for proposed land use associated with the proposed development. The soil analysis has then been compared to the lowest GAC for each contaminant for the proposed land uses in order to make an initial conservative assessment of the potential risk to human health. A soil organic matter (SOM) content of 1% has been used to provide an initial assessment.

10.1.10 The chronic exposure risk assessment is based on the current proposals. If the proposed end uses change to a more sensitive use then revaluation of the data may be required.

Table 10.2 Summary of proposed infrastructure in the development

Infrastructure proposed	Generic assessment criteria	Justification
Hotel	Female Adult Commercial	The future occupants of hotel may include children using the hotel. However, their exposure is likely to be infrequent and short in duration. Therefore, the most sensitive receptor is considered to be those working at the hotel, who are likely to have more prolonged exposure.
Energy centre		General public are unlikely to access the energy centre, therefore the most sensitive receptor is considered to be those working at the energy centre.
Café		Future visitors the café may include children, however their exposure is likely to be infrequent and short in duration. Therefore, the most sensitive receptor is considered to be those working at the café.
Offices/light industrial premises		The most sensitive receptor is considered to be those working at the office/light industrial premises.
Areas of landscaping	Female child 0 – 6 years – Public open space	These areas of the proposed scheme are likely to be accessible to the general public meaning children accessing the site may have occasional contact with soils and or inhalation of gases/vapours. Therefore, public open space criteria for a child aged 0-6 years has been considered sufficiently protective of end users of this area.

Infrastructure proposed	Generic assessment criteria	Justification
Car parking associated with the office/industrial units	Female adult maintenance worker for open space	No potential for accumulation of vapours or gases in indoor air. Areas to be covered in hardstanding so no potential for member of the public to come into contact with underlying soils. Therefore, main receptor is considered to be a maintenance worker who may have occasional direct contact with soils.
Airport Access Road		No potential for accumulation of vapours or gases in indoor air. Areas to be covered in hardstanding so no potential for member of the public to come into contact with underlying soils. Therefore, main receptor is considered to be a maintenance worker who may have occasional direct contact with soils.
Extension of the Luton DART from T1 and new Luton DART station.	Female Adult Commercial	The future users of the airport will be members of the public including children. However, their exposure is likely to be infrequent and short in duration. Therefore, the most sensitive receptor is considered to be those working at the airport, who are likely to have more prolonged exposure.
New terminal building, apron, stands and taxiways		

Dioxin, furans and dioxin like polychlorinated biphenyls (PCBs) compounds

10.1.11 The approach outlined in the above sections has been used for assessing the chronic exposure risk to all contaminants with the exception of dioxin, furans and dioxin like polychlorinated biphenyls (PCBs) compounds. These compounds were identified as potential contaminant of concern in Area A from the PRA. A different approach is required for these compounds as the published GACs are based on the assumption that the source is atmospheric deposition. This is unlikely to be the case for Area A, as sources are more likely to be from material deposited in the landfill such as electrical equipment. Therefore, the published Environment Agency excel worksheet for PCDD, PCDFs and dioxin-like PCB compounds for a commercial land use scenario (Ref. 40) has been used to enable a site-specific comparison of total exposure from these compounds in soil with the health criteria value. This results in a Hazard Index (HI). A HI greater than 1.0 indicates a potential risk and further consideration is required. A HI of less than 1.0 indicates that the concentration does not pose a potential risk to future users of the site.

Acute exposure risk assessment

10.1.12 The principal risks to human health are from the chronic risks resulting from long term exposure to specific contaminants. Chronic risks often occur at lower doses than acute risks, therefore they are often the key risk driver. The Society of Brownfield Risk Assessment (SoBRA) recently published an approach for assessing acute risks to human health from short term exposure to soil contamination and associated acute generic assessment criteria (AGAC) (Ref. 41). The SoBRA approach looks at two scenarios:

a. Short term exposure of the public by direct contact or ingestion. In addition, inhalation of dusts or vapours arising from excavation activities (e.g. during construction or remediation) The direct contact pathways assumes trespass onto an active construction site, which is considered unlikely but has been included as a conservative assessment of the risks; and
b. Short term exposure by workers involved with excavations.

10.1.13 It is not intended to replace health and safety guidance on managing risk and controlling exposure, or replace monitoring, or other controls. It is intended to highlight potential acute risks prior to work commencing and/or inform the design of appropriate cover systems.

10.1.14 The maximum soil concentrations have been compared to the AGAC derived by SoBRA.

Groundwater vapours

10.1.15 Volatile contaminants in groundwater have the potential to cause risk to human health via volatilisation and migration of vapours into overlying buildings or outdoor air space followed by inhalation.

10.1.16 The groundwater in the underlying chalk aquifer is at a significant depth below the ground level, typically 40 mbgl, beneath both the landfill and Airport Access Road and as such there is not considered to be a potential risk to the future development from volatilisation of contaminants. However, during the 2018 GI some perched water was encountered in the landfill. Therefore, the potential risks associated with volatile contaminants in perched water has been assessed.

10.1.17 In order to assess this the measured concentrations of volatile contaminants in groundwater have been compared with published groundwater vapour generic assessment criteria (GACgwvap) developed by SoBRA (Ref. 42).

10.1.18 Further details of the assessment criteria used for both soil and groundwater are presented **in Appendix E.**

Soil gas vapours

10.1.19 There are no generic assessment criteria for assessing soil gas vapour concentrations. Therefore, PCLs associated with soil gas vapours have been considered through DQRA and are presented in the DQRA for Human Health (Ref. 53), **Appendix 17.3** of the ES **[TR020001/APP/5.02]**.

Asbestos

10.1.20 The term 'asbestos' refers mainly to six fibrous minerals that are known to cause serious health effects when inhaled. The main commercially exploited forms are chrysotile (white asbestos), amosite (brown asbestos) and crocidolite (blue asbestos). Between 1900 and 1980, asbestos was widely used in a plethora of construction and insulation products due to the physical, thermal and chemical properties of the fibres. The importation of crocidolite had ceased by 1970 (except for limited specialised applications such as battery casings). The importation of amosite ceased in 1980. The importation and use of asbestos in the UK was finally banned (for nearly all purposes) in 1999 (Ref. 43).

10.1.21 Asbestos-containing materials (ACMs) are found commonly in buildings constructed up to the year 2000 as floor and ceiling tiles, pipe lagging, insulation board, roofing materials, protective coatings, textured decorations, as well as being widely used in brake linings.

10.1.22 Historical waste management and demolition practice has resulted in asbestos-containing materials (ACMs) being potentially present in the soil or made ground at any brownfield site (Ref. 43).

10.1.23 In order for asbestos found within soil to pose a risk to health, it has to be present in a form that can release fibres to air for inhalation. Currently there is no UK soil guideline criteria for Asbestos Containing Soils (ACS) in relation to the risk from long-term environmental exposure to human health. The research to date suggests (Ref. 43) there is no safe or threshold level for asbestos exposure below which there is no discernible increase in risk.

10.1.24 In the absence of any published threshold value the WHO Air Quality Guideline (Ref. 44) value of <0.001 fibres/ml (equivalent to 0.001 %w/w) has been used as initial screening criteria to determine whether further assessment is required.

10.2 Results

Comparison of soil analysis to GAC's

Chronic assessment criteria

10.2.2 Comparison of the soil samples against the GAC indicated exceedances within Area A as summarised in **Table 10.4** and shown on **Figure 16** of this document.

10.2.3 No exceedances were observed along the Airport Access Road against the GAC for commercial /industrial end use. However several samples exceeded the soil saturation limits for particular TPH chains and a few PAHs, see **Table 10.3.** The full screening assessment is provided in **Appendix E.**

Table 10.3 Exceedance of soils saturation limits for TPH and PAHs for the Airport Access Road.

Contaminant	Number of exceedances/ (total samples tested)	Location	Depth (mbgl)	Maximum Conc. (mg/kg)	Soil Saturation Limit	GAC (mg/kg)
PAHs						
Indeno (1,2,3-c,d)pyrene	15/(43)	PFCPRC24	15.0	1.54	0.15	506
Dibenzo(ah) anthracene	9/(43)	PFCPRC24	15.0	0.21	0.0098	3.55
Benzo (g,h,i) perylene	22/(43)	PFCPRC24	15.0	1.47	0.04	3950
Chrysene	1/(43)	PFCPRC24	15.0	1.23	1.10	352
TPH						
Aromatic C21-C35	5/43	PFCPRC04	0.6	236	12.1	28400
Aliphatic C16-C21	2/43	PFCPRC04	0.6	103	21.2	10700000
Aliphatic C21-C35	5/43	PFCPRC04	0.6	584	21.2	10700000

10.2.4 The samples where the soil saturation limits are exceeded are all Made Ground and generally reworked chalk with limited visual or olfactory evidence of potential contamination sources other than occasional gravel of clinker. Exploratory hole PFCPRC24 which has the maximum concentrations recorded strong hydrocarbon/organic odour. Although the soil saturation limits are exceeded none of exploratory hole logs recorded any free-phase petroleum products. The TPH fractions which are recorded as exceeding the soil saturation limit all have a carbon chain greater than C16 (The ‘C’ refers to the length of the carbon chain in the chemical compound). These fractions have an air-water partition coefficient (K_{aw}) lower than 4 x10^{-4}, which means they are not considered to be volatile (Ref. 45). Combined with the fact there is no free-phase and no evidence of a contaminant source it is unlikely a potential vapour pathway from soil contaminants would be formed and therefore this has been excluded from further assessment.

Table 10.4 Exceedances of contaminants in soil when compared to generic assessment criteria (GAC) for Area A.

Contaminant	Number of exceedances/ (total samples tested)	Location	Depth (mbgl)	Concentration (mg/kg)	Waste type	GAC (mg/kg)
Polyaromatic Hydrocarbons						
Benzo(b) fluoranthene	7/(357)	BH05*	0.10	18.8	Non-chalky cover	13.2[i]
		BH231*	4.35	13.3	Non-chalky cover	
		BH232*	5.80	14.1	Old Domestic	
		TP214	1.50	45.0	Construction	
		TP223	3.5	22.2	Recent Domestic	
		TP232	2.3	15.5	Industrial	
		WS224	4.5	103	Construction	
Benzo(a)pyrene	12/(357)	BH05*	0.10	18.5	Non-chalky cover	10.8[i]
		TP214	1.50	43.1	Construction	
		TP232*	2.30	13.6	Industrial	
		TP258*	1.50	11.5	Construction	
		WS224	4.50	83.7	Construction	
		BH231*	4.35	13.4	Non-chalky cover	
		TP213	3.5	11.4	Industrial	
		TP214	1.5	43.1	Construction	
		TP223	3.50	25.6	Recent Domestic	
		TP232	2.30	13.6	Industrial	
		TP258*	1.5	11.5	Construction	
		WS224	4.5	83.7	Construction	

Contaminant	Number of exceedances/ (total samples tested)	Location	Depth (mbgl)	Concentration (mg/kg)	Waste type	GAC (mg/kg)
Dibenzo(ah) anthracene	10/(357)	BH05*	0.10	2.9	Non-chalky cover	1.15 i
		BH232*	5.80	1.16	Old Domestic	
		TP207	1.6	1.51	Industrial	
		TP214	1.5	4.98	Construction	
		TP223	3.5	3.79	Recent Domestic	
		TP232	2.3	2.03	Industrial	
		TP243*	4.3	1.27	Old Domestic	
		TP258*	1.50	1.58	Construction	
		TP270	5.60	1.17	Commercial	
		WS224	4.5	7.69	Construction	
Indeno(1,2,3-cd) pyrene	1/(357)	WS224	4.50	80.4	Construction	44 iii
Chrysene	1/(357)	WS224	4.50	114	Construction	91 iii
Benzo(a)anthracene	2/(357)	TP214	1.50	51	Construction	48.8 i
		WS224	4.50	134	Construction	
Naphthalene	1/(357)	GW203B	4.70	285	Industrial	193 ii
2-Methyl-naphthalene	2/(186)	GW203B	4.70	425	Industrial	193 ii
		TP220	2.50	213	Recent Domestic	
Metals						
Lead	13/(481)	BH09	6.40	15700	Recent Domestic	1300 i
		BH203	5.30	1490	Recent Domestic	
		BH217	13.20	2170	Non-Chalky Cover	
		BH219	16.00	1470	Recent Domestic	

Contaminant	Number of exceedances/ (total samples tested)	Location	Depth (mbgl)	Concentration (mg/kg)	Waste type	GAC (mg/kg)
		BH222*	3.55	6680	Chalky cover	
		BH231*	3.80	1600	Non-Chalky Cover	
		BH231*	6.50	2410	Construction	
		BWS215*	3.40	3410	Construction	
		LW202	7.60	1570	Construction	
		TP228	2.50	1590	Industrial	
		TP250*	4.10	2000	Old Domestic	
		TP261	5.50	3790	Recent Domestic	
		WS224	3.60	2430	Construction	
Nickel	8/(481)	BH209 (PFCP73)	4.70	2310	Construction	804 [i]
		BH231*	3.80	847	Non-Chalky Cover	
		TP211	3.00	5620	Recent Domestic	
		TP216	2.80	2350	Recent Domestic	
		TP241	1.50	1080	Construction	
		TP242	5.50	18100	Old Domestic	
		TP274	2.50	1040	Construction	
		WS218	3.70	1330	Construction	
Beryllium	1/(477)	BH228	10.80	13.5	Natural-not within waste	11.7[ii]
Chromium**	1/(481)	TP242	5.50	8670	Old Domestic	8570 [ii]
Copper	2/(481)	TP241	4.50	78200	Industrial	44400[i]
		TP243*	4.30	87600	Old Domestic	

Contaminant	Number of exceedances/ (total samples tested)	Location	Depth (mbgl)	Concentration (mg/kg)	Waste type	GAC (mg/kg)
Petroleum Hydrocarbons						
1,2,4-Trimethylbenzene	5/(161)	BH231 *	3.80	514	Non-Chalky Cover	39.4 ii
		BH231 *	4.35	200	Non-Chalky Cover	
		GW203B	4.70	5570	Industrial	
		LW204	7.80	58.9	Construction	
		WS224	3.60	658	Construction	
TPH Aliphatic >C8-10	1/(208)	WS224	3.60	2320	Construction	2000 ii
TPH Aromatic >C21-35	1/(209)	LW204	7.80	10500	Construction	7820 ii
Other organics						
Bis(2-chloroethoxy) methane	1/(158)	LW204	7.80	1.890	Construction	0.956 ii
Dibenzofuran	5/(158)	BH08	3.40	31.4	Construction	10.8 i
		BH225	3.10	93.8	Recent Domestic	
		TP213A	3.50	11.7	Industrial	
		TP232	2.30	12.4	Industrial	
		WS224	4.50	68.4	Construction	
Carbazole	2/(158)	BH225	3.10	53.7	Recent Domestic	10.8 i
		WS224	4.50	48.3	Construction	

Notes:
Green shaded cells indicate exceedances are within an order of magnitude of the GAC
Orange shaded cells indicate exceedance are within two orders of magnitude of the GAC
Red shaded cells indicate GAC is exceeded by more than two orders of magnitude of the GAC
i Public Open Space Park GAC
ii Commercial GAC
iii Public Open Space Maintenance Worker GAC
* Locations are within area which will be excavated to form the aviation platform
**GAC is based on chromium III, no exceedances of chromium VI GAC.

10.2.5 Comparison to the assessment criteria indicated the following for Area A:

a. Overall there was very few exceedances in relation to the number of tests undertaken. For all contaminants less than 3 % of the samples undertaken for analysis had exceedances.

b. The majority of the exceedances were within the construction waste type (40 %). Non-chalky cover, recent domestic and industrial waste types had 14 %, 15 % and 17 % of the overall exceedances respectively. The fewest exceedances were in the old domestic (11 %), commercial (1 %) and chalky cover (1 %) waste types.

c. Exceedances were mainly for polyaromatic hydrocarbons (PAHs) and metals. The risk driving pathway for these contaminants is through direct contact pathways such as dermal contact, soil ingestion and inhalation of soil derived dusts. These contaminants are not volatile and therefore do not pose a risk through inhalation of vapours.

d. The majority of the exceedances are within one order of magnitude of the GAC, with a number only marginally exceeding the criteria.

e. One marginal exceedance for beryllium was noted in the natural strata at BH228 (10.8m bgl). Future receptors will not come into contact with material at this depth and therefore it is not considered a potential risk.

f. Occasional exceedances were noted which were greater than one order of magnitude of the GAC for nickel, lead and 1,2,4-Trimethylbenzene. These occasional elevated concentrations reflect the variable nature of the waste. The main risk from lead and nickel contamination is through direct exposure to the contaminant in the soils i.e. ingestion or inhalation of soil derived dusts. The exceedances were located at 6.4 m and 5.5 m respectively, any future receptors are unlikely to come into contact with contaminants at this depth. 1, 2, 4- Trimethylbenzene is a volatile aromatic hydrocarbon. The highest exceedances of this compound was at GW203B (4.7m bgl) and was co-located with other volatile compounds which exceeded their respective GACs i.e. naphthalene and 2-methylnaphthalene. The main risk driving pathways from these compounds is inhalation. The risks from soil vapours requires further consideration and is assessed further as part of a DQRA.

g. Overall the concentration of contaminants are not significantly elevated. The majority of contaminants present pose a risk through direct contact and as the development is largely hardstanding (see **Figure 16** of this document) future users are unlikely to come into direct contact with the underlying material. However, given the heterogeneous nature of landfills and the lack of engineered cover system, it should be assumed that measures will be required, particularly in landscape areas, to prevent direct contact with the waste.

Acute assessment criteria

10.2.6 Comparison of the soil samples against the AGAC is shown in **Table 10.5.** The results only indicated one exceedance for arsenic of the oral criteria for a child trespasser within Area A. As previously discussed this scenario is considered unlikely. Appropriate measures should be undertaken during construction to ensure the site is secure and dusts are controlled. Based on the results of the acute assessment no special precautions, above and beyond best practice, are considered necessary during construction works to control potential acute risks.

Table 10.5 Comparison of maximum soil concentrations to AGAC.

Contaminant	Receptor	Pathway	AGAC (mg/kg)	Max Recorded Value (mg/kg)	
				Area A	Airport Access Road
Arsenic	Child	Oral	80	113	17
		Dermal	7,000,000		
	Adult	Oral	7,000		
		Dermal	14,000,000		
Benzene	Child	Oral	47	0.37	<LOD
		Dermal*	14,000,000		
		Inhalation	190		
	Adult	Oral*	4,100		
		Dermal*	79,000,000		
		Inhalation	370		
Cadmium	Child	Oral	140	73.9	10.6
		Inhalation	1,800,000		
	Adult	Oral	12,000		
		Inhalation	3,500,000		
Free Cyanide	Child	Oral	24	<LOD	No Testing
		Inhalation	380		
	Adult	Oral	2,100		
		Inhalation	1,400		
Phenol	Child	Oral	2,000	370	No Testing
		Inhalation*	160,000		
	Adult	Oral*	175,000		
		Inhalation*	320,000		
Trichloroethene (TCE)	Child	Inhalation	16,000	0.24	<LOD
	Adult		33,000		
Vinyl Chloride	Child	Inhalation	110	<LOD	<LOD
	Adult		220		

Notes:
* AGAC likely to exceed soil saturation limits.
<LOD = all results less than Limit of Detection

Groundwater Vapour Assessment

10.2.7 Comparison of the perched groundwater samples against the GACgwvap is summarised in **Table 10.6.** The assessment was completed for Area A only no groundwater samples were obtained for the Airport Access Road and this PCL has been discounted for this area as there are no buildings or enclosed spaces planned. See **Appendix E** for the detailed assessment.

Table 10.6 Exceedances of contaminants in groundwater when compared to generic assessment criteria (GACgwvap).

Contaminant	Location	Installation response zone	Concentration (mg/l)	GAC (mg/l)
TPH >C10-C12 Aliphatic	WS224	1-5m	3.64	3.6*
			4.51	
1,2,4 Trimethylbenzene			4.49	2.2**
			3.04	
Notes: * Solubility limit for contaminant is 0.034 mg/l ** Solubility limit for contaminant is 559 mg/l				

10.2.8 The results for Area A indicated the following:

a. Only one location, WS224, had exceedances of contaminants in the perched groundwater when compared to the GACgwvap. This location is within the LTCP;

b. The solubility limit for TPH >C10-C12 aliphatic was exceeded, suggesting that free product may be present at this location. During the monitoring rounds a thin layer of product was consistently noted on the surface of the water at this location and the laboratory comments confirmed that this sample contained oil/product;

c. Observations from site during the GI works at location WS224 showed heavy black staining between 4-5m bgl (Photograph 3), suggesting the presence of localised product. An elevated PID reading of 185.6 ppm at 3.6m bgl (see Table 4.4) was also noted at this location;

d. No product was noted at any other locations within the LTCP. Therefore, this location appears to be an isolated hotspot; and

e. WS224 is in proximity to the excavation works for the aviation platform and there is the potential for the product present to be mobilised during the works and a pathway created to the underlying Chalk. Therefore, the free product at this location should be removed as part of the works. Any perched water in the material should also be removed. The material from this location is unlikely be suitable for reuse without treatment to remove the product present. The removal of this material has been included within the ORS (Ref. 46) (**Appendix 17.5** of the ES **[TR020001/APP/5.02]**).

10.3 Asbestos

Photograph 3 Staining noted in core at location WS224 between 4-5m bgl.

Area A

10.3.1 There are two identified potential sources of asbestos within Area A:

a. Former landfill - historically asbestos has been used in a wide range of products and forms. Therefore, there is the potential for asbestos products to be present in the landfill; and

b. Former scrap yard - the area which is currently occupied by Tidy Tip (see **Figure 4** of this document) was identified in **Appendix 17.1** of the ES (Ref. 1) **[TR020001/APP/5.02]** as historically been used as a scrapyard. Therefore, asbestos products may be presented associated with clutch and brake linings. Any asbestos waste from the scrapyard may have been disposed of in the landfill and dispersed or may still be present locally in the area of the former scrapyard.

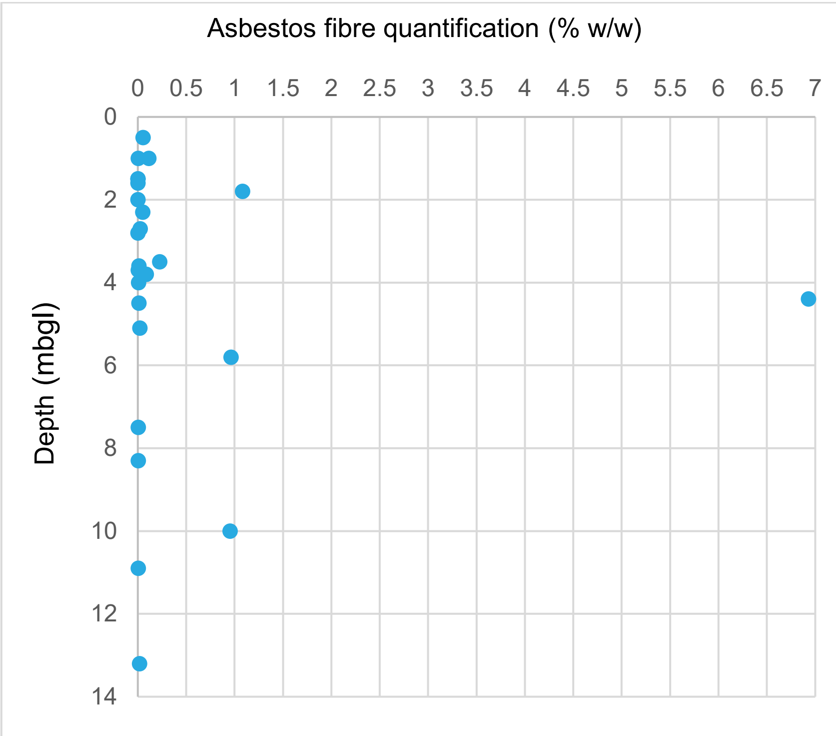
Former Landfill

10.3.2 Asbestos testing has been undertaken during both the preliminary and detailed GI. During the initial phase of investigation in 2016/17 asbestos testing was undertaken on 28 samples and was found to be present in three locations. Where asbestos was found, quantification was undertaken. Loose fibres of chrysotile were identified at LF-BH03, LF-BH07 and LF-BH08 and all were less than the LOD (<0.001% w/w).

10.3.3 Asbestos testing was undertaken on 355 samples and asbestos fibres/ACMs were visually identified and/or confirmed to be present in 73 samples. The asbestos was generally in the form of chrysotile or amosite fibres or combination of chrysotile and amosite. Only one sample proved positive for crocidolite, which was present combined with chrysotile.

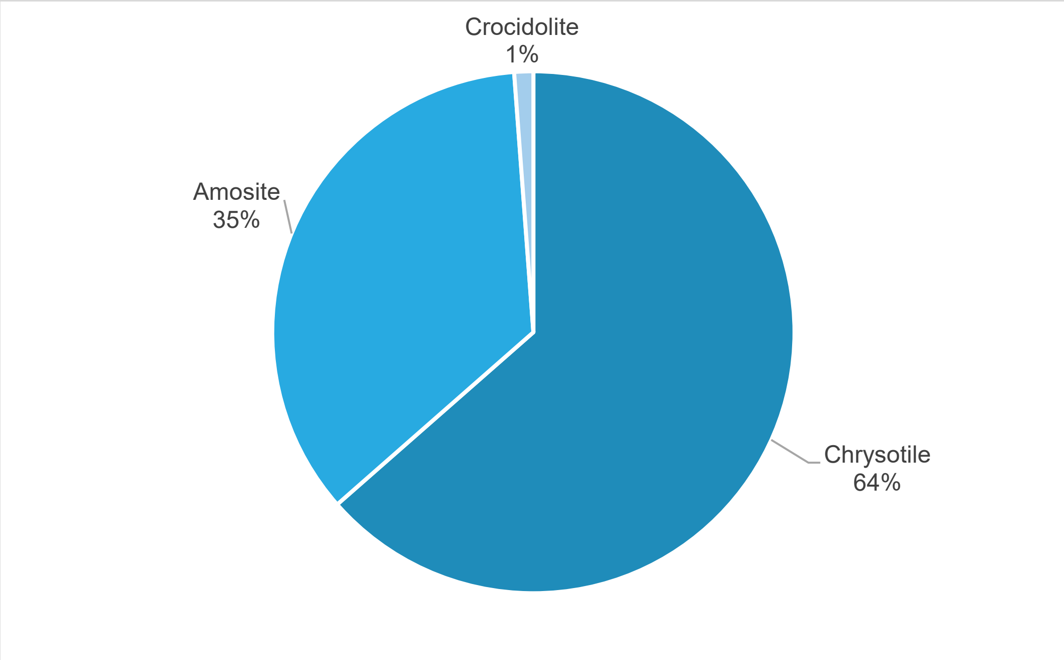
10.3.4 No asbestos caches or ‘cells’ of asbestos waste were identified, results indicate asbestos fibres and ACMs are dispersed throughout the landfill mass at various depths. Asbestos quantification was undertaken on 68 samples, the distribution of results is shown in **Drawing 11** and this indicates that higher asbestos fibre quantities were detected in the top 5m of the landfill. However, this is likely to be a result of the higher sampling frequency at this depth, see **Section 10.1.**

Drawing 11 Asbestos quantification in the landfill compared to depth.



10.3.5 Chrysotile (white asbestos) was historically the most commonly used form of asbestos in the UK (Ref. 47). This is reflected in the results from the GIs which indicated 64% of the asbestos fibre detections were for chrysotile (see **Drawing 12**).

Drawing 12 Percentage of asbestos types identified during the GIs.



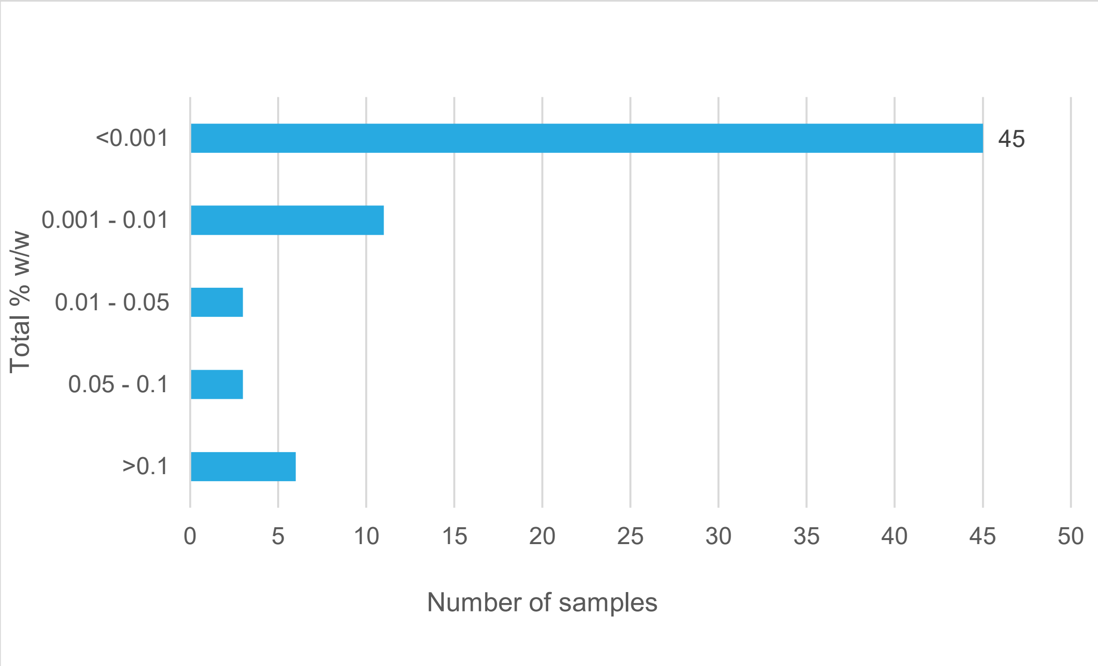
10.3.6 Asbestos was detected in all eras of waste (see **Table 10.7**), indicating its extensive use in products throughout the period of filling at the landfill. The highest fibre contents were seen in the 1960-1970 waste.

Table 10.7 Asbestos detections and fibre content by era of waste.

Waste Era	No of samples	No. with asbestos fibres detected	% of detections	Min (%w/w)	Max (%w/w)
Pre 1947	7	3	43%	0.0037	0.963
1947-1955	7	2	29%	<0.001	0.001
1955-1960	17	2	12%	<0.001	0.0856
1960-1970	43	11	26%	<0.001	6.93
1970-1980	244	52	21%	<0.001	0.953

10.3.7 The results of the quantification analysis indicated that the asbestos fibre content was generally <0.001% (46 out of 68 samples). Only six samples had asbestos fibres content above the hazardous waste threshold of <0.1%. The results of the quantification analysis from the GIS is shown in **Drawing 13.**

Drawing 13 Total % w/w asbestos identified.



10.3.8 Whilst the majority of the asbestos fibres in the soils detected were below 0.001% there are some higher results. In general, higher concentrations of asbestos in soil have the capacity to liberate higher concentrations of asbestos fibres into the air but this is also very dependent on the type of ACM present and its ability to release fibres.

Former Scrapyard

10.3.9 The former scrapyard was situated on the north western boundary of the landfill, in the location of the current Tidy Tip and is shown on aerial photography from late 1960s until early 1970s.

10.3.10 A ground investigation was undertaken in this area as part of work to examine the potential relocation of Hangar 24 (Ref. 48). During the GI 26 samples were tested for the presence of asbestos, eight samples positively identified the presence of asbestos (30% of samples). The results are shown in **Table 10.8**. The results of the quantification analysis indicated that the asbestos fibre content was generally <0.001%, only three were above the detection limit. Only one had asbestos fibres content above the hazardous waste threshold of <0.1 %.

10.3.11 It should also be noted that one location was terminated during the works (TP104) due to potential bundles of loose asbestos fibres at the base of the trial pit to prevent fibre release.

Table 10.8 Locations where asbestos was detected during the Hangar 24 GI (Ref. 48).

Location	Depth (m)	Asbestos detected	Form	Quantification (%w/w)
TP101	1.10	Chrysotile	Small bundles of fibres	<0.001
TP102	0.90	Amosite & Chrysotile	Bundles of fibres	0.008
			Cement	0.369
TP104	0.30	Amosite	Bundles of fibres	< 0.001
TP104	2.60	Chrysotile & Crocidolite	Cement	n/a
TP105	1.30	Chrysotile	Bundles of fibres	0.001
TP107	0.90	Amosite	Bundles of fibres	< 0.001
BH103	1.00	Amosite	Small bundles of fibres	<0.001

10.3.12 The nature of the asbestos encountered in the area of the former scrapyard appeared to be different from that encountered within the landfill, no visible bundles of fibres were noted in the landfill during the GI.

10.3.13 The presence of asbestos appears to be limited to the bunds on the boundary of the Tidy Tip site. Demolition or possible landfill type materials (including bricks, concrete, metal and plastic) were evident in all of the samples recording positive results. Based on a review of historical aerial photographs the material within the bund appears to have originated from the scrapyard.

Risk from Asbestos

10.3.14 Due to the nature of the works to be undertaken within Area A i.e. extensive excavation and the detection of some higher concentrations of asbestos fibres in the GIs, further assessment is required. The further assessment has been considered as part of a DQRA to understand whether specific remediation is required to address this risk prior to construction works.

Airport Access Road

10.3.15 Asbestos testing was undertaken on 53 samples across the route and asbestos fibres were confirmed to be present in 7 samples of Made Ground. The asbestos was generally in the form of chrysotile fibres with one occurrence of amosite fibres and amosite board. Four samples were measured to have a concentration of <0.001%, two samples with a concentration of 0.002% and one sample with 6.622%. No asbestos containing materials were recorded as part of the investigative works.

10.3.16 The distribution of the detected samples was typically limited between Dairyborn Escarpment/Airport Way and Percival Way/Presidents Way. A summary of detected asbestos is presented in **Table 10.9.**

Table 10.9 Locations where asbestos detected along the route of Airport access Road.

Area	Location	Depth (mbgl)	Asbestos Type	Asbestos Identification	Asbestos Quantification	Site observations
Percival Way / Presidents Way	PFWS10	1.00	Loose Fibres	Chrysotile	<0.001	No visual ACM
	PFWS12	0.20	Loose Fibres	Chrysotile	<0.001	No visual ACM
	PFWS12	1.00	Loose Fibres	Chrysotile	0.002	No visual ACM
Dairyborn Escarpment/ Airport Way	PFCP60	0.30	Loose Fibres	Amosite	<0.001	No visual ACM
	PFWS41	1.50	Board (Loose Fibres)	Amosite	6.622	No visual ACM
	PFWS44	0.50	Loose Fibres	Chrysotile	0.002	No visual ACM
	PFWSHH01	0.50	Loose Fibres	Chrysotile	<0.001	No visual ACM

Risk from Asbestos

10.3.17 The greatest potential risks from asbestos will be during enabling and construction works, when soils are disturbed and may allow fibres to be released into ambient air. Further consideration of the potential risks from asbestos fibres should be undertaken at the detailed design stage to inform the risks to construction workers. The likely classification of works under the Control of Asbestos Regulations (Ref. 47) and risks to construction workers will need to be assessed using CL:AIRE's Joint Industry Working Group (JIWG) Decision Tools (Ref. 49) prior to any works.

10.4 Area A- PCBs

10.4.1 Using the PCDD, PCDFs and dioxin-like compounds worksheet for a commercial land use scenario a HI was derived for Area A. The spreadsheets are provided in **Appendix E**. The HI for each of the samples is presented below in **Table 10.10.** None of the concentrations had a hazard index greater than 1.0 indicating that the concentrations are unlikely to pose a risk to future users of the site.

Table 10.10 Derived Hazard Index (HI) for PCDD, PCDF and dioxin like compounds in soils.

Location	Depth (mbgl)	Hazard Index (HI)
LFBH02	6.0	0.00
LFBH04	5.5	0.07
LFBH06	5.0	0.02

Location	Depth (mbgl)	Hazard Index (HI)
LFBH07	3.5	0.01
LFBH08	3.4	0.00
LFBH09	6.4	0.00
LFBH10	4.0	0.00
LFBH12	6.5	0.01
BH202A	8.6	0.00
BH207A	12.3	0.00
BH216	6.1	0.00
BH217	13.5	0.04
BH219	16.2	0.01
BH221	7.1	0.00
BH233	6.2	0.01
GW206	7.8	0.00
LW201	13.9	0.00
LW204	1.9	0.00
TP206	3.5	0.00
TP209	1.6	0.00
TP214	2.6	0.01
TP221	3.6	0.00
TP222	2.2	0.01
TP229	4.5	0.01
TP242	5.5	0.02
TP246	4.4	0.01
TP260	4.4	0.00
TP274	5.6	0.02
WS224	3.9	0.02

11 GROUND GAS RISK ASSESSMENT

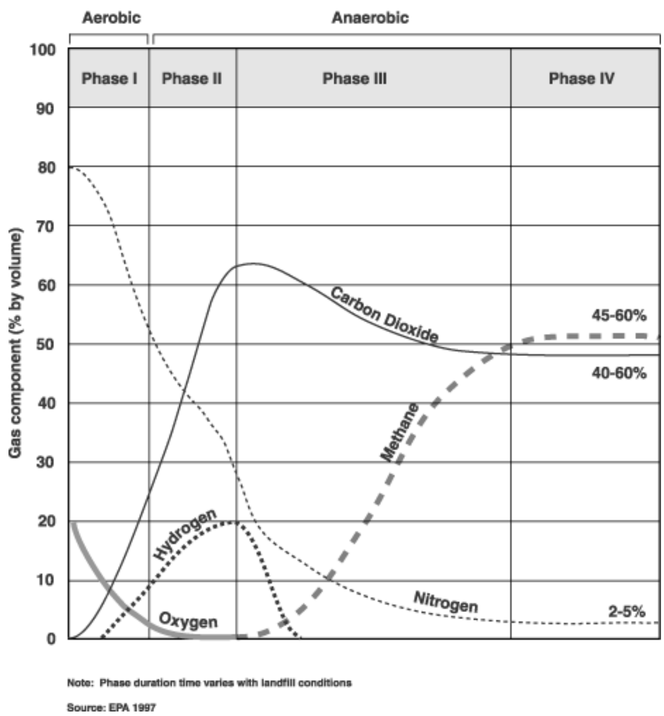
11.1 Introduction

11.1.1 There is known to be methane, carbon dioxide and potentially other trace gas present within Area A due to its former use as a landfill.

11.1.2 Landfill gas is a complex mixture of gases created by the action of microorganisms within a landfill. The volume that a landfill gases depends on its age, the decomposition status of the waste and the types of waste within it. Generally, more recently buried waste will produce more gas than older waste. Landfills usually produce appreciable amounts of gas within 1 to 3 years. Peak gas production usually occurs 5 to 7 years after wastes are dumped. Almost all gas is produced within 20 years after waste is dumped; however, small quantities of gas may continue to be emitted from a landfill for 50 or more years. The phases of landfill gas generation are shown in **Drawing 14.**

11.1.3 By volume, landfill gas typically contains 45% to 60% methane and 40% to 60% carbon dioxide. Landfill gas also includes small amounts of nitrogen, oxygen, ammonia, sulphides, hydrogen, carbon monoxide, and nonmethane organic compounds (NMOCs) such as trichloroethylene, benzene, and vinyl chloride.

Drawing 14 Phases of gas generation in a landfill.



11.1.4 Significant depths of Made Ground have been recorded in certain areas of the Airport Access Road. However, the proposed access road does not include any buildings, as such there is no potential for accumulation of vapours or gases in indoor air. However, further GI and/or assessment may be required at the detailed design stage to inform the risks to construction workers and future maintenance workers.

11.1.5 Other areas of Made Ground across the wider airport site may also be a potential source of ground gases, however these are considered to be less significant than the landfill. Therefore the following sections provide an assessment of Area A only.

11.2 Methodology

11.2.1 Current UK guidance on the monitoring of ground gas emissions, the associated assessment of risk and the implications for the design of new development is contained in the following principal documents:

a. CIRIA C665 2007, Assessing risks posed by hazardous ground gases to buildings (Ref. 50); and
b. British Standard, BS 8485:2015+A1:2019, Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings (Ref. 51).

11.2.2 In addition, reference has been made to the following document in order to inform the design of the gas monitoring regime:

a. Chartered Institute of Environmental Health (2008) The Local Authority Guide to Ground Gas (Ref. 30).

11.2.3 The results of the spot gas monitoring were assessed using the classification system presented within CIRIA C665 (Ref. 50) for Situation A, to provide an indication of the gassing regime at the site. The classification system uses gas concentrations and recorded flow rates for methane and carbon dioxide to determine a gas screening value (GSV). The GSV is calculated by multiplying the maximum recorded flow rate (l/hr) against the maximum recorded gas concentration (%) from all individual wells across the site to determine a value reflecting the 'worst credible' scenario. The GSV is used to determine a Characteristic Situation (CS) for the site. The CS is a qualitative method of defining the risk to a proposed development constructed on gassing ground. The CS ranges from 1 to 6, where 1 is very low risk and 6 is very high risk. The characteristic situations are shown below in **Table 11.1.**

Table 11.1 Characteristic situations used in ground gas assessment (Ref. 50)

CS (CIRIA 665)	Risk classification	Gas screening value (CH_4 or CO_2) (l/h)	Additional factors	Typical source of generation
1	Very low risk	<0.07	Typically CH_4 not to exceed 1 percent by volume and /or CO_2 not to exceed 5 percent by volume	Natural soils with low organic content

CS (CIRIA 665)	Risk classification	Gas screening value (CH_4 or CO_2) (l/h)	Additional factors	Typical source of generation
			otherwise consider increase to CS 2	"Typical" made-up ground
2	Low risk	<0.7	Borehole air flow rate not to exceed 70 l/hr otherwise consider increase to CS3	Natural soil, high peat/organic content
3	Moderate risk	<3.5		Old landfill, inert waste, mineworking flooded
4	Moderate to high risk	<15	Quantitative risk assessment required to evaluate scope of protective measures	Mineworking-susceptible to flooding, completed landfill.
5	High risk	<70		Mineworking unflooded inactive with shallow workings near surface
6	Very high risk	>70		Recent landfill site

11.2.4 The CIRIA C665 guidance document (Ref. 50) and Local Authority Ground Gas Guidance (Ref. 52) details the monitoring requirements for the period and frequency of monitoring for a low sensitivity (commercial) development with a high source gas generation potential. The requirements have been met as follows:

a. **Monitoring frequency** – the requirements detailed in CIRIA 665 are 12 monitoring occasions over a 12 month period with at least two sets of readings at low and falling atmospheric pressure (but not restricted to periods below <1,000 mb). The current spot monitoring data alongside the continuous monitoring data obtained during 2018 is considered sufficient to meet the requirements of CIRIA C665 and to inform the design of ground gas protection measures.

b. **Number of monitoring points within the landfill**- the requirements for number of monitoring points, frequency and duration of ground gas monitoring is detailed in a number of best practice guidance documents including CIRIA 665 and Local Authority Ground Gas Guidance. For older domestic landfills (moderate hazard potential) and low sensitivity of end use it details a spacing of 25-75 m spacing. The higher end of the spacing was adopted as continuous monitoring techniques, in conjunction with conventional spot sampling give additional confidence in the ground gas regime. The 75 m spacing across 450,000 m2 site is equal to 80 locations. 24 locations were undertaken in the preliminary GI and 55 locations during the detailed GI. A mixture of deeper (boreholes) and shallow locations (window samples) has been undertaken to profile the gassing occurring in the waste.

c. **Number of boundary monitoring points** – **Table 5.2** in the Local Authority ground gas guidance details recommended range of typical borehole spacing for boundary monitoring to assess off-site conditions. For fissure or fracture flow dominated permeable strata (for example blocky sandstone or igneous rock) and development within 150 m, the borehole monitoring spacing should be 5-20 m. A range of spacing has been used around the boundary depending on the proximity and sensitivity of the land use. Full details area provided in the GI strategy (Arup (2018)). The number of locations undertaken during the GIs meets the requirements of the guidance.

11.3 Results

Area A -Landfill

11.3.1 Gas measurements were taken from all monitoring wells installed within the landfill waste as follows:

a. Boreholes installed as part of 2016 Airport Access Road GI (Ref. 8) monitored on up to 8 occasions between October and November 2016;

b. Boreholes installed as part of 2017 landfill GI (Ref. 6) monitored on up to 4 occasions in 2017 and up to 12 monthly rounds between April 2018 and March 2019;

c. Boreholes installed as part of 2018 GI monitored on up to 6 occasions over a 3 month period following installation (Ref. 48); and

d. Continuous gas monitoring in 4 wells between August and October 2018 (Ref. 48).

11.3.2 Only the spot monitoring results have been considered in this GQRA. The continuous gas monitoring has been as part of a DQRA (Ref. 53) for Human Health, **Appendix 17.3** of the ES **[TR020001/APP/5.02]**.

11.3.3 The analysis shown in **Table 11.2** and **Figure 17** of this document indicates that the majority of gas spot monitoring results were considered to be CS2 with a few CS3 readings. The CS3 readings recorded were as a result of negative flow rates, which were considered to be a positive flow rate for the purposes of the initial assessment. Negative flow rates indicate that the gas pressures within the ground are below that of atmospheric pressure and can occur due rapid changes in atmospheric pressure. It is noted from the monitoring results that in many instances the negative flow rate was only recorded on initial opening of the gas tap. The effect of atmospheric pressure on the gas regime is more accurately measured with continuous gas monitoring. The detailed assessment of the effect of atmospheric pressure and the gas regime of the site has been further considered as part of a DQRA.

11.3.4 The full gas results are presented in **Appendix F.**

Table 11.2 Ground gas assessment summary within landfill waste.

Location	Maximum Recorded Value			GSV Methane (l/hr)	GSV Carbon Dioxide (l/hr)	Characteristic Situation (CS)
	Flow rate (l/hr)	Methane (%)	Carbon Dioxide (%)			
Spot monitoring data						
PFCPRC38[1]	0.4[2]	48.0	16.9	0.192	0.068	2
PFCPRC39[1]	6.0[2]	46.0	19.5	2.76	1.17	3
PFCPRC40[1]	5.7[2]	31.8	24.2	1.81	1.37	3
PFCPRC41[1]	1.8	59.8	20.8	1.07	0.37	3
PFCPRC41A[1]	3.3[2]	46.2	19.6	1.52	0.65	3
PFCPRC43[1]	0.3	42.7	25.8	0.13	0.077	2
PFCPRC44[1]	2.4[2]	31.0	23.5	0.74	0.56	2
LFBH03G[3]	0.1	51.8	21.8	0.052	0.022	2[4]
LFBH04G[5]	0.3	28.2	15.1	0.084	0.045	2
LFBH06[3]	0.3	56.3	20.3	0.17	0.061	2
LFBH07[3]	0.2	61.2	23.6	0.12	0.047	2
LFBH08G[3]	0.2	62.1	53.1	0.12	0.11	2
LFBH09[5]	0.1	43	15.9	0.043	0.016	2[4]
LFBH10GA[3]	0.1	40.5	7.6	0.041	0.008	2[4]
LFBH12A[3]	0.1	6.2	20.8	0.006	0.021	2[4]
PFWS58A[6]	0.1	2	4.9	0.002	0.005	2[4]
BWS212[6]	0.3	48.1	16	0.14	0.048	2
BWS216[6]	0.1	0.8	11.9	0.0008	0.012	2[4]
BWS217[7]	9[2]	25.6	6.9	2.3	0.621	3
WS201[6]	0.2	0.8	9.4	0.002	0.019	2[4]
WS203[6]	0.1	54.9	30.3	0.055	0.03	2[4]
WS204[6]	0.1	48.3	15.7	0.048	0.016	2[4]
WS205A[6]	0.1	64.5	48.3	0.065	0.048	2[4]
WS206A[6]	0.1	69.6	29.6	0.07	0.03	2
WS207[6]	0.1	40.6	17.2	0.041	0.02	2[4]
WS208[6]	0.1	65.2	30	0.065	0.03	2[4]
WS209[6]	0.1	59	34.3	0.059	0.03	2[4]

Location	Maximum Recorded Value			GSV Methane (l/hr)	GSV Carbon Dioxide (l/hr)	Characteristic Situation (CS)
	Flow rate (l/hr)	Methane (%)	Carbon Dioxide (%)			
WS210[6]	0.1	64.5	25	0.065	0.025	2[4]
WS211[6]	0.1	37.4	20.3	0.037	0.02	2[4]
WS212[6]	0.1	73.7	32.2	0.074	0.03	2
WS213[6]	0.1	56.2	27.3	0.056	0.03	2[4]
WS214[7]	4.6[2]	46.2	5.9	2.13	0.271	3
WS215A[6]	0.1	37	21.8	0.037	0.02	2[4]
WS216[6]	0.1	37.3	22.7	0.037	0.02	2[4]
WS217B[6]	0.1	0.9	6.6	0.001	0.007	2[4]
WS218[6]	0.1	52.3	23.6	0.052	0.024	2[4]
WS219[6]	0.1	53.6	25.9	0.054	0.026	2[4]
WS220[7]	0.4	72.9	23.2	0.292	0.093	2
WS221[6]	0.1	38.6	13	0.039	0.013	2[4]
WS222[7]	0.3	76.8	10.1	0.230	0.030	2
WS223[7]	0.9	42	8.8	0.378	0.079	2
WS224[7]	0.1	80.6	7.6	0.081	0.008	2
WS225[7]	0.8[2]	59.2	18.6	0.474	0.149	2
BH201[6]	0.1	32.2	25.5	0.032	0.026	2[4]
BH203[6]	0.1	45.7	21.2	0.046	0.021	2[4]
BH204[6]	0.3[2]	50.7	20.5	0.152	0.062	2
BH205A[6]	0.1	57.7	32.2	0.058	0.032	2[4]
BH207[6]	0.1	74	25.2	0.074	0.025	2
BH209[6]	0.1	68.9	47.6	0.069	0.048	2[4]
BH210[7]	0.6	64.2	12.5	0.39	0.08	2
BH212A[6]	0.1	37.4	29.6	0.037	0.030	2[4]
BH213[6]	0.1	59	24.7	0.059	0.025	2[4]
BH214[6]	0.1	41.6	33.4	0.042	0.033	2[4]
BH216[7]	0.7	57.4	16.8	0.4	0.12	2
BH217[7]	0.9	62.6	12.3	0.56	0.11	2
BH218[6]	0.1	68	28.6	0.068	0.029	2[4]
BH219[6]	0.1	26.6	22.4	0.027	0.022	2[4]
BH220[6]	0.1	56.4	27.6	0.056	0.028	2[4]
BH221[6]	0.1	29.3	18.7	0.029	0.019	2[4]
BH222[7]	0.1	73.4	17.1	0.073	0.017	2

Location	Maximum Recorded Value			GSV Methane (l/hr)	GSV Carbon Dioxide (l/hr)	Characteristic Situation (CS)
	Flow rate (l/hr)	Methane (%)	Carbon Dioxide (%)			
BH223[7]	0.1	74.5	60	0.075	0.06	2
BH225[6]	0.2[2]	26.3	18.9	0.053	0.038	2[4]
BH226[6]	0.1	14.9	17.1	0.015	0.017	2[4]
BH227[7]	0.1	34.4	16.4	0.034	0.016	2[4]
BH228[7]	0.2[2]	45.2	16.7	0.09	0.033	2
BH229[6]	0.1	43.9	27.3	0.044	0.027	2[4]
BH231[7]	0.2	75.6	8.2	0.151	0.016	2
BH232[7]	0.1	60.7	18.1	0.061	0.018	2[4]
BH233[6]	0.1	16.6	18.6	0.017	0.019	2[4]

[1] Well monitored on up to 8 occasions October 2016 to November 2016
[2] Maximum flow rate recorded was a negative pressure. For purposes of this assessment the flow rate was assumed to be positive pressure for a conservative initial assessment
[3] Well monitored on up to 4 occasions in 2017, and on up to 12 monthly rounds between April 2018 and March 2019
[4] Characteristic Situation increased to CS2 based on elevated methane and/or carbon dioxide concentrations due to presence of potential high risk gas source.
[5] Well monitored on up to 4 occasions February to May 2017
[6] Well monitored on up to 6 occasions August to October 2018
[7] Well monitored on up to 7 occasions January to March 2019
[8] Continuous gas monitoring for 12 weeks between August and October 2018

Outside landfill

11.3.5 Outside of the landfill includes perimeter wells and monitoring wells along the proposed Airport Access Road alignment. The concentrations of gas recorded are low, with the general exception of BWS203, BWS211, BWS214, BBH209, BBH210 and LF-BH05G, which are all located adjacent to the landfill boundary. LF-BH05G and BBH210 are located within an area which has a significant thickness of Made Ground. Flow rates across the holes were low. The analysis shown in **Table 11.3** indicates that the area outside the landfill ranges from CS1 to CS2, which is considered low risk, although care should be taken during the design and construction phases of the development to ensure that no preferential pathways are created.

Table 11.3 Ground gas assessment summary outside landfill waste.

Location	Maximum Recorded Value			GSV Methane (l/hr)	GSV Carbon Dioxide (l/hr)	Characteristic Situation (CS)
	Flow rate (l/hr)	Methane (%)	Carbon Dioxide (%)			
Spot monitoring						
GW201 (gas)[1]	0.1	0.9	5.6	0.0009	0.006	1

Location	Maximum Recorded Value			GSV Methane (l/hr)	GSV Carbon Dioxide (l/hr)	Characteristic Situation (CS)
	Flow rate (l/hr)	Methane (%)	Carbon Dioxide (%)			
BWS203[1]	0.1	4.1	12.2	0.004	0.012	2[2]
BWS206[1]	0.2	0.5	3.2	0.001	0.006	1
BWS207[1]	0.2	0.5	1	0.001	0.002	1
BWS209[1]	0.2	0.5	5.9	0.0001	0.012	1
BWS210[1]	0.2	0.4	0.9	0.0008	0.002	1
BWS211[1]	0.2	54.4	29.7	0.109	0.059	2
BWS213[1]	0.1	0.7	23	0.0007	0.023	2[2]
BWS214[1]	0.1	9.3	12.7	0.009	0.013	2[2]
BWS218[1]	0.2	0.4	1.1	0.0008	0.002	1
BBH204[1]	0.2	0.5	3.6	0.001	0.007	1
BBH209[1]	0.1	27.7	20.5	0.028	0.021	2[2]
BBH210[1]	0.2[3]	9.3	3.3	0.019	0.007	2[2]
LFBH01[8]	0.1	0.1	5.4	0.0001	0.005	1
LFBH05[8]	0.2	0.4	1.1	0.0008	0.002	1
LFBH05G[4]	0.1	8.7	9.7	0.009	0.01	2[2]
LFBH10[8]	0.1	<0.1	2.6	0.0001	0.003	1
LFBH13[8]	0.1	0.2	1.7	0.0002	0.002	1
H24-BH101[5]	6	<0.1	2.9	0.006	0.174	2
H24-BH102[5]	0.1	<0.1	0.6	0.0001	0.0006	1
MPT-BH101-Deep[6]	0.1	0.1	2.8	0.0001	0.003	1
MPT-BH101-Shallow[6]	0.1	<0.1	3	0.0001	0.003	1
MPT-BH102-Shallow[6]	0.1	<0.1	0.7	0.0001	0.0007	1
MPT-BH105[6]	0.1	<0.1	2.7	0.0001	0.003	1
MPT-BH116-Deep[6]	0.5[3]	<0.1	0.7	0.0005	0.004	1
MPT-BH116-Shallow[6]	0.2	<0.1	0.1	0.0002	0.0002	1
MPT-BH117[6]	0.2	<0.1	1.8	0.0002	0.004	1
CP-BH11[7]	0.1	<0.1	2	0.0001	0.002	1
CP-BH12[7]	0.1	<0.1	3.7	0.0001	0.004	1
CP-BH24[7]	0.1	0.1	2.5	0.0001	0.003	1

Location	Maximum Recorded Value			GSV Methane (l/hr)	GSV Carbon Dioxide (l/hr)	Characteristic Situation (CS)
	Flow rate (l/hr)	Methane (%)	Carbon Dioxide (%)			
CP-BH27[7]	0.6	0.1	1.4	0.0006	0.008	1
CP-BH29[7]	0.1	0.1	1.8	0.0001	0.002	1
CP-BH32[7]	0.1	0.1	1.2	0.0001	0.001	1
CP-BH50[7]	0.1	0.2	1.3	0.0002	0.001	1
CPBH51[7]	0.1	0.1	1.7	0.0001	0.002	1
CP-BH55[7]	0.1	0.1	2.2	0.0001	0.002	1
PFCP31[9]	0.1	<0.1	0.6	0.0001	0.0006	1
PFCP33[9]	0.2	<0.1	0.3	0.0002	0.0006	1
PFCP36[9]	0.2	<0.1	6.2	0.0002	0.012	1
PFCPRC02[9]	0.2	0.1	2.2	0.0001	0.004	1
PFCPRC07[9]	0.2	<0.1	1.2	0.0002	0.002	1
PFCPRC18[9]	0.2[3]	<0.1	2.4	0.0002	0.005	1
PFCPRC24[9]	0.4[3]	<0.1	0.5	0.0004	0.002	1
PFCPRC25[9]	0.2	<0.1	4.1	0.0002	0.008	1
PFCPRC27[9]	0.1[3]	<0.1	0.3	0.0001	0.0003	1
PFCPRC46[9]	0.8[3]	0.1	2.7	0.0008	0.022	1
PFWS02[9]	0.2	<0.1	6.2	0.0002	0.012	1
PFWS04[9]	0.1	<0.1	3.1	0.0001	0.003	1
PFWS05[9]	0.2	<0.1	2.8	0.0002	0.006	1
PFWS08[9]	1.1	<0.1	4.2	0.001	0.046	1
PFWS13[9]	0.3[3]	<0.1	2.7	0.0003	0.008	1
PFWS26[9]	0.1	<0.1	2.8	0.0001	0.003	1
PFWS30	0.1	<0.1	0.8	0.0001	0.0008	1
Concept-BH01[10]	0.1	<0.1	0.5	0.0001	0.0005	1
Concept-BH04[10]	0.1	<0.1	2.3	0.0001	0.0023	1
Concept-BH06[10]	0.1	<0.1	0.4	0.0001	0.0004	1
Concept-BH07A[10]	0.1	<0.1	0.5	0.0001	0.0005	1
Concept-BH08[10]	0.1	<0.1	7.9	0.0001	0.008	1

Location	Maximum Recorded Value			GSV Methane (l/hr)	GSV Carbon Dioxide (l/hr)	Characteristic Situation (CS)
	Flow rate (l/hr)	Methane (%)	Carbon Dioxide (%)			
Concept-WS05[10]	0.1	<0.1	<0.1	0.0001	0.0001	1
Concept-WS03[10]	0.1	<0.1	0.3	0.0001	0.0003	1

[1] Well monitored on up to 6 occasions August to October 2018

[2] Characteristic Situation increased to CS2 based on elevated CH4 and/or CO2 concentrations due to presence of potential high risk gas source.

[3] Maximum flow rate recorded was a negative pressure. For purposes of this assessment the flow rate was assumed to be positive pressure for a conservative initial assessment

[4] Well monitored on up to 4 occasions in 2017, and on up to 12 monthly rounds between April 2018 and March 2019

[5] Well monitored on up to 6 occasions October 2017 to January 2018

[6] Well monitored on up to 8 occasions January to March 2017

[7] Well monitored on up to 5 occasions October to December 2016

[8] Well monitored on up to 5 occasions November 2016 to May 2017

[9] Wells monitoring on up to 9 occasions October to November 2016

[10] Wells monitored on up to 4 occasions November 2014 to February 2015

12 CONTROLLED WATERS GENERIC QUANTITATIVE RISK ASSESSMENT

12.1 Methodology

12.1.1 The potential pollution risks to controlled waters have been assessed in accordance with the Environment Agency's Remedial Targets Methodology (RTM) (Ref. 54).

12.1.2 The first stage of risk assessment comprises an initial screening of the contaminants to identify those which are at concentrations above screening criteria and warrant further detailed investigation. The landfill site is considered to be the main source of potential contamination within the Main Application site.

Area A

12.1.3 The most sensitive controlled water receptor is considered to be groundwater within the chalk principal aquifer which is abstracted for public water supply. The nearest abstraction is located at Kings Walden 1.5km northeast of the Main Application Site boundary (approximately 2.8 km from the boundary of the landfill). A private water supply abstraction well is located at approximately the same distance as the Kings Walden abstraction, to the north east and a second private groundwater abstraction within the Mimram catchment is 1.5km south east of the Main Application Site. The nearest surface waterbody down-gradient of the landfill is the River Mimram 6 km to the southeast. As the river is a considerable distance from the site it has not been considered to be a receptor.

12.1.4 The GQRA has considered available contaminant data (soil and leachate) from within the landfill waste and groundwater data from the chalk aquifer.

Airport Access Road

12.1.5 No groundwater sampling or soil leachate testing was undertaken as part of the GI on the proposed New Road. It is not envisaged that the proposed earthworks will interact with the groundwater which is approximately 40m bgl. However, this will need to be reviewed at the detailed design stage. Therefore no further assessment is required for controlled water risks this stage.

12.1.6 The drainage strategy for the road will also be undertaken at the detailed design stage but it should ensure that no infiltration will occur across the landfill area or in other areas of Made Ground along the alignment.

Groundwater assessment

12.1.7 The screening criteria used for assessing the data, and for deriving remedial targets, were based on published water quality guideline values. As the chalk aquifer is used for public water supply, UK Drinking Water Standards (DWS) were used. Where DWS have not been derived for certain contaminants the following hierarchy was followed when selecting suitable screening criteria:

a. Freshwater EQS (FEQS);
b. World Health Organisation (WHO); and
c. United States Environmental Protection Agency (USEPA).

12.1.8 In some cases, no standard was available, therefore a substitute screening value from the same group of contaminants with similar or higher mobility in groundwater was applied. Justification for all of the screening values used in the controlled waters assessment are provided in **Appendix G.**

12.1.9 The available groundwater data which has been screened as part of this GQRA is summarised in **Table 12.1.**

Table 12.1 Data used in GQRA to assess contaminants in groundwater in the chalk (see **Figure 9 and 10** of this document for locations).

Data	Source	Purpose
Groundwater beneath the landfill (Mimram catchment)	2017 and 2018 GI and long-term monitoring data	Groundwater quality in the chalk aquifer directly beneath the landfill has been assessed to determine if there is any evidence of impact to groundwater as a result of leaching of contaminants from the landfill.
Groundwater upgradient of the landfill (Mimram catchment)	Data from GW201 and GW202 monitored as part of 2018 GI	To provide background groundwater quality and assess if there is evidence of contaminant migration within the chalk from off-site sources.
Groundwater down-gradient of the landfill (Mimram catchment)	2017 and 2018 monitoring data from wells installed to east and southeast of the landfill site	To assess if there is evidence of any significant migration of contaminants down gradient which could be attributed to the landfill or wider airport area.
Groundwater from wider airport site (Lee catchment)	Concept 2015 and MPT 2017 GI monitoring data	Not used in GQRA but has been used to inform background quality measurements in the wider area (see **Table 6.2).** Limited groundwater sampling beneath the wider airport area was undertaken during 2015 and 2017. The landfill site lies within the Mimram catchment and therefore the data from this catchment is considered the most representative to assess the potential impacts of the landfill.

Soil, soil leachate and leachate assessment

12.1.10 In addition to the groundwater data, the following has also been assessed:

a. The soil/ landfill waste chemical data to determine the potential for this material to leach to groundwater;

b. Soil leachate data, which are tests undertaken to confirm the leaching potential of the soil/landfill waste material; and

c. Landfill leachate and perched groundwater within the landfill collected from wells on site.

12.1.11 **Table 12.2** summarises the data used, and the methodology used to assess this data.

Table 12.2 Data and approach used in soil, soil leachate and landfill leachate assessment.

Data	Source	Assessment approach
Total soil concentrations within landfill waste	2017 and 2018 GI	Data compared to soil screening values calculated from controlled waters screening criteria (see methodology in **12.1.12** below)
Soil leaching tests (10:1) within landfill waste	2017 and 2018 GI	Data compared directly to controlled waters screening criteria
Leachate quality data	Leachate monitoring wells, 2017 and 2018 GIs	
Perched groundwater quality data	Perched groundwater samples from wells located within landfill waste, 2018 GI	

12.1.12 To determine the risk to groundwater of contaminants leaching from the soil, the groundwater screening values were first converted to soil screening values using the Level 1 equation in the Environment Agency RTM re-arranged as follows:

$$Cs = Cl \times \left[\frac{Kd + (\emptyset w + \emptyset a \times H)}{P}\right]$$

Where:

Cs = soil concentration (mg/kg)

Cl = target concentration for water (mg/l)

Kd = partition coefficient (l/kg)

θw = water filled porosity (fraction)

θa = air filled porosity (fraction)

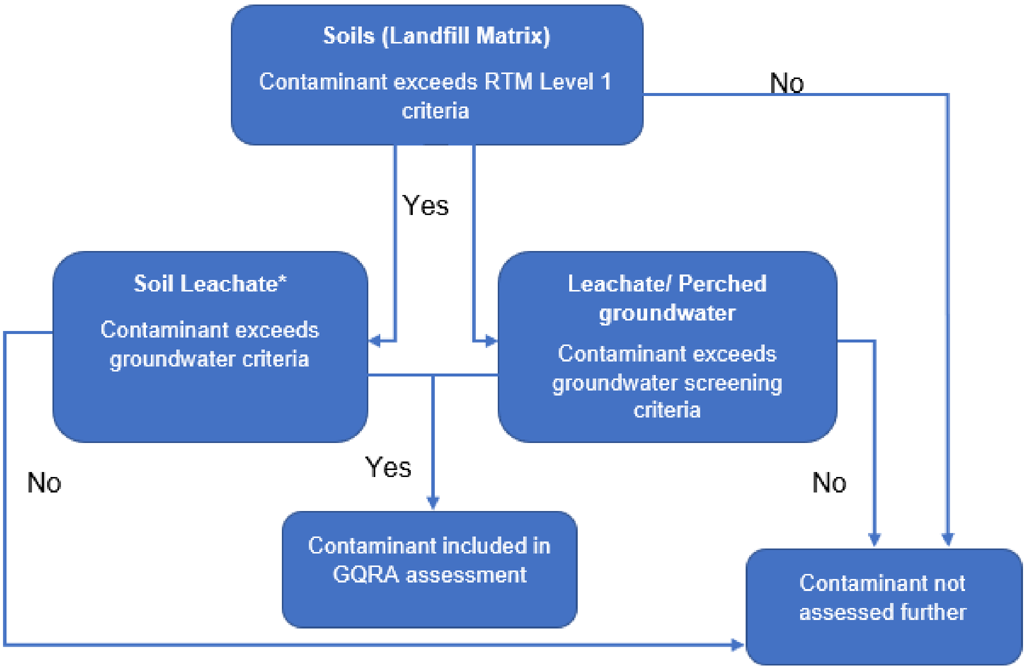
H = Henry's Law constant (dimensionless)

P = soil dry density (g/cm³)

12.1.13 The methodology follows the guidance for RTM Level 1 Soil (Ref. 54). This considers whether leaching of contaminants from the Made Ground within the landfill poses a risk to the receptor, while ignoring dilution, dispersion and attenuation along the pathway.

12.1.14 Comparison of soil concentrations to soil screening values based on theoretical calculations is conservative and concentrations often exceed the criteria. The soil leachate and leachate/perched groundwater data available is considered to be a more realistic representation of potential contaminants in the landfill which could pose a risk to controlled waters. In order to determine the key contaminants of concern for the assessment the contaminants which exceeded the RTM Level 1 values were then compared to soil leachate and leachate/perched ground. The process of selecting the key contaminants of concern is shown in **Drawing 15.**

Drawing 155 Process for selecting key contaminants of concern in the soils (landfill matrix).



*Due to the nature of the analysis, soil leachate testing is only valid for metals and inorganic contaminants

Statistical analysis

12.1.15 Statistical analysis has been used within the controlled waters GQRA in order to determine whether contaminant exceedances were considered statistically insignificant (i.e. rare exceedance) or likely to pose a risk to controlled waters. When calculating the statistics, where concentrations were below the laboratory LOD, the LOD value was used.

12.1.16 The statistical analysis has been used to determine whether further assessment beyond GQRA is required for specific contaminants. The criteria for determining whether contaminants require further DQRA is in **Table 12.3.**

Table 12.3 Criteria to determine whether further controlled water assessment is required for contaminants.

Criteria	Action
No samples exceed the criteria value	No further assessment required
97th percentile concentration less than criteria value	No further assessment required
97th percentile concentration less than 2x criteria value	Requires further review
97th percentile concentration less than 10x criteria value	Requires further review / likely to require DQRA
97th percentile concentration greater than 10x criteria value	Likely to require DQRA

12.2 Results

Groundwater

12.2.1 This section presents the results of the screening assessment of groundwater samples collected from the chalk principal aquifer. and the follows the guidance for RTM Level 2 Groundwater assessment. This considers an assessment of groundwater beneath the site to determine if groundwater has been impacted by contaminants which may have leached from the landfill or sourced from other parts of the airport or the wider Luton area.

12.2.2 The results of the screening assessment for contaminants within the groundwater are presented in in **Appendix G.**

12.2.3 A summary of the contaminants with concentrations exceeding the screening values within the groundwater is presented in **Table 12.4 to Table 12.8.**

Table 12.4 Summary of groundwater concentrations of metal and organotin contaminants which exceed the screening criteria.

Contaminant	Units	Screening criteria value	Criteria source	Groundwater beneath landfill				Groundwater down gradient of landfill				Groundwater up-gradient of landfill			
				No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max
Boron	µg/l	1,000	DWS	61	7	1,502	4,060	121	1	645.2	1,100	6	0	39.8	40
Hexavalent chromium	µg/l	3.4	FEQS	80	0	-	<LOD	121	2	10	17	6	0	-	<LOD
Iron	mg/l	0.2	DWS	80	9	0.42	0.7	155	2	0.16	0.42	6	2	0.55	0.58
Manganese	µg/l	50	DWS	80	50	818	964	155	26	146.9	950	6	6	603	641
Mercury	µg/l	1	DWS	79	3	0.98	3.9	165	2	0.588	2.15	6	0	0.01	0.014
Nickel	µg/l	20	DWS	80	4	22.6	25	165	2	13	30	6	0	3.93	4.11
Selenium	µg/l	10	DWS	80	2	5.8	11	165	0	3.4	9.8	6	0	2.32	2.56
Tributyltin compounds	ng/l	0.2	FEQS	80	0	-	<LOD	130	0	-	<LOD	6	1	4.79	5.11
Dibutyltin	ng/l	0.2	FEQS	80	0	-	<LOD	130	2	10	600	6	0	-	<LOD

Legend: green (97th percentile < criteria, maximum>criteria); Yellow (97th percentile <2x criteria); Orange (97th <10x criteria); Red (97th percentile >x10 criteria)

Table 12.5 Summary of groundwater concentrations of inorganic contaminants which exceed the screening criteria.

Contaminant	Units	Screening criteria value	Criteria source	Groundwater beneath landfill				Groundwater down gradient of landfill				Groundwater up-gradient of landfill			
				No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max
Sulphate	mg/l	250	DWS	80	4	270	319	155	0	53.68	94	6	0	32.4	33.6
Chloride	mg/l	250	DWS	80	4	257	361	155	0	120	200	6	0	107	108
Ammoniacal nitrogen	mg/l	0.39	DWS	80	18	2.37	5.93	155	22	1.9	7.2	6	2	0.432	0.433
Thiocyanate	mg/l	0.05	DWS	80	2	0.20	0.21	122	2	0.20	0.31	6	0	-	<LOD
Nitrate as NO3	mg/l	50	DWS	80	9	67.8	88.3	155	10	60.0	71.1	6	0	5.17	5.23
Nitrite as NO2	mg/l	0.5	DWS	80	2	0.9	1.04	155	4	0.42	12	6	2	0.833	0.832

Legend: green (97th percentile < criteria, maximum >criteria); Yellow (97th percentile <2x criteria); Orange (97th <10x criteria); Red (97th percentile >x10 criteria)

Table 12.6 Summary of groundwater concentrations of petroleum hydrocarbon contaminants which exceed the screening criteria.

Contaminant	Units	Screening criteria value	Criteria source	Groundwater beneath landfill				Groundwater down gradient of landfill				Groundwater up-gradient of landfill			
				No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max
TPH >C21-C35 aliphatics	µg/l	300	WHO	80	2	1443	1,530	132	0	-	<LOD	6	5	1,518	1,710
TPH >C16-C21 aromatics	µg/l	90	WHO	75	0	-	<LOD	136	0	10	19	6	1	100.9	103
TPH >C21-C35 aromatics	µg/l	90	WHO	75	0	10	50	136	0	10	31	6	2	509	546
Legend: green (97th percentile < criteria, maximum >criteria); Yellow (97th percentile <2x criteria); Orange (97th <10x criteria); Red (97th percentile >x10 criteria)															

Table 12.7 Summary of groundwater concentrations of PAH, phenol, VOC and SVOC contaminants which exceed the screening criteria.

Contaminant	Units	Screening criteria value	Criteria source	Groundwater beneath landfill				Groundwater down gradient of landfill				Groundwater up-gradient of landfill			
				No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max
Phenol (SVOC)	µg/l	7.7	FEQS	80	0	3.46	4.25	152	0	-	<LOD	6	1	16.9	19.7
Fluoranthene	µg/l	0.0063	FEQS	80	8	0.01	0.04	162	0	-	<LOD	6	5	0.47	0.48
Benzo(b) fluoranthene	µg/l	0.1	DWS	80	0	-	<LOD	162	0	-	<LOD	6	3	0.76	0.788
Benzo(k) fluoranthene	µg/l	0.1	DWS	80	0	-	<LOD	162	0	-	<LOD	6	3	0.31	0.317
Benzo(a) pyrene	µg/l	0.01	DWS	80	0	0.0033	0.00408	162	0	-	<LOD	6	4	0.56	0.57
Indeno(1,2,3-cd)pyrene	µg/l	0.1	DWS	80	0	-	<LOD	162	0	-	<LOD	6	3	0.24	0.243
Benzo(ghi)perylene	µg/l	0.1	DWS	80	0	-	<LOD	162	0	-	<LOD	6	3	0.37	0.378
Vinyl chloride	µg/l	0.5	DWS	80	15	6.26	7.1	152	0	-	<LOD	6	0	-	<LOD

Contaminant	Units	Screening criteria value	Criteria source	Groundwater beneath landfill				Groundwater down gradient of landfill				Groundwater up-gradient of landfill			
				No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max
1,1-Dichloroethane	µg/l	3	DWS	80	4	1	5	152	0	1	2.1	6	0	-	<LOD
1,2-Dichloroethane	µg/l	3	DWS	80	11	4.83	7.44	152	0	-	<LOD	6	0	-	<LOD
Trichloroethene	µg/l	10	DWS	80	24	11.03	131	152	2	6.26	60.5	6	0	-	<LOD
Bis(2-ethylhexyl) phthalate	µg/l	8	WHO	80	1	6.92	89	152	0	2	5.9	6	0	-	<LOD
Legend: green (97th percentile < criteria, maximum >criteria); Yellow (97th percentile <2x criteria); Orange (97th <10x criteria); Red (97th percentile >x10 criteria)															

Table 12.8 Summary of groundwater concentrations of pesticides/herbicides and PFAS contaminants which exceed the screening criteria.

Contaminant	Units	Screening criteria value	Criteria source	Groundwater beneath landfill				Groundwater down gradient of landfill				Groundwater up-gradient of landfill			
				No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max
PFOS	µg/l	0.01	DWS (T2)	61	22	0.15	0.19	110	54	0.23	0.33	10	1	0.01	0.0102
PFOA	µg/l	0.01	DWS (T2)	62	15	0.14	0.17	110	43	0.13	0.14	10	3	0.02	0.02
PFOS	µg/l	0.1	DWS (T3)	61	7	0.15	0.19	110	24	0.23	0.33	10	0	0.01	0.0102
PFOA	µg/l	0.1	DWS (T3)	62	9	0.14	0.17	110	9	0.13	0.14	10	0	0.02	0.02
PFOS	µg/l	1	DWS (T4)	61	0	0.15	0.19	110	0	0.23	0.33	10	0	0.01	0.0102
PFOA	µg/l	1	DWS (T4)	62	0	0.14	0.17	110	0	0.13	0.14	10	0	0.02	0.02
Metaldehyde	µg/l	0.1	DWS	45	6	0.4	0.4	111	20	0.54	1	0	-	-	-
Metoxuron	µg/l	0.1	DWS	75	0	-	<LOD	121	1	0.2	4.9	6	0	-	<LOD
Atrazine	µg/l	0.1	DWS	75	2	0.09	0.155	121	18	0.15	0.18	6	5	0.55	0.59
Simazine	µg/l	0.1	DWS	75	0	0.04	0.05	121	0	0.09	0.1	6	3	0.14	0.141
Mecoprop	µg/l	0.1	DWS	75	29	0.6	0.841	121	15	0.22	0.49	6	0	0.037	0.04

Contaminant	Units	Screening criteria value	Criteria source	Groundwater beneath landfill				Groundwater down gradient of landfill				Groundwater up-gradient of landfill			
				No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max
Dichlorprop	µg/l	0.1	DWS	75	2	0.07	0.457	121	0	0.02	0.05	6	0	0.01	0.01
Dicamba	µg/l	0.03	DWS	75	1	0.02	0.11	121	1	0.02	0.12	6	0	-	<LOD
2,4-D	µg/l	0.1	DWS	75	0	-	<LOD	121	1	0.02	0.12	6	0	-	<LOD
Bentazone	µg/l	0.1	DWS	75	0	-	<LOD	121	1	0.04	0.25	6	0	-	<LOD
Triclopyr	µg/l	0.1	DWS	75	0	-	<LOD	121	1	0.02	0.59	6	0	-	<LOD
Azinphos-methyl	µg/l	0.1	DWS	80	0	-	<LOD	130	0	-	<LOD	6	0	-	<LOD
Diuron	ng/l	100	DWS	75	13	230	290	121	11	154.3	200	6	0	89.4	90
Monuron	ng/l	100	DWS	75	4	137	260	121	0	50	64	6	0	84.5	87
Legend: green (97th percentile < criteria, maximum >criteria); Yellow (97th percentile <2x criteria); Orange (97th <10x criteria); Red (97th percentile >x10 criteria)															

12.2.4 Several groundwater samples contained contaminants that exceeded the groundwater criteria both from beneath the landfill site and from adjacent areas (see **Table 12.4-Table 12.8**). The following is noted about these exceedances:

Metals, Organotins and inorganics

a. Concentrations of manganese were elevated in a number of samples directly beneath the landfill and in some samples down-gradient. Manganese can be elevated due to natural impurities in the Chalk, however as the maximum concentrations recorded in groundwater beneath the landfill are above the background concentrations it is considered that this requires further assessment.

b. Hexavalent chromium and dibutyltin were not detected in the groundwater directly beneath the landfill. However, two samples of hexavalent chromium and dibutyltin down-gradient of the landfill exceeded the screening criteria. Hexavalent chromium was detected in BH51 and BH13 on one occasion (on 14 April 2018 and 8 August 2018 respectively) all other occasions it was below detection the LOD Dibutyltin was detect in BH01 and BH13 on one occasion (both on 7 March 2017), all other occasions it was below limit of detection. Given that these contaminants are not being continuously detected, despite significant monitoring being undertaken and appear to be random spikes they are not considered significant and therefore further assessment is not required. This is in accordance with the government published groundwater protection guidance (Ref. 55).

c. Tributyltin was only detected up-gradient of the landfill on one occasion in GW201 and not in the groundwater directly beneath the landfill or down-gradient. Therefore, the landfill is not considered to be the source of the concentrations detected at this location and further assessment is not required.

d. Mercury and selenium recorded a few marginal exceedances in the groundwater directly beneath the landfill and in the case of mercury two exceedances down gradient of the landfill. For both of these contaminants the 97th percentile concentration was less that the criteria value, indicated marginal sporadic exceedances. Therefore, further assessment of these contaminants is required.

e. Several other metals (iron and nickel and boron) recorded exceedances within groundwater directly beneath the landfill and/or down-hydraulic gradient for which the 97th percentile was greater than two times the criteria value. Therefore, these contaminants require further assessment.

f. Ammoniacal nitrogen is often found in landfill leachate and therefore the exceedances recorded in groundwater below the landfill may indicate the presence of leachate in the groundwater and therefore requires further assessment. Ammoniacal nitrogen was recorded in some wells immediately down-gradient of the landfill which suggests some migration of this contaminant may be occurring (see Figure 18 of this document). Therefore, this contaminant requires further assessment.

g. Nitrate and nitrite are present in the groundwater both beneath the landfill and down-gradient. These are compounds which can occur naturally, but can also be present in elevated concentrations due to anthropogenic sources and the decomposition of organic material in soils. Ammoniacal nitrogen also oxidises to form nitrate and nitrite. These compounds can therefore be both an indicator of the presence of landfill leachate, and be common in agricultural areas. The concentrations of nitrate recorded beneath the landfill may indicate the presence of landfill leachate, however the concentrations down-hydraulic gradient show minimal impact. Therefore this contaminant requires further assessment.

h. Marginal exceedances of both chloride and sulphate were recorded below the landfill, however the exceedances were only in a low number of samples and therefore further assessment is not considered necessary.

i. Two exceedances of thiocyanate were noted in groundwater below the landfill and two down-gradient. The exceedances were noted in different locations on individual monitoring rounds, all other occasions it was below the LOD. Given that thiocyanate is not being continuously detected, and significant monitoring has been undertaken, the detections appear to be random spikes and are not considered significant and therefore further assessment is not required.

Petroleum hydrocarbons, PAHs, Phenols, VOCs and SVOCs

a. TPH Aliphatic >C21-C35 was detected in groundwater directly beneath the landfill in GW206 on two occasions (13 February 2019 and 7 March 2019), it was not detected in any of the subsequent monitoring rounds. No other TPH fractions were detected in the groundwater beneath the landfill. Guidance on hydrocarbons in groundwater indicates that TPH Aliphatic C21-35 has a very low mobility in groundwater (Ref. 56.) This is supported by the fact it was not detected in groundwater down-gradient of the landfill. Given that it is not being continuously detected, despite significant monitoring being undertaken and it has very low mobility in groundwater the exceedances are not considered significant and no further assessment is required.

b. Exceedances of TPH Aromatic >C16-21 and >C21-35 were recorded in samples obtained from the up-gradient background wells but not in groundwater directly beneath the landfill, which indicates there may be a localised off-site source of TPH. Therefore, the landfill is not considered to be the source of these exceedances and further assessment is not required.

c. Elevated concentrations of phenol and several PAH compounds (benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, benzo(g,h,i) perylene) were detected with 97th percentile concentration greater than two times the assessment criteria in up-gradient wells. These compounds were not detected above the assessment criteria in groundwater beneath the landfill, indicating that there may be a localised off-site source impacting groundwater. Therefore, the landfill is not considered to be the source of these exceedances and further assessment is not required.

d. Fluoranthene was detected in seven groundwater samples beneath the landfill, with the 97th percentile concentration exceeding the assessment criteria by at least two times. This contaminant was also detected at elevated levels downgradient. Therefore, further assessment of this contaminants is required.

e. Trichloroethene (TCE) and its breakdown products, 1,2-dichlroethane and vinyl chloride, were detected above the screening criteria in several samples directly beneath the landfill, with the 97th percentile concentration exceeding the assessment criteria by at least two times. Low levels of TCE, but none of the breakdown products, have been recorded in groundwater down-gradient of the landfill (CP-BH55). Therefore, further assessment of this contaminant is required.

f. Bis(2-ethylhexyl)phthalate is not considered to require further assessment as there was only one exceedance and the 97th percentile concentration did not exceed the assessment criteria. Therefore the exceedance is not considered significant and no further assessment is required.

PFAS

a. Concentrations of perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) have been recorded above the laboratory LOD in a number of groundwater samples obtained from the site. Both PFOS and PFOA are two of the most abundant substances of a group of contaminants known collectively as poly and perfluoroalkyl substances (PFAS).

b. Historically, PFAS was manufactured for a wide range of industrial, commercial and household applications. PFAS were common components of fire-fighting foams and are commonly encountered at airports, military sites, fire training areas and other large industrial facilities [Ref. 49] The use of fire-fighting foam products containing >0.001 %wt PFOS was banned in the EU in June 2011. Disposal to landfill is often the end life cycle for consumer products that contain PFAS and household wastes in landfill such as carpets, textiles and clothing can contribute as a source. Additionally, industrial waste can be a significant source in landfills and landfill leachate (Ref. 57).

c. The highest concentrations of PFOS recorded in groundwater have typically been in groundwater wells which are located close to the airports fire training facility. It is understood that the airport does not use fire-fighting foams which contain PFAS and therefore the presence of PFAS in groundwater is a result of historic use of fire-fighting foams at the airport and other industrial sites across the wider Luton area.

d. Samples have been compared to assessment criteria recently published by the Drinking Water Inspectorate (Ref. 58) which include a tiered assessment. As the tiers increase, the onus of the minimum action to be taken increased.

e. Tier 1 is a qualitative assessment based where PFAS should be considered a hazard. Tiers 2 to 4 provide a drinking water guidance value to assess concentrations against.

f. Minor exceedances of Tier 2 guidance values are observed upgradient of the landfill, with no further exceedances of Tiers 3 and 4 criteria. 36% of samples from groundwater beneath the landfill are recorded as above Tier 2 criteria, which reduces to 11% exceeding Tier 3 criteria. No samples are above Tier 4 criteria. 49% of samples downgradient are exceeding Tier 2 criteria which reduces to 22% exceeding Tier 3 criteria. No exceedances of Tier 4 criteria are observed.

g. The minimum action to be taken as recommended by the DWI for Tier 2 exceedances is additional monitoring to establish long term trends and risks. Minimum actions recommended by the DWI for Tier 3 exceedances is to consult with appropriate persons to reduce concentrations as soon as is practicable.

h. It is pertinent to note that the assessment using the DWI values is considered conservative as they are applicable to treated drinking water and applying the criteria to the principal aquifer is extremely conservative. The use of the DWI values within this report is to provide an indicative risk. As the majority of exceedances are values between Tier 2 and Tier 3, the risk to controlled waters is considered to be low. Therefore, at this stage PFAS have not been taken forward to a DQRA. However, there is work ongoing by the Environment Agency to understand the risks and develop pragmatic approaches to PFAS assessment. Further monitoring and assessment will be required based on the assessment to date. Although monitoring suggests that the risk with respect to PFAS is low at the development site they should be considered contaminants of concern until the guidance is available and any further assessment work completed.

Pesticides

a. A number of pesticides have been recorded within the groundwater, however the exceedances are generally localised and typically only marginally above the screening criteria. The sources of pesticides within the groundwater are likely to have arisen from a number of sources including agricultural application across the wider development site. More frequent exceedances of mecoprop and diuron have been recorded in groundwater beneath the landfill and are therefore considered to require further assessment.

12.2.5 Overall relatively few exceedances of potential contaminants of concern have been recorded in groundwater beneath the site. Those which did exceed tended to be in boreholes beneath or close to the landfill and were typically in localised areas. There is limited evidence of any significant contaminant plume migrating down-hydraulic gradient of the landfill.

12.2.6 The following contaminants of concern **(Table 12.9)** have been identified in the groundwater which exceed the screening criteria. These are considered to potentially pose a risk to controlled waters receptors and should be further assessed. The maximum concentrations of these contaminants recorded in the groundwater monitoring wells is shown on **Figure 18** of this document.

Table 12.9 Summary of contaminants of concern within groundwater requiring further assessment.

Contaminants of Concern
Metals and Inorganics
Manganese
Ammoniacal nitrogen
Nitrate
Boron
Iron
Nickel

Contaminants of Concern
Metals and Inorganics
Petroleum hydrocarbons, PAHs, Phenols, VOCs and SVOCs
Fluoranthene
Trichloroethene (TCE)
Vinyl chloride
1,2-dichloroethane
Pesticides
Diuron
Mecoprop

Soil, soil leachate and leachate

12.2.7 Comparison of the total soil concentrations to RTM Level 1 values indicated a large number of exceedances. The contaminants where the maximum value exceeded the RTM by at least 100 times are summarised in **Table 12.10**. The full results are provided in **Appendix G.**

Table 12.10 Contaminants in the soil (landfill matrix) for which the maximum value exceeded the RTM Level 1 values by at least 100 times.

Determinand	RTM screening Value	Units	No. results >LOD	No. results >RTM	Range	
					Max	Min
Cyanide	0.26	mg/kg	132	125	155.0	<0.1
Complex Cyanide	0.26	mg/kg	16	16	346.0	<0.2
Ammoniacal Nitrogen	0.11	mg/kg	20	20	242.0	<2
Naphthalene	0.08	mg/kg	191	117	51.6	<0.009
Phenanthrene	3.35	mg/kg	406	69	372.0	<0.015
Anthracene	0.16	mg/kg	310	179	119.0	<0.016
Fluoranthene	0.01	mg/kg	412	412	339.0	<0.017
Pyrene	1.88	mg/kg	415	126	267.0	<0.015
Benzo(b)fluoranthene	0.61	mg/kg	390	181	103.0	<0.015
Benzo(a)pyrene	0.07	mg/kg	386	358	83.7	<0.015
Indeno(1,2,3-cd)pyrene	0.51	mg/kg	372	147	56.4	<0.018
Antimony	1.26	mg/kg	216	172	311.0	<1
Cadmium	0.50	mg/kg	581	384	73.9	<0.1
Chromium	315.49	mg/kg	717	13	8670	<0.9
Lead	10.00	mg/kg	714	636	15700	<0.002
Nickel	10.01	mg/kg	721	613	18100	<0.004
Benzene	0.0043	mg/kg	11	10	0.4	<0.001
Ethylbenzene	0.53	mg/kg	94	28	904	<0.001
Xylene	0.23	mg/kg	129	69	370	<0.001
Bis(2-chloroethoxy)methane	14.30	ug/kg	1	1	1890	<100
Propylbenzene	284.42	ug/kg	32	12	29700	<1

Determinand	RTM screening Value	Units	No. results >LOD	No. results >RTM	Range	
					Max	Min
1,3,5-Trimethylbenzene	152.89	ug/kg	66	43	4010000	<1
1,2,4-Trimethylbenzene	247.69	ug/kg	84	50	5570000	<1
O Xylene	233.63	ug/kg	54	21	730000	<1
M&P Xylene	233.63	ug/kg	105	62	2910000	<1
2,4-Dinitrotoluene	0.58	ug/kg	1	1	876	<100
2,6-Dinitrotoluene	1484.17	ug/kg	4	3	11200	<100
2-Nitrophenol	29.64	ug/kg	2	2	3390	<100
Di-N-Butyl Phthalate	0.52	mg/kg	59	35	103	<0.1
Carbazole	0.01	mg/kg	52	52	53.7	<0.1
2,4-Dimethylphenol	1184.53	ug/kg	12	5	17200	<100
4-Methylphenol	532.43	ug/kg	13	8	78700	<100
Dibenzofuran	487.75	ug/kg	62	35	93800	<100
Dibutyl Tin	0.0000157	mg/kg	5	5	0.2	<0.02
Tributyltin	0.0000157	mg/kg	2	2	0.1	<0.02
Tetrabutyl Tin	0.0000157	mg/kg	1	1	0.1	<0.02
4-Nitroaniline	3.39	ug/kg	3	3	1220	<100
4-Chloroaniline	8.39	ug/kg	2	2	1040	<100

12.2.8 The key contaminants of concern for assessment was selected as described in **Section 12.1.14.** A summary of the key contaminants of concern is presented in **Table 12.11 to Table 12.15.**

Table 12.11 Summary of soil leachate, leachate and perched groundwater concentrations of metal contaminants which exceed the screening criteria.

Contaminant	Units	Screening criteria value	Criteria source	Soil leachate				Leachate				Perched groundwater			
				No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max
Antimony	µg/l	5	DWS	25	14	240	459	23	6	10.7	15.3	19	0	2.4	2.96
Arsenic	µg/l	10	DWS	25	2	20	46.9	23	8	23.7	36.7	19	6	30.5	32
Barium	µg/l	700	WHO	25	0	300	358	23	11	2,006	2,600	19	5	2,929	3,080
Boron	µg/l	1,000	DWS	25	2	2,290	2,300	23	14	2,334	2,400	19	9	26,110	28,000
Hexavalent chromium	µg/l	3.4	FEQS	25	1	30	37.4	24	1	33	39.6	19	0	-	<LOD
Iron	mg/l	0.2	DWS	25	7	1.2	1.82	23	18	37.8	38.1	19	17	29	31.4
Lead	µg/l	10	DWS	25	1	10	11	23	0	3.2	5.8	19	1	21.1	40.8
Manganese	µg/l	50	DWS	25	8	410	676	23	20	2,080	2,100	19	19	4,688	5,590
Molybdenum	µg/l	70	WHO	25	4	480	922	22	0	33.8	56.8	19	0	12.6	13.9
Nickel	µg/l	20	DWS	25	5	120	146	23	8	48.2	54.7	19	10	46.7	54.9
Selenium	µg/l	10	DWS	25	0	-	<LOD	23	3	14	14	19	0	1.3	1.68

Contaminant	Units	Screening criteria value	Criteria source	Soil leachate				Leachate				Perched groundwater			
				No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max
Vanadium	µg/l	20	WHO	25	2	20	25.1	23	2	54.1	97.9	19	0	4.6	4.7
Tributyltin compounds	ng/l	0.2	FEQS	0	-	-	-	13	0	-	<LOD	15	5	219.5	355
Dibutyl tin	ng/l	0.2	FEQS	0	-	-	-	13	0	-	<LOD	15	2	202.2	240
Legend: green (97th percentile < criteria, maximum>criteria); Yellow (97th percentile <2x criteria); Orange (97th <10x criteria); Red (97th percentile >x10 criteria)															

Table 12.12 Summary of soil leachate, leachate and perched groundwater concentrations of inorganic contaminants which exceed the screening criteria.

Contaminant	Units	Screening criteria value	Criteria source	Soil leachate				Leachate				Perched groundwater			
				No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max
Sulphate	mg/l	250	DWS	25	1	259.4	299	21	1	200	278	19	2	288	322
Fluoride	mg/l	1.5	DWS	25	2	2.27	2.49	24	0	0.933	0.967	19	0	0.879	0.892
Chloride	mg/l	250	DWS	25	0	27.97	31.5	21	7	1,212	1,230	18	12	1,208.3	1,500
Ammoniacal nitrogen	mg/l	0.39	DWS	25	20	23.34	24.2	23	20	167.3	168	19	17	290.8	293
Total cyanide	mg/l	0.05	DWS	25	0	-	<LOD	23	0	0.0147	0.016	18	1	0.05	0.051
Thiocyanate	mg/l	0.05	DWS	25	1	0.12	0.292	23	6	0.43	0.45	18	3	0.109	0.119
Bromate	mg/l	0.01	DWS	0	-	-	-	22	0	-	<LOD	16	2	0.014	0.017
Nitrite as NO2	mg/l	0.5	DWS	25	1	0.33	0.546	23	0	0.21	0.25	18	0	0.26	0.324
Legend: green (97th percentile < criteria, maximum >criteria); Yellow (97th percentile <2x criteria); Orange (97th <10x criteria); Red (97th percentile >x10 criteria)															

Table 12.13 Summary of leachate and perched groundwater concentrations of petroleum hydrocarbon contaminants which exceed the screening criteria.

Contaminant	Units	Screening criteria value	Criteria source	Leachate				Perched groundwater			
				No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max
TPH >C8-C10 aliphatic	µg/l	300	WHO	21	0	39	40	17	1	380	568
TPH >C10-C12 aliphatic	µg/l	300	WHO	21	0	59	64	17	2	620	912
TPH >C12-C16 aliphatic	µg/l	300	WHO	21	1	547	993	16	3	3,621	4,570
TPH >C16-C21 aliphatic	µg/l	300	WHO	21	3	2,486	3,080	16	5	17,720	22,400
TPH >C21-C35 aliphatic	µg/l	300	WHO	21	9	17,120	20,600	16	11	89,865	99,900
TPH >C8-C10 aromatics	µg/l	300	WHO	20	0	55	58	17	1	385	548
TPH >C10-C12 aromatics	µg/l	90	WHO	21	0	39	43	17	2	413	608
TPH >C12-C16 aromatics	µg/l	90	WHO	21	1	682	1,330	16	3	1,218	1,470
TPH >C16-C21 aromatics	µg/l	90	WHO	21	6	3,000	4,020	16	6	4,590	5,170
TPH >C21-C35 aromatics	µg/l	90	WHO	21	9	11,460	12,600	16	9	19,270	9,900
Benzene	µg/l	1	DWS	9	0	-	<LOD	17	5	2	2.4
Ethylbenzene	µg/l	20	FEQS	9	0	-	<LOD	17	1	18.7	26.4
Xylene	µg/l	30	FEQS	18	0	22	23	17	4	101.4	129
Legend: green (97th percentile < criteria, maximum > criteria); Yellow (97th percentile <2x criteria); Orange (97th <10x criteria); Red (97th percentile >x10 criteria)											

Table 12.14 Summary of leachate and perched groundwater concentrations of PAH, phenol, VOC and SVOC contaminants which exceed the screening criteria.

Contaminant	Units	Screening criteria value	Criteria source	Leachate				Perched groundwater			
				No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max
Cresol	µg/l	100	FEQS	22	3	189	220	17	0	30	40
Phenol	µg/l	7.7	FEQS	22	3	51	70	17	1	22	40
Naphthalene	µg/l	2	FEQS	21	3	5.6	7.1	19	2	74.7	76.1
Acenaphthylene	µg/l	2	FEQS	21	1	2.1	2.7	16	0	1.1	1.5
Fluorene	µg/l	2	FEQS	21	2	26.0	50.2	16	3	8.9	9.8
Phenanthrene	µg/l	2	FEQS	21	5	167.6	290.0	16	6	29.2	31.0
Anthracene	µg/l	0.1	FEQS	21	8	42.4	73.1	16	10	7.1	8.3
Fluoranthene	µg/l	0.0063	FEQS	21	10	299.4	402.0	16	16	36.9	41.0
Pyrene	µg/l	2	FEQS	21	7	280.4	371.0	16	7	30.1	34.8
Benzo(a)anthracene	µg/l	2	FEQS	21	5	126.4	142.0	16	7	9.2	11.9
Chrysene	µg/l	2	FEQS	21	4	50.7	114.0	16	7	7.8	10.1
Benzo(b)fluoranthene	µg/l	0.1	DWS	21	9	239.8	295.0	16	13	11.8	12.5
Benzo(k)fluoranthene	µg/l	0.1	DWS	21	8	38.4	81.7	16	12	5.4	5.5
Benzo(a)pyrene	µg/l	0.01	DWS	21	10	82.1	160.0	16	15	9.5	10.8
Indeno(1,2,3-cd)pyrene	µg/l	0.1	DWS	21	9	137.6	164.0	16	12	5.6	6.0

Contaminant	Units	Screening criteria value	Criteria source	Leachate				Perched groundwater			
				No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max
Dibenz(ah)anthracene	µg/l	2	FEQS	21	3	20.4	22.0	16	0	1.2	1.3
Benzo(ghi)perylene	µg/l	0.1	DWS	21	9	153.4	169.0	16	12	6.8	6.9
Chlorobenzene	µg/l	0.4	FEQS	21	3	1.54	1.65	17	1	1.69	2.33
Iso-propylbenzene	µg/l	1	DWS	21	3	4.21	4.88	17	1	1.7	2.35
Propylbenzene	µg/l	1	DWS	21	1	1.25	1.63	17	2	4.41	7.27
1,3,5-trimethylbenzene	µg/l	1	DWS	21	1	1.47	2.17	17	4	52.7	69.2
1,2,4-trimethylbenzene	µg/l	1	DWS	21	2	4.07	7.97	17	8	121.1	173
sec-butylbenzene	µg/l	1	DWS	21	0	-	<LOD	17	1	1.62	2.2
4-methylphenol	µg/l	100	FEQS	20	3	203	260	16	0	-	<LOD
2-methylnaphthalene	µg/l	2	FEQS	20	0	-	<LOD	16	1	34.6	46.5
Carbazole	µg/l	2	FEQS	20	0	-	<LOD	16	1	11.4	12.6
di-n-butylphthalate	µg/l	8	FEQS	20	0	-	<LOD	16	3	1,643	2,790
Bis(2-ethylhexyl)phthalate	µg/l	8	WHO	14	3	20.98	21.6	18	2	349.2	468
Butyl benzyl phthalate	µg/l	7.5	FEQS	20	0	-	<LOD	16	3	5,826	10,500
Legend: green (97th percentile < criteria, maximum > criteria); Yellow (97th percentile <2x criteria); Orange (97th <10x criteria); Red (97th percentile >x10 criteria)											

Table 12.15 Summary of leachate and perched groundwater concentrations of pesticides/herbicides and PFAS contaminants which exceed the screening criteria.

Contaminant	Units	Screening criteria value	Criteria source	Leachate				Perched groundwater			
				No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max
PFOS	µg/l	0.01	DWS (T2)	10	6	0.67	1	16	14	1.19	1.73
PFOA	µg/l	0.01	DWS (T2)	4	2	2.35	2.74	16	10	0.069	0.079
PFOS	µg/l	0.1	DWS (T3)	10	6	0.67	1	16	7	1.19	1.73
PFOA	µg/l	0.1	DWS (T3)	4	2	2.35	2.74	16	0	0.069	0.079
PFOS	µg/l	1	DWS (T4)	10	0	0.67	1	16	2	1.19	1.73
PFOA	µg/l	1	DWS (T4)	4	1	2.35	2.74	16	0	0.069	0.079
n-Nitroso-n-dipropylamine	µg/l	0.1	DWS	14	1	18.3	30	18	0	-	<LOD
Clopyralid	µg/l	0.1	DWS	14	1	0.35	0.55	16	0	-	<LOD
Mecoprop	µg/l	0.1	DWS	14	6	3.1	3.51	16	6	1.47	1.64
Dichlorprop	µg/l	0.1	DWS	14	0	0.06	0.09	16	3	0.298	0.363

Contaminant	Units	Screening criteria value	Criteria source	Leachate				Perched groundwater			
				No of Samples	No > criteria	97th percentile	Max	No of Samples	No > criteria	97th percentile	Max
Dieldrin	µg/l	0.03	DWS	13	0	0.02	0.02	16	1	1.16	2.09
o,p-TDE (o,p-DDD)	µg/l	0.1	DWS	13	0	0.03	0.04	16	1	0.18	0.316
p,p-TDE (o,p-DDD)	µg/l	0.1	DWS	13	0	0.07	0.1	16	1	0.65	1.16
Azinphos-methyl	µg/l	0.1	DWS	15	1	0.31	0.52	19	0	-	<LOD
Diuron	ng/l	100	DWS	14	0	-	<LOD	16	1	110.2	130
Monuron	ng/l	100	DWS	14	4	285.9	291	16	3	216	225
Legend: green (97th percentile < criteria, maximum > criteria); Yellow (97th percentile <2x criteria); Orange (97th <10x criteria); Red (97th percentile >x10 criteria)											

12.2.9 The GQRA indicated that the following contaminants in the matrix of the landfill may pose a risk to controlled waters:

Metals and inorganics

a. Antimony, arsenic, barium, boron, iron, manganese and nickel were found to be potentially leachable and/or to be present in elevated concentrations in leachate/perched groundwater. While a number of these metals are known to be found naturally in groundwater within the chalk, the concentrations recorded exceed the typical background values and those recorded on site up-gradient of the landfill. A number of these contaminants were also detected in elevated concentration in the groundwater beneath the landfill (see Section 12.2.4). Therefore, these contaminants require further assessment.

b. A number of metals contaminants (lead, molybdenum, selenium and vanadium) were found to exceed the screening criteria in soil leachate. Lead, molybdenum and vanadium were not detected in the groundwater above the assessment criteria and selenium only exceeded in one sample but the 97th percentile was below the assessment criteria (see Section 12.2.4). As such there is not considered to be a significant source of these contaminants in the landfill which could pose a risk to controlled waters and therefore no further assessment is required.

c. Concentrations of hexavalent chromium were elevated in one leachate and one soil leachate sample, however all other results were below the laboratory LOD. Hexavalent chromium was not continuously detected in groundwater (see Section 12.2.4 above), despite significant monitoring being undertaken, with only random spikes detected. As such there is not considered to be a significant source of hexavalent chromium in the landfill which could pose a risk to controlled waters and therefore no further assessment is required.

d. Tributyltin compounds were elevated in five samples of perched groundwater but not within the soil leachate or leachate samples. Elevated concentrations recorded in BWS217 and BH214 were only recorded in these wells on one occasion with other samples being below the laboratory LOD. Dibutyl tin was also only elevated in two samples of perched groundwater and in BH209 was below LOD in a second sample. Neither of these contaminants were detected above LOD in the groundwater beneath the landfill (see Section 12.2.4). As such there is not considered to be a significant source of these contaminants in the landfill which could pose a risk to controlled waters and therefore no further assessment is required.

e. Sulphate, fluoride, bromate and total cyanide exceeded the assessment criteria. None of these contaminants were detected above assessment criteria in the groundwater beneath the landfill. As such there is not considered to be a significant source of these contaminants in the landfill which could pose a risk to controlled waters and therefore no further assessment is required.

f. Nitrite only has one exceedance within the soil leachate and the 97th percentile concentration did not exceed the assessment criteria. Therefore the exceedance is not considered significant and no further assessment is required.

g. Ammoniacal nitrogen was found to have elevated concentrations throughout the landfill. Ammoniacal nitrogen is a typical component of landfill leachate and therefore is considered a potential contaminant of concern. Further assessment of ammoniacal nitrogen is required.

h. A number of samples recorded elevated concentrations of thiocyanate. Thiocyanate is typically produced from the reaction between free cyanide and sulphate and can occur in landfills with a significant component of industrial waste. Thiocyanate is generally considered to be less toxic than cyanide. Thiocyanate was also detected in the groundwater beneath the landfill but not down-gradient (see Section 12.2.4). Thiocyanate is considered to require further assessment to determine whether the concentration could pose a risk to controlled waters.

Petroleum hydrocarbons, PAHs, Phenols, VOCs and SVOCs

a. Petroleum hydrocarbon aliphatic and aromatic fractions TPH C12-C16, C16-C21 and C21-35 are considered to present a potential risk to controlled waters. Several samples have reported maximum concentrations which are close to or above solubility limits which suggests the presence of free phase product, these wells (BH231, BH223 and WS224) are all located within the south east of the LTCP and may indicate the presence of localised product within the landfill waste. A hydrocarbon sheen was present on groundwater sampled from WS224. While only a small number of samples recorded an elevated concentration of xylene, the maximum concentrations of benzene and xylene were significantly above the screening criteria and should be assessed further. TPH C12 and above have been flagged for further assessment, see Table 12.16.

b. Petroleum hydrocarbon aliphatic and aromatic fractions TPH >C8-C10, and>C10-C12 are not considered to pose a risk to controlled waters as elevated concentrations were only recorded on up to two occasions. In addition, neither of these fractions were detected above assessment criteria in the groundwater beneath the landfill. As such there is not considered to be a significant source of these contaminants in the landfill which could pose a risk to controlled waters and therefore no further assessment is required.

c. Phenol and cresols were only elevated in three leachate samples and are therefore considered unlikely to pose a risk to controlled waters. Neither of these contaminants were detected above assessment criteria in the groundwater beneath the landfill. As such there is not considered to be a significant source of these contaminants in the landfill which could pose a risk to controlled waters and therefore no further assessment is required.

d. Widespread elevated concentrations of PAHs were recorded in both the leachate and perched groundwater. For further assessment benzo(a)pyrene, naphthalene, fluoranthene and anthracene will be considered as these are considered as representative marker compounds for the other PAHs.

e. Several VOC and SVOC's have been recorded above the screening criteria. However, most were isolated occurrences with the majority of results recording concentrations below the laboratory LOD. 1,2,4-trimethylbenzene exceeds in a several samples and is therefore considered to require further assessment.

PFAS

a. Elevated concentrations of PFAS were recorded in both the perched groundwater within the landfill and within the leachate throughout the duration of the monitoring. Whilst exceedances of PFAS have been observed within the leachate and groundwater perched within the landfill, the detections in groundwater beneath the landfill (see **Section 12.2.4**) are not as significantly elevated. Whilst the landfill should be considered a source of PFAS, monitoring data suggests that the impact to controlled waters is low. As discussed in **Section 12.2.4** the Environment Agency are currently developing a pragmatic approach to PFAS assessment. PFAS should be considered a contaminant of concern until the guidance is available and additional monitoring will be required.

Pesticides

a. A number of pesticides have been recorded within the leachate and perched groundwater. However, the exceedances are localised, with the exception of mecoprop where more frequent exceedances have been recorded and requires further assessment. All of the pesticides detected within the landfill are no longer in use in the UK (Ref. 50).

12.2.10 The following contaminants of concern within the landfill **(Table 12.16)** exceed the screening criteria and are considered to potentially pose a risk to controlled waters and should therefore be further assessed. The locations of these exceedances within the landfill are shown in **Figure 18** of this document.

Table 12.16 Summary of contaminants of concern within landfill requiring further assessment.

Metals and Inorganics	
Antimony	Iron
Arsenic	Manganese
Barium	Ammoniacal nitrogen
Boron	Nickel
Thiocyanate	
Petroleum hydrocarbons, PAHs, Phenols, VOCs and SVOCs	
Benzene	Xylene
Aromatic TPH C12-C16	Benzo(a)pyrene
Aliphatic TPH C12-C16	Naphthalene
Aliphatic TPH C16-C21	Fluoranthene
Aliphatic TPH C21-C35	Anthracene
Aromatic TPH C16-C21	1,2,4-trimethylbenzene
Aromatic TPH C21-C35	
Pesticides	
Mecoprop	

13 REVISED CONCEPTUAL SITE MODEL

13.1 Introduction

13.1.1 The preliminary conceptual site model detailed in **Section 3** has been updated following the quantitative risk assessment. The same methodology as detailed in **Appendix 17.1** of the ES (Ref. 1) **[TR020001/APP/5.02]**, has been used for assessing the risk.

13.1.2 The revised CSM takes into account the understanding of the ground model which is presented in **Section 7** and the landfill waste characteristics and quantitative assessments described in **Sections 8** to **12.** The updated CSM is provided in **Table 13.1** Revised Conceptual Site Model (CSM) updated following GQRA for Area A(Area A) and **Table 13.2** (Airport Access Road). The CSM for Area A is shown in **Figure 19** of this document.

13.1.3 It has been indicated within **Table 13.1** whether the PCLs apply either:

a. during excavation, remediation and construction phase; or
b. future use of proposed development.

13.1.4 In addition, the PCLs have been classified as follows:

	Confirmed relevant pollutant linkage (RCL) require inclusion in the ORS
	PCL requires further consideration through Detailed Quantitative Risk Assessment (DQRA)
	Impact is possible but can be mitigated by design and/or managed under an alternative regime such as permitted operation or occupational safety. Measure should be included in the ORS.
	Impact ruled out no further assessment required

Table 13.1 Revised Conceptual Site Model (CSM) updated following GQRA for Area A.

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
1	DEV	Ground gases from former landfill e.g. methane	Migration into future buildings and build-up of gases	Users of future development – public/airport operatives/ Green Horizons Park users	Very High	The GQRA indicated that the Characteristic Situation is 2 to 3. However, further DQRA is required to understand the gassing conditions.
2	DEV		Migration off-site	Adjacent site users (e.g. residential housing and other buildings on Luton Airport, WVP Community Centre/ pavilion)	Moderate	The GQRA indicated little evidence of off-site migration of gases. Further DQRA is required to understand the gassing conditions.
	CON					Measures will be required to treat existing preferential pathways e.g. TVD.
3	DEV	Volatile radionuclides occupying buildings overlying radioactive land contamination	Migration into future buildings and build-up of gases	Users of future development – public/airport operatives/Green Horizons Park users	Low	The recent GI included testing for radionuclides, which indicated levels observed were consistent with background levels (see **Section 10.1.3).** No further risk assessment of the radionuclide risks is required. However, a watching brief will be required during excavation works and procedures in place to ensure any suspected
4	DEV		Migration off-site through preferential pathways	Adjacent site users (e.g. residential housing and other buildings on Luton Airport, WVP Community Centre/ pavilion)	Low	

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
						radionuclide containing material encountered is appropriately managed.
5	CON	Waste in former landfill	Direct contact e.g. dermal contact, soil ingestion	Construction worker	Low	Based on the results of the GQRA no special precautions, above and beyond best practice, are considered necessary during construction works to control potential acute risks. Appropriate measures should be undertaken during construction to ensure the site is secure and dusts are controlled. Any risks to construction worker can be reduced by adoption of appropriate site management protocols and PPE.
6	DEV	Waste in former landfill		Future maintenance workers	Low/ Moderate	The GQRA indicated there was very few exceedances and the risk to maintenance workers of the new airport development is low. Maintenance workers may be exposed to areas of landfill waste during future

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
						excavation. This can be reduced by placing of services in a clean cover system.
7	DEV	Waste in former landfill		Users of future development – public/airport operatives/Green Horizons Park users	Low	The GQRA indicated there was very few exceedances and the risk to future users of the new airport development is low. The future development will comprise buildings & hardstanding, therefore there is unlikely to be any contact with landfilled wastes. However, given the heterogeneous nature of landfills and the lack of engineered cover system, it should be assumed that measures will be required, particularly in landscape areas to prevent direct contact with the waste.
8	CON		Direct or indirect contact with radionuclides – incurring radiation dose	Construction workers	Low/ Moderate	Potential for radioactive materials to be present within the earlier waste which was deposited prior to the introduction of the Radioactive Substances Act in 1963.

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
			by indirect dose received from ingestion of radium (or other alpha emitting contaminated material) or direct risk from contact with beta emitters such as Carbon-14 or Caesium-137			Potential for arisings from piling and foundation activities to encounter such materials. The recent GI included testing for radionuclides, which indicated levels observed were consistent with background levels. Procedures during construction should be in place to detect any radionuclides which may be encountered.
9	DEV	Waste in former landfill		Future maintenance workers	Low	The recent GI included testing for radionuclides, which indicated levels observed were consistent with background levels **(see Section 10.1.3).** However, given the heterogeneous nature of landfills and the lack of engineered cover system, it should be assumed that measures will be required. Maintenance workers may be exposed to areas of landfill waste during future excavation. This can be

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
						reduced by placing of services in a clean cover system.
10	DEV			Users of future development – public/airport operatives/Green Horizons Park users	Low	The recent GI included testing for radionuclides, which indicated levels observed were consistent with background levels **(see Section 10.1.3**). However, given the heterogeneous nature of landfills and the lack of engineered cover system, it should be assumed that measures will be required, particularly in landscape areas to prevent direct contact with the waste.
11	CON		Inhalation of vapours	Construction worker	Low	There are no generic assessment criteria for assessing soil gas vapour concentrations. Therefore, PCLs associated with soil gas vapours require further DQRA.
12	DEV			Future maintenance workers	Low	

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
13	DEV			Users of future development – public/airport operatives/Green Horizons Park users	Low	There are no generic assessment criteria for assessing soil gas vapour concentrations. Therefore, PCLs associated with soil gas vapours require further DQRA.
14	DEV		Inhalation of airborne contaminants/ dust/ asbestos fibres and microorganisms	Users of future development – public/airport operatives/Green Horizons Park users	Low	Further assessment required to understand mitigation measures required with respect to asbestos fibres, considered with DQRA.
15	CON			Adjacent site users (e.g. residential housing, Luton Airport visitors and operatives, users of WVP)	High	Further assessment required to understand mitigation measures required with respect to asbestos fibres, considered with DQRA.
16	CON			Construction workers	Moderate	Further assessment required to understand mitigation measures required with respect to asbestos fibres, considered with DQRA.

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
17	CON		Driving of contaminants downward during any future piling	Principal aquifer in Chalk	Moderate	The GQRA has indicated that there are isolated hot spots of contaminants present and a localised area of free product was encountered at location WS224. Care will be required during construction not to create a pathway. This may involve localised removal of hotspots in locations where works may create a pathway. Incorporation of localised removal at select locations in ORS for site to reduce potential for creation of pathways Risk from piling and construction can be mitigated by completion of piling risk assessment report to determine appropriate assessment for pile design and construction.
18	DEV		Direct contact of foundations of future development	Foundations of future buildings	Moderate	Presence of landfill waste in contact with building foundations may cause damage to foundations

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
						through aggressive ground conditions. Site investigation data will be considered in the design of the foundation. Risk can be mitigated by appropriate geotechnical design to select suitable foundation materials/concrete classification.
19	CON	Japanese Knotweed	Direct contact with rhizomes on floor slabs, external pavement and drainage	Floor slabs/drainage/pavement	Moderate/ Low	Japanese Knotweed has been identified in WVP, this can cause damage to buried infrastructure/buildings and pavement through growth of rhizome. Risk can be mitigated through application of treatment with herbicide/removal/on-site burial/containment.
20	CON	Leachate in former landfill[4]	Direct contact e.g. dermal contact	Construction workers	Moderate/ Low	Construction workers may be exposed to landfill leachate during future excavation works. The GI undertaken indicates there is likely to be limited leachate present.

[4] The source of the leachate in assumed to be the landfill waste material

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
						Any excavation work would adopt appropriate site management protocols and PPE.
21	DEV			Future maintenance workers	Moderate/ Low	The GI findings indicate there is likely to be limited leachate present. Maintenance workers may be exposed to areas of landfill waste during future excavation. This can be reduced by placing of services in a clean cover system.
22	DEV			Users of future development – public/airport operatives/Green Horizons Park users	Low	The GI findings indicate there is likely to be limited leachate present. The future development will be buildings and hardstanding and is likely to include an engineered cover layer and leachate control system, therefore there is limited potential for contact with any leachate in the landfill.
23	DEV		Downward migration of leachate	Principal aquifer in Chalk	Moderate/ Low	Further detailed risk assessment is required to inform the risks from this PCL.

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
24	DEV		Direct contact with foundations of future development	Foundations of future buildings	Moderate/ Low	Presence of leachate in contact with building foundations may cause damage to foundations through aggressive ground conditions. The GI findings indicate there is likely to be limited leachate present. Consider in the geotechnical design.
25	DEV		Leachate breakout and plant uptake	Areas of Landscaping in the airport and Green Horizons Park developments/WVP allotments	Low	There is no evidence that of leachate breakout is occurring. The GI findings indicate there is likely to be limited leachate present. A clean cover system with suitable depth of growth medium will further reduce this risk.
26	CON	Contaminants in perched water	Driving of contaminants downward during any future piling	Principal aquifer in Chalk	Low	GQRA indicated that perched water was present in some locations within the landfill. The GQRA indicated that there are isolated hot spots of contaminants present and a localised area of free product. Care will be required during

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
						construction not to create a pathway. This may involve localised removal of hotspots in locations where works may create a pathway. Risk from piling and construction can be mitigated by completion of piling risk assessment report to determine appropriate assessment for pile design and construction.
27	CON		Migration of contaminants via preferential pathways e.g. drainage	Principal aquifer in Chalk	Moderate	Survey and assessment to understand the purpose of the drain passing through the landfill to be undertaken and incorporated into design. Measure to be incorporated in design to prevent creation of preferential pathways.
28	CON	Contaminants in Made Ground (car park, capping material)	Direct contact e.g. dermal contact, soil ingestion	Construction workers	Moderate/ Low	Based on the results of the GQRA no special precautions, above and beyond best practice, are considered necessary during construction works to control potential acute risks. Appropriate measures should be

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
						undertaken during construction to ensure the site is secure and dusts are controlled. Any risks to construction worker can be reduced by adoption of appropriate site management protocols and PPE.
29	DEV	Contaminants in Made Ground (car park, capping material)		Future maintenance workers	Moderate/ Low	The GQRA indicated there was very few exceedances and the risk to future maintenance workers is low. Maintenance workers may be exposed to areas of Made Ground during future excavation. This can be reduced by placing of services in a clean cover system and adoption of appropriate site management protocols and PPE.
30	DEV			Users of future development – public/ airport workers/users of Green Horizons Park	Low	The GQRA indicated there was very few exceedances and the risk to future users of the development is low. The Proposed Development will comprise buildings &

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
						hardstanding, therefore there is unlikely to be any contact Made Ground. However, given the heterogeneous nature of landfills and the lack of engineered cover system, it should be assumed that measures will be required, particularly in landscape areas to prevent direct contact with the Made Ground.
31	CON		Inhalation of soil derived dusts/asbestos fibres	Construction workers	Moderate	Further assessment is required to establish the mitigation measures with respect to asbestos fibres, considered with DQRA.
32	DEV			Future maintenance workers	Moderate/ Low	Further assessment is required to establish understand mitigation measures with respect to asbestos fibres, considered with DQRA.
33	DEV			Users of future development – public/ airport workers/users of Green Horizons Park	Low	Further assessment is required to establish mitigation measures with respect to asbestos fibres, considered with DQRA.

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
34	CON			Adjacent site users (e.g. residential housing, Luton Airport, WVP)	Moderate/ Low	Further assessment is required to establish mitigation measures with respect to asbestos fibres, considered with DQRA.
35	CON		Inhalation of vapours	Construction worker	Low	There are no generic assessment criteria for assessing soil gas vapour concentrations. Therefore, PCLs associated with soil gas vapours require further DQRA.
36	DEV			Future maintenance workers	Low	
37	DEV			Users of future development – public/ airport workers/users of Green Horizons Park	Moderate/ Low	There are no generic assessment criteria for assessing soil gas vapour concentrations. Therefore, PCLs associated with soil gas vapours require further DQRA.
38	DEV			Adjacent site users (e.g. residential housing, Luton Airport, WVP Buildings)	Low	There are no generic assessment criteria for assessing soil gas vapour concentrations. Therefore, PCLs associated with soil gas vapours require further DQRA.
39	CON		Balancing pond	Principal aquifer in Chalk	Very Low	Thames Water balancing pond present in the north of the former landfill area, it will remain in place during the

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
						construction of the Proposed Development. Appropriate site management and construction techniques will be required during the development construction process in the vicinity of the current pond to reduce the risk.
40	DEV	Contaminants in groundwater (dissolved phase)	Lateral migration of contaminants in groundwater	Controlled waters (including potable water groundwater abstraction)	Moderate	Further detailed risk assessment is required to inform the risks from this PCL.
41	CON	Unexploded Ordnance	Driving of piles impact UXO	Construction workers/public/ terminal buildings	High/ Moderate	Based on detailed UXO Risk Assessment there is a 'Very High' probability of UXO on-site. There is 'Low risk' where works are to be undertaken within post war fill material- correct detection and monitoring procedures will be required during site works to mitigate risks. Works should take due regard of the CIRIA Guidance on UXO (Ref. 59)

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
KEY: CON- PCL during excavation, remediation and construction phase DEV- PCL associated with future use of proposed development						

Table 13.2 Revised Conceptual Site Model (CSM) updated following GQRA for Airport Access Road.

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
1	CON	Contaminants in Made Ground	Direct contact e.g. dermal contact and/or ingestion	Construction workers	Low	GI has been completed across most of the area for the proposed Airport Access Road. The GQRA has indicated that the contaminant concentrations recorded do not exceed the GAC. However additional GI will be required for detailed design to address the CoC which have not been investigated. No further detailed assessment is required at this stage and no requirement for remediation has been

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
						identified. However, future excavation works should adopt appropriate site management protocol and controls identified by the appointed contractor's method statement and risk assessment (MSRA).
2	DEV			Maintenance workers	Low	Future workers and end users are unlikely to encounter contaminated material due to the presence of the road hardstanding which breaks any plausible exposure pathways. If excavation was required workers would adopt appropriate site management protocols and PPE
3	CON		Inhalation of soil derived dusts/asbestos fibres from the Made Ground	Construction workers	Low	Construction workers will be exposed to Made Ground during excavation/construction. The generic assessment of risk from asbestos

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
						fibres has concluded a low risk with asbestos above the LOD detected in a small number of samples. Further sampling and analysis should be completed at design stage. Any future excavation work would adopt appropriate site management protocols and PPE, based on completion of a JIWG assessment, prior to any works.
4	DEV			Maintenance workers	Low	Future workers and end users are unlikely to encounter contaminated material due to the presence of the road hardstanding which breaks any plausible exposure pathways. If excavation was required workers would adopt appropriate site management protocols

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
						and PPE, identified in the MSRA.
5	DEV			Adjacent site users (e.g. commercial units, residential areas, Luton Airport)	Low	There is the potential for soil derived dusts which contain contaminants to be generated during construction works. asbestos fibres have been recorded in Made Ground. Good site management practices and mitigation measures would reduce the potential risk, to include perimeter monitoring, detail included in the ORS, **Appendix 17.5** of the ES **[TR020001/APP1/5.02]** and CoCP **Appendix 4.2** of the ES **[TR020001/APP1/5.02]** .

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
6	CON		Inhalation of vapours	Construction worker	Very Low	Evidence of TPH odours were recorded during previous GIs, generally at significant depth. Exposure to construction workers and future maintenance workers is considered to be low as it would be in outdoor air and therefore vapours will be diluted. Future excavation works should adopt appropriate site management protocol and controls identified by the appointed contractor's method statement and risk assessment (MSRA).
7	DEV			Future maintenance workers	Very Low	
8	DEV			Adjacent site users (e.g. commercial units, Luton airport, buildings)	Low	The Airport Access Road will replace existing hardstanding at the eastern end, however, the western end the route will pass through currently undeveloped land, if volatile contaminants are present this could impact

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
						vapour migration pathways. The GQRA has not identified any significant soil source and therefore this PCL has been excluded from further assessment at this stage. Additional GI at detailed design stage will be required to support this conclusion.
9	DEV		Leaching of contaminants to groundwater	Principal aquifer in the Chalk	Low	The presence of road hardstanding will reduce the infiltration and potential mobilisation of leachable contaminants It is also anticipated that the Airport Access Road will have a drainage and collection system to minimise percolation through contaminated material. In addition the groundwater is anticipated to be at approximately 40m bgl in this area . There are no structures which are likely to require

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
						deep foundations which could interact with the aquifer. No further assessment is therefore required at this stage. The previous GI did not include leachate testing or groundwater sampling and analysis, this should be scoped into any GI completed at detailed design stage to confirm this conclusion.
10	DEV	Ground gases from Made Ground e.g. methane, carbon dioxide	Migration into buildings and build-up of gases (off-site)	Users of adjacent commercial properties – public/airport operatives	Low	Ground gases may be produced where a significant thickness of Made Ground is present. Significant depth of Made Ground is present at the western end of the proposed Airport Access Road. Monitoring to date has not recorded methane above 0.0% by volume and low concentrations of CO_2. No further assessment is required at this stage but additional

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
						GI to fill in data gaps and confirm mitigation and design requirements prior to construction.
11	DEV	Contaminants in soils	Direct contact with contaminated materials	Building infrastructure (foundations / piled foundations), Services (water supply pipes)	Moderate	Aggressive ground conditions have not been assessed as part of previous reporting. Chemical attack on foundations may lead to expedited deterioration and cause stability issues to the final construct. Contaminants may permeate through Water supply pipes laid within contaminated soils. A BRE SD1 assessment of aggressive ground conditions should be undertaken to provide suitable classification of concrete. Should water supply pipes be included in the final scheme then a UKWIR assessment should be undertaken to inform pipe selection.

PCL No.	Phase applicable to (see key)	Source	Pathway	Receptor	Qualitative Assessment of Risk	Justification of Qualitative Assessment of Risk
						Both assessments to be completed at detailed design stage.
12	CON	Unexploded Ordnance	Encountering UXO during excavation,	Construction workers/public/ commercial units	Low/Moderate	Correct detection and monitoring procedures will be required during site works to mitigate risks (Ref. 59).
KEY: CON- PCL during excavation, remediation and construction phase DEV- PCL associated with future use of proposed development						

14 CONCLUSIONS OF GENERIC QUANTITATIVE RISK ASSESSMENT

14.1.1 This GQRA report focussed on the main area of concern with respect to potential contamination identified in the PRA, which is a former landfill site (Area A). In addition, the Airport Access Road to the west of the airport was also assessed as the PRA identified that GI work had been undertaken previously but no assessment of the results had been undertaken to determine the risk from the contamination.

14.1.2 The following sections report the findings of the GQRA for these two areas and summarise where further work is required.

14.2 Airport Access Road

14.2.1 Two phases of ground investigation have been undertaken for the new road in 2017 (Ref. 8) and 2018 (Ref. 9) which were reviewed in **Appendix 17.1** of the ES (Ref. 1) **[TR020001/APP/5.02]**. The sampling locations are distributed across the route at approximately 50m spacing. Chemical testing was not undertaken at each location, so in some areas the chemical sampling density does not meet that of an exploratory investigation as set out in BS10175. Samples were tested for a range of analytes relevant to the past contaminative land uses and provides a preliminary dataset to assess the risks posed to human health.

14.2.2 The conclusions of the GQRA for the new road are discussed in the sections below.

Human health

Soils

14.2.3 There were no exceedances of the chronic or acute assessment criteria for human health when compared to the soils data.

14.2.4 However as noted above in **Section 14.2.1** the current chemical sampling density does not meet that of best practice guidance set out in BS10175 and there may areas of potential contamination which have not yet been sampled. Notwithstanding this, the overall risk to future users of the road is considered to be very low as the road will be predominately hard standing minimising potential exposure to underlying soils. Therefore no further detailed risk assessment is required at this stage. Further ground investigation may be required at detailed design stage to inform the risks to construction workers and future maintenance workers.

Groundwater and soil vapours

14.2.5 The proposed Airport Access Road does not include any buildings, as such there is no potential for accumulation of vapours in indoor air. However, further GI and/or assessment may be required at the detailed design stage to inform the risks to construction workers, future maintenance workers.

Asbestos

14.2.6 Assessment of the asbestos fibres detected in the soils indicated that the majority were below 0.001% v/v, however there are some higher results. The distribution of the detected samples was typically limited between Dairyborn Escarpment/Airport Way and Percival Way/Presidents Way.

14.2.7 The greatest potential risks from asbestos will be during enabling and construction works, when soils are disturbed and may allow fibres to be released into ambient air. No further detailed assessment is required at this stage but further consideration of the potential risks from asbestos fibres should be undertaken at the detailed design stage to inform the risks to construction workers. The likely classification of works under the Control of Asbestos Regulations (Ref. 43) and risks to construction workers will need to be assessed using CL:AIRE's Joint Industry Working Group (JIWG) Decision Tools (Ref. 39) prior to any works.

Controlled waters

14.2.8 No groundwater sampling or soil leachate testing was undertaken as part of the GI on the proposed new road (Airport Access Road). It is not envisaged that the proposed earthworks will interact with the groundwater, which is recorded at approximately 40m bgl. However, this will need to be reviewed at the detailed design stage. Therefore no further assessment is required for controlled water risks at this stage.

14.2.9 The drainage strategy for the road will be undertaken at the detailed design stage but it should ensure that no infiltration will occur across the landfill area or in other areas of Made Ground along the alignment.

Ground gas

14.2.10 The proposed Airport Access Road does not include any buildings, as such there is no potential for accumulation of gases in indoor air. However, further GI and/or assessment may be required at the detailed design stage to inform the risks to construction workers, future maintenance workers and adjacent site users.

14.2.11 Ground gas monitoring collected during the GI works has been used as part of an overall assessment of the area outside of Eaton Green Landfill.

14.3 Area A- landfill

14.3.1 A preliminary and detailed GI have been undertaken within the landfill area. The sampling locations have a good spatial, lateral and vertical distribution, encompassing all the main eras of waste deposition. A significant number of soil (1219 samples), groundwater and leachate (328 tests) and gas/VOC samples (96 tests) have been undertaken and analysed to industry standards providing a comprehensive data set for the area. The investigations undertaken to date provide a good understanding of the general composition of the waste, groundwater, leachate and landfill gas conditions within this area. The data was considered adequate to inform the risk assessment.

14.3.2 The waste characteristics described in **Section 8** indicated that overall there is no distinct spatial variation in the waste types or chemistry. As such it was not considered necessary to sub-divide the landfill for the risk assessment.

14.3.3 The risk assessment considered a reasonable worst-case scenario is representative of the conditions at the landfill. This is considered conservative but allows for the heterogenous nature of the landfill in the assessments.

14.3.4 However, due to the nature of historic landfills i.e. no specific controls on waste types deposited, there is likely to be a high degree of heterogeneity in the waste. Whilst a substantial amount of GI data is available; no GI can completely characterise a site and contamination may exist in an area where contamination was not expected. Therefore, the ORS, **Appendix 17.5** of the ES **[TR020001/APP/5.02]** includes measures to detect and deal with unexpected contamination.

14.3.5 The conclusions of the human health, controlled waters and gas GQRA for Area A are discussed in the sections below.

14.4 Human health

Soils

Chronic assessment

14.4.2 The GQRA indicated that overall there were very few exceedances in relation to the overall number of tests undertaken. For all contaminants less than 3% of the samples undertaken for analysis had exceedances. Most of the exceedances are within one order of magnitude of the GAC, with a number only marginally exceeding the criteria.

14.4.3 The majority of the exceedances were within the construction waste type (40%).

14.4.4 Exceedances for trimethylbenzene were noted which is a volatile aromatic hydrocarbon. The exceedances were co-located with other volatile compounds which exceeded their respective GACs i.e. naphthalene and 2-methylnaphthalene. The risks from soil vapours requires further consideration (see below).

14.4.5 Overall, the concentration of contaminants in the landfill are not significantly elevated. The majority of contaminants which exceeded present a risk through direct contact. The development is largely hardstanding (see **Figure 16** of this document) and therefore future users are unlikely to come into direct contact with the underlying material. However, given the heterogeneous nature of landfills and the lack of engineered cover system, it should be assumed that measures will be required, particularly in landscape areas to prevent direct contact with the waste.

14.4.6 No further detailed assessment is required to inform the chronic risks from soils.

Acute assessment

14.4.7 Comparison of the soil samples against the AGAC indicated one exceedance for arsenic of the oral criteria for a child trespasser during construction works, which was considered an unlikely scenario. Appropriate measures should be undertaken during construction to ensure the site is secure and dusts are controlled. Based on the results of the acute assessment no special precautions, above and beyond best practice, are considered necessary during construction works to control potential acute risks.

14.4.8 No further detailed quantitative assessment of the acute risks to human health are required.

14.4.9 As detailed above, due to the heterogenous nature of landfills, measures should be taken during construction works to detect and deal with unexpected contamination i.e. a watching brief. If significant unexpected contamination is encountered further risk assessment may be required.

Soil vapours

14.4.10 There are no generic assessment criteria for assessing soil gas vapour concentrations. Therefore, PCLs associated with soil gas vapours require further DQRA.

Groundwater vapours

14.4.11 Volatile contaminants in groundwater have the potential to cause risk to human health via volatilisation and migration of vapours into overlying buildings or outdoor air space followed by inhalation. During the 2018 GI some perched water was encountered, therefore, the potential risks associated with volatile contaminants in perched water were assessed.

14.4.12 Exceedances for TPH >C10-C12 Aliphatic and 1,2,4- Trimethylbenzene were noted at one location (WS224). The solubility limit for TPH >C10-C12 aliphatic was exceeded, suggesting that free product may be present at this location. Site observations and during the monitoring rounds confirmed the presence of free product at this location.

14.4.13 WS224 is located close to the proposed excavation of landfill materials for the airside platform and there is the potential for the product present to be mobilised during the works and a pathway created to the underlying chalk. Therefore, the free product at this location should be removed as part of the works. Any perched water in the material will also be removed. The material from this location is unlikely be suitable for reuse without treatment to remove the product present.

14.4.14 No further detailed assessment is required to inform the risks from groundwater vapours in perched groundwater.

14.4.15 As detailed above, due to the heterogenous nature of landfills, measures should be taken during construction works to detect and deal with unexpected contamination i.e. a watching brief. If significant unexpected contamination is encountered further risk assessment may be required.

Asbestos

14.4.16 Assessment of the asbestos fibres detected in the soils indicated that the majority were below 0.001% v/v, however there are some higher results. In general, higher concentrations of asbestos in soil have the capacity to liberate higher concentrations of asbestos fibres into the air but this is also very dependent on the type of ACM present and its ability to release fibres.

14.4.17 The nature of the asbestos encountered in the area of the former scrapyard appeared to be different from that encountered within the landfill, no visible bundles of fibres were noted in the landfill during the GI.

14.4.18 Due to the nature of the works to be undertaken at the site i.e. extensive excavation and the detection of some higher concentrations of asbestos fibres in the GIs, further detailed assessment is required. The detailed assessment is presented in the DQRA for Human Health and Ground Gas (Ref. 60), provided as **Appendix 17.3** of the ES **[TR020001/APP/5.02]**.

14.5 Ground gas

14.5.1 The gas spot monitoring results were considered to be CS2 with a few CS3 readings. The CS3 readings recorded were as a result of negative flow rates, which were considered to be a positive flow rate for the purposes of the initial assessment. Negative flow rates indicate that the gas pressures within the ground are below that of atmospheric pressure and can occur due rapid changes in atmospheric pressure. The effect of atmospheric pressure on the gas regime is more accurately measured with continuous gas monitoring. The detailed assessment of the effect of atmospheric pressure and the gas regime of the site is presented in the DQRA: Human Health and Ground Gas (Ref. 60), **Appendix 17.3** of the ES **[TR020001/APP/5.02]**.

14.5.2 Outside of the landfill, the levels of gas recorded are low, with the general exception of BWS203, BWS211, BWS214, BBH209, BBH210 and LF-BH05G, which are all located adjacent to the landfill boundary. LF-BH05G and BBH210 are located within an area which has a significant thickness of Made Ground. Flow rates across the holes were low. The analysis indicates that the area outside the landfill is CS2, which is considered low risk, although care should be taken during the design and construction phases of the development to ensure that no preferential pathways are created.

14.5.3 Further detailed gas risk assessment is required of the ground gas including consideration of the continuous gas monitoring to inform the likely protection measures. The detailed assessment is presented in **Appendix 17.3** of the ES **[TR020001/APP/5.02]** (Ref. 60).

14.6 Controlled waters

14.6.1 The GQRA undertaken indicated that overall there were relatively few exceedances of potential contaminants of concern recorded in groundwater beneath the site. Those which did exceed tended to be in boreholes beneath or close to the landfill and were typically in localised areas. There is limited evidence of any significant contaminant plume migrating down-hydraulic gradient of the landfill.

14.6.2 The assessment of the material in the landfill, its leachability and the landfill leachate indicated there were more exceedances than within the groundwater. The contaminants of concern identified from the GQRA which required further detailed assessment are summarised in **Table 14.1.** Results are provided in the DQRA: Controlled Waters (Ref. 61), provided as **Appendix 17.4** of the ES **[TR020001/APP/5.02]**.

14.6.3 Whilst PFAS has been observed to exceed DWI guidance values it is pertinent to note that the use of the DWI values is conservative when applied to an aquifer body. Therefore, at this stage, PFAS have not been taken forward to DQRA. The Environment Agency are currently developing their understanding and approach to assessing and managing the risks from PFAS. Further assessment may be required at detailed design stage.

Table 14.1 Key contaminants of concern in the groundwater and landfill requiring further detailed controlled waters assessment.

Groundwater	**Landfill (Soils, Soil leachate and leachate)**
Metals and Inorganics	Antimony
Manganese	Arsenic
Ammoniacal nitrogen	Barium
Nitrate	Boron
Boron	Thiocyanate
Nickel	Iron
Iron	Manganese
	Ammoniacal nitrogen
	Nickel
Petroleum hydrocarbons, PAHs, Phenols, VOCs and SVOCs	
Trichloroethene (TCE)	Benzene

Vinyl chloride	Aromatic TPH C12-C16
1,2-dichloroethane	Aliphatic C12-C16
Fluoranthene	Aliphatic C16-C21
	Aliphatic C21-C35
	Aromatic C16-C21
	Aromatic C21-C35
	Xylene
	Benzo(a)pyrene
	Naphthalene
	Fluoranthene
	Anthracene
	1,2,4-trimethylbenzene
Pesticides	
Diuron	Mecoprop
Mecoprop	

GLOSSARY/ABBREVIATIONS

Term	Definition
Abbreviations	
ACM	asbestos containing material
AGAC	acute generic assessment criteria
AOD	above ordnance datum
BTEX	benzene, toluene, ethylbenzene, xylenes
BGS	British Geological Survey
BOD	biochemical oxygen demand
BS	British Standard
CL:AIRE	Contaminated Land: Applications in Real Environments
CoCP	Code of Construction Practice
CoC	contaminants of concern
COD	chemical oxygen demand
COMAH	Control of Major Accident Hazards
CIRIA	Construction Industry Research and Information Association
CLR	contaminated land report
CLEA	contaminated land exposure assessment
CPT	cone penetration test
CS	characteristic situation
CSM	conceptual site model
CWS	County wildlife site
Luton DART	Luton Direct Air-Rail Transport
DCO	Development Consent Order
DEFRA	Department of Environment Food and Rural Affairs
DO	dissolved oxygen
DOC	degradable organic carbon
DQRA	Detailed Quantitative Risk Assessment
DWS	drinking water standards
EIA	Environmental Impact Assessment
EQS	environmental quality standards
ES	Environmental Statement
FBO	fixed base operation
FEQS	freshwater environmental quality standards
GAC	generic assessment criteria
GSV	gas screening value
GQMB	groundwater quality monitoring points
GQRA	Generic Quantitative Risk Assessment
GI	ground investigation
HI	hazard index
HGV	heavy goods vehicle
LCRM	Land Contamination Risk Management
LOD	limit of detection
LLAOL	London Luton Airport Operator Limited
LTCP	long-term car park

mppa	million passengers per annum.
MSRA	method statement and risk assessment
MTBE	methyl tertiary butyl ether
NAPLs	non-aqueous phase liquids
NHBC	National House Building Council
NGR	national grid reference
ORS	Outline Remediation Strategy
PAH	polyaromatic hydrocarbons
PCB	polychlorinated biphenyls
PCL	potential contaminant linkage
PFAS	per- and polyfluoroalkyl substances
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulphonate
PID	photoionisation detector
PCDD	polychlorinated dibenzo-para-dioxins
PCDF	polychlorinated dibenzofurans
PPE	personal protective equipment
PRA	Preliminary Risk Assessment
PSSR	Preliminary Sources Study Report
RTM	remedial target methodology
RCL	relevant contaminant linkage
SoBRA	Society of Brownfield Risk Assessment
SOM	soil organic matter
SPZ	source protection zone
SVOC	semi-volatile organic compounds
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TVD	Thames Valley Drain
UXO	unexploded ordnance
VFA	volatile fatty acids
VOC	volatile organic compound
WVP	Wigmore Valley Park
Glossary	
Above ordnance datum (AOD)	Above ordnance datum (AOD) is a vertical measurement used by ordnance survey as the basis for deriving altitudes on maps, usually by comparison with the mean sea level.
Aquifer	An aquifer is an underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand, or silt).
Application Site	The area covered by the proposed planning application boundary.
Baseline	A description of the current state of the environment without implementation of the project.
Code of Construction Practice (CoCP)	This document outlines the environmental management and mitigation requirements to be implemented throughout the construction period for the delivery of the Proposed Development.

Glossary	
Conceptual Site Model (CSM)	A representation of the characterisation of a site in diagrammatic and/or written form that shows the possible relationships between the contaminants, pathway and receptors. This helps to evaluate the potential risks that the site poses given the intended operations and future use of the site.
Cone Penetration Test (CPT)	A rapid ground investigation method to collect information on the variations of soil type and its properties with depth. As the electric cone is pushed into the soil, sensors on the tip measure resistance, friction and dynamic porewater pressure.
Controlled waters	These are fully defined in section 104 of the Water Resources Act 1991. Controlled waters include, in summary: a. Relevant territorial waters which extend seaward for three miles from the low-tide limit from which the territorial sea adjacent to England and Wales is measured b. Coastal waters from the low-tide limit to the high-tide limit or fresh-water limit of a river or watercourse c. Inland freshwaters: natural and artificial lakes, ponds, reservoirs, rivers or watercourses above the fresh-water limit d. Natural and artificial underground rivers and watercourses e. Surface water sewers, ditches and soakaways that discharge to surface or groundwater it also includes those that may be currently dry f. Groundwaters – any waters contained in underground strata.
Department for Environment and Rural Affairs (Defra)	UK government department responsible for safeguarding the natural environment, supporting the food and farming industry, and sustaining a thriving rural economy.
Detailed assessment	Method applied to gain an in-depth appreciation of the beneficial and adverse consequences of the project and to inform project decisions. Detailed Assessments are likely to require detailed field surveys and/or quantified modelling techniques.
Development Consent Order (DCO)	A Development Consent Order (DCO) is the means of obtaining permission for developments categorised as Nationally Significant Infrastructure Projects. This includes energy, transport, water and waste projects.
Effect	Term used to express the result/consequence of an impact (expressed as the 'significance of effect').

Glossary	
Emission	A material that is expelled or released to the environment. Usually applied to gaseous or odorous discharges to the atmosphere.
Environment Agency	The Environment Agency is responsible for environmental protection and regulation in England and plays a central role in implementing the government's environmental strategy. The Environment Agency is the main body responsible for managing the regulation of major industry and waste, treatment of contaminated land, water quality and resources, fisheries, inland river, estuary and harbour navigations, and conservation and ecology. They are also responsible for managing the risk of flooding from main rivers, reservoirs, estuaries and the sea.
Environmental Statement (ES)	A statutory report (this document) produced by the developer including: a. A description of the project b. A description of the likely significant effects of the project on the environment c. A description of the features of the project and/or measures envisaged in order to avoid, prevent or reduce and, if possible, offset likely significant adverse effects on the environment d. A description of the reasonable alternatives e. A non-technical summary f. Any additional information relevant to the characteristics of a project
Gas Screening Values (GSV)	The product of the groundwater flow rate and gas concentration within a borehole.
Groundwater	Groundwater is the water present beneath Earth's surface in rock and soil pore spaces and in the fractures of rock formations.
Groundwater divide	The boundary between groundwater basins; defined by a line connecting the high points on the water table or other potentiometric surface. Groundwater flows away from a groundwater divide.
Hard standing	Ground improvement by the use of compacted stone or other materials which facilitates increased surface loading from vehicles or other plant.
Hazardous waste	Waste which displays one or more of the hazardous properties listed in Annex III of the Waste Framework Directive.

Glossary	
Impact	The change or action. Either beneficial or adverse.
In-situ	In the natural, original or appropriate position.
Inert materials	Inert material is material which is neither chemically or biologically reactive and will not decompose. Examples of this are sand, drywall, and concrete. This has particular relevance to landfills as inert materials typically require lower disposal fees than biodegradable waste or hazardous waste.
Limit of Detection (LOD)	The lowest contaminant concentration that can be detected by the apparatus used, usually dependent on the resolution of the equipment.
Leachate	A liquid that forms within waste accumulations such as landfills that contain increased concentrations of contaminants, specifically heavy metals, ammoniacal nitrogen and organic compounds. It is therefore hazardous and either must be indefinitely contained within the landfill or collected and suitably disposed of.
Local authorities	An administrative body in local government. The Proposed Development is situated within three authority boundaries: Luton Borough Council (LBC); North Hertfordshire District Council (NHDC); and Central Bedfordshire Council (CBC).
Made Ground	Made Ground is an area where the pre-existing (natural or artificial) land surface is raised or filled by artificial deposits consisting of materials such as refuse, demolition rubble etc.
Main Application Site	The airport site excluding off-site works.
Mitigation measure	Measure aiming at preventing/reducing an adverse environmental effect.
Non-hazardous waste	Waste that is not covered under Article 2 (c) of the Landfill Directive (1999/31/EC), i.e. neither classed as hazardous nor as inert.
Pollutant	A substance that pollutes something, especially water or the atmosphere.
Potable water	Water that is safe to drink/consume.

Glossary	
Potential contaminant linkage	The potential contaminant linkage determines how contaminant travels from the contaminant source to a receptor.
Preliminary Environmental Information (PEI) Report	The PEI Report was prepared in compliance with the EIA Regulations to enable the local community, any other interested person and stakeholders to understand the environmental effects of the Proposed Development and enable an informed response to the consultation. The document set out how each environmental topic area is being assessed, the potential environmental effects of the Proposed Development based on the information available at the time, and measures proposed to avoid or reduce such effects. This is to support consultees in developing an informed view of the likely significant environmental effects of the Proposed Development, and allow them to provide additional information for inclusion in the EIA.
Proposed Development	The proposed expansion of Luton Airport with new terminal and stands and associated developments (as described in **Chapter 4**).
Receptor (sensitive)	A component of the natural, created, or built environment such as human
Relevant contaminant linkage	Where a PCL has been identified and mitigation measures inherent in the construction or operation of the Proposed Development might not be sufficient to break the pollutant linkage, these are assessed to be a RCL and would require specific remediation measures to be implemented.
Source protection zone (SPZ)	Source Protection Zones (SPZ) are defined around large and public potable groundwater abstraction sites. The purpose of SPZs is to provide additional protection to safeguard drinking water quality through constraining the proximity of an activity that may impact upon a drinking water abstraction.
Study area	Defined area surrounding the site in which is collected and analysed in order to set the site into its context. This varies as stated within each technical assessment.
Surface water	Water that collects on the surface of the ground.
Topography	The natural and artificial physical features of an area.
Trace Components	Chemical constituents present in soil gas or air at trace levels derived directly from materials present in waste materials in the subsurface or from degradation of waste.
Unexploded ordnance (UXO)	Unexploded ordnance (UXO), unexploded bombs, or explosive remnants of war are explosive weapons that did not explode when they were employed and still pose a risk of detonation, sometimes many decades after they were used or discarded.
Volatile Fatty Acids (VFA)	Monocarboxylic acids that are strongly malodorous, created by the anaerobic degradation of waste materials.

Glossary	
Volatile Organic Compounds (VOC)	Organic compounds that are volatile under normal environmental/atmospheric conditions. They may be found in the ground in a solid or liquid phase form as well as in a gaseous phase form.
Waste	Waste is defined in Article 3(1) of the European Waste Framework Directive 2008/98/EC (OJL 312/3) as any substance or object which the holder discards or intends or is required to discard. The term ‘holder’ is defined under article 3(6) as ‘the waste producer or the natural or legal person who is in possession of the waste’. The waste ‘producer’ is defined under article 3(5) as ‘anyone whose activities produce waste (original waste producer) or anyone who carries out pre-processing, mixing or other operations resulting in a change in the nature or composition of the waste’. Waste can be further classified as hazardous, non-hazardous or inert.
Water quality	Water quality refers to the chemical, physical, and biological characteristics of water based on the standards of its usage.
World Health Organisation (WHO)	The World Health Organization (WHO) is a specialised agency of the United Nations that is concerned with international public health.
Worst-case (scenario)	The definition of a ‘worst-case’ varies by the field to which it is being applied, however ultimately it is the most unfavourable foreseen scenario. Often assessments use a worst-case scenario.

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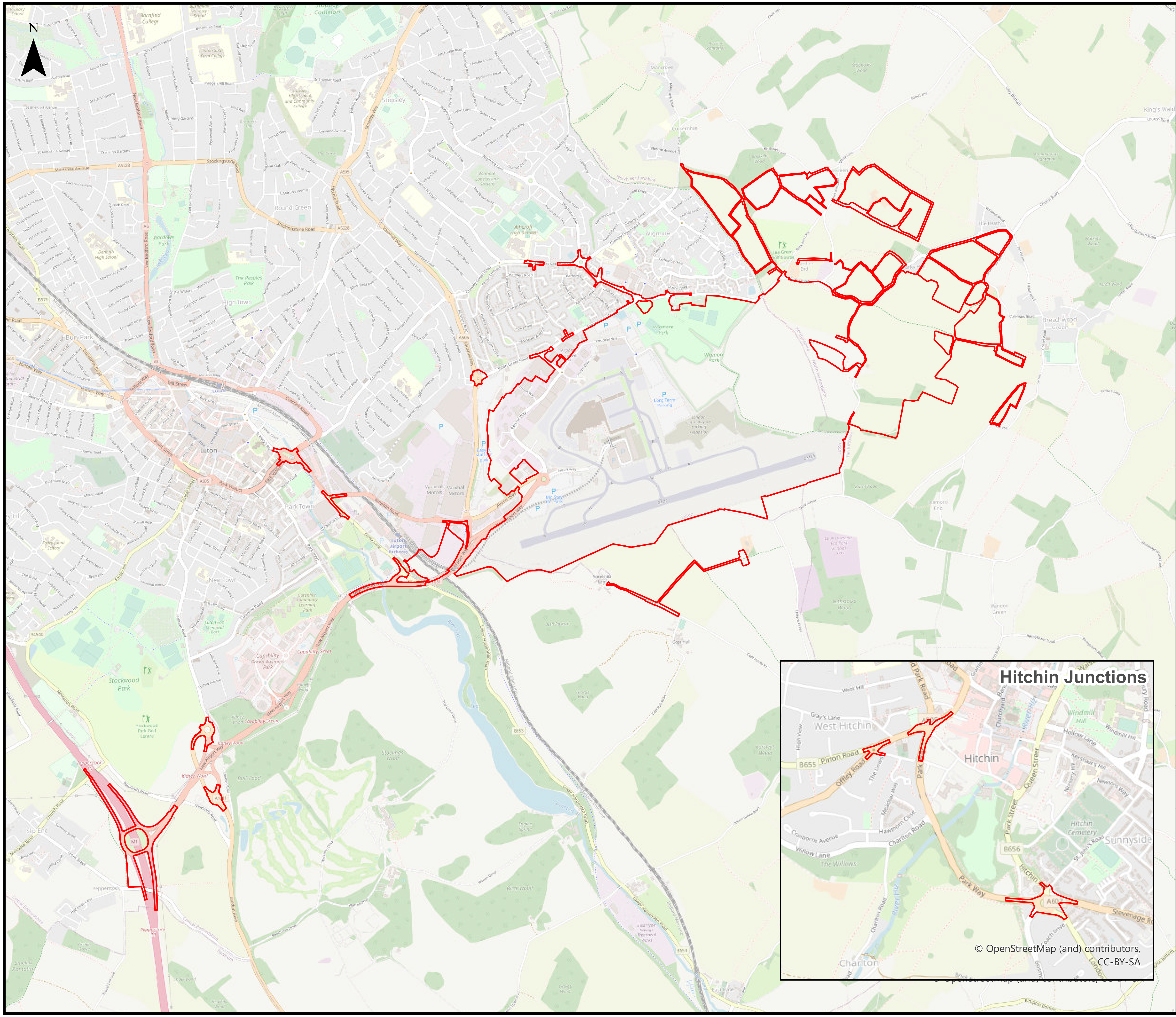
FIGURES

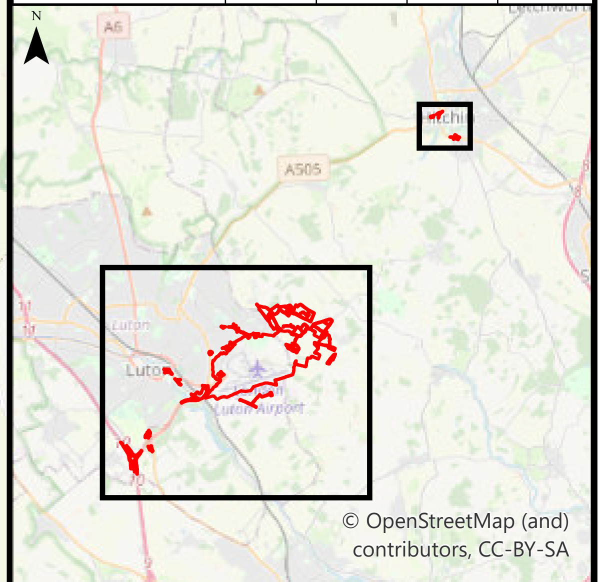


All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

Legend

Order Limits

First Issue	AB	RB / TB	26/09/22	P02
Revision History	Drawn	Checked / Approved	Date	Rev.



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Drawing Title

Figure 1
Location of Proposed Development

Purpose of issue					Suitability
SUITABLE FOR INFORMATION					S2
Drawn	Checked	Approved	Date	Scale	Size
AB	RB	TB	26/09/22	1:25,000	A3

DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001	(APFP 5(2)(a))	TR020001/APP/5.03

Drawing Number	Revision
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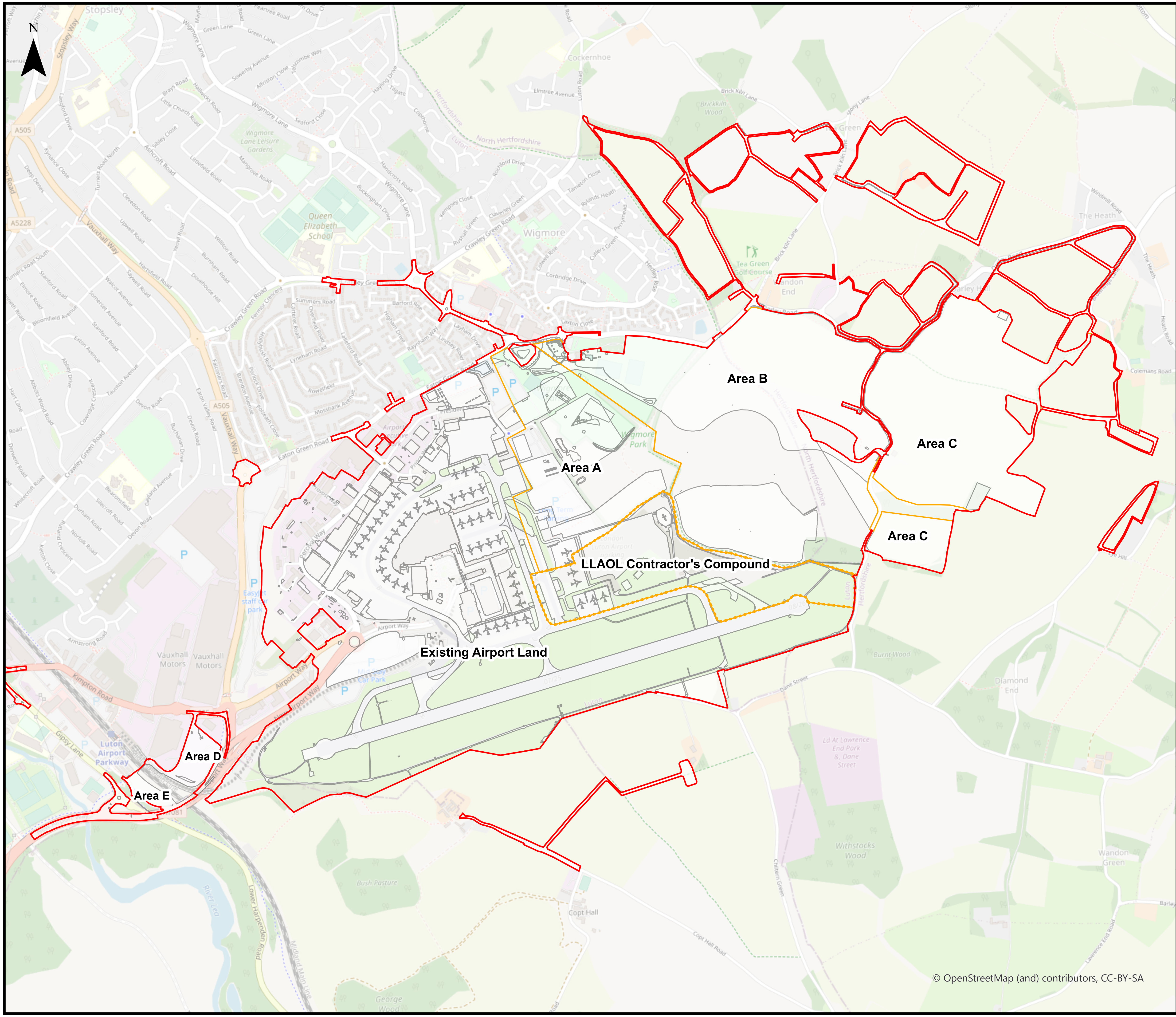
Project - Phase - Originator - Asset/Zone - Sub Asset - Type- Discp. - Number



All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

Legend

- Order Limits
- Site Subdivisions
- Airport Infrastructure Layout - Assessment Phase 1

Revision History	Drawn	Checked / Approved	Date	Rev.
First Issue	AB	RB / TB	26/09/22	P02

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Drawing Title

Figure 2a
Proposed Masterplan - Assessment Phase 1

Purpose of issue	Suitability
SUITABLE FOR INFORMATION	S2

Drawn	Checked	Approved	Date	Scale	Size
AB	RB	TB	26/09/22	1:15,000	A3

DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001	APFP 5(2)(a)	TR020001/APP/5.03

Drawing Number	Revision
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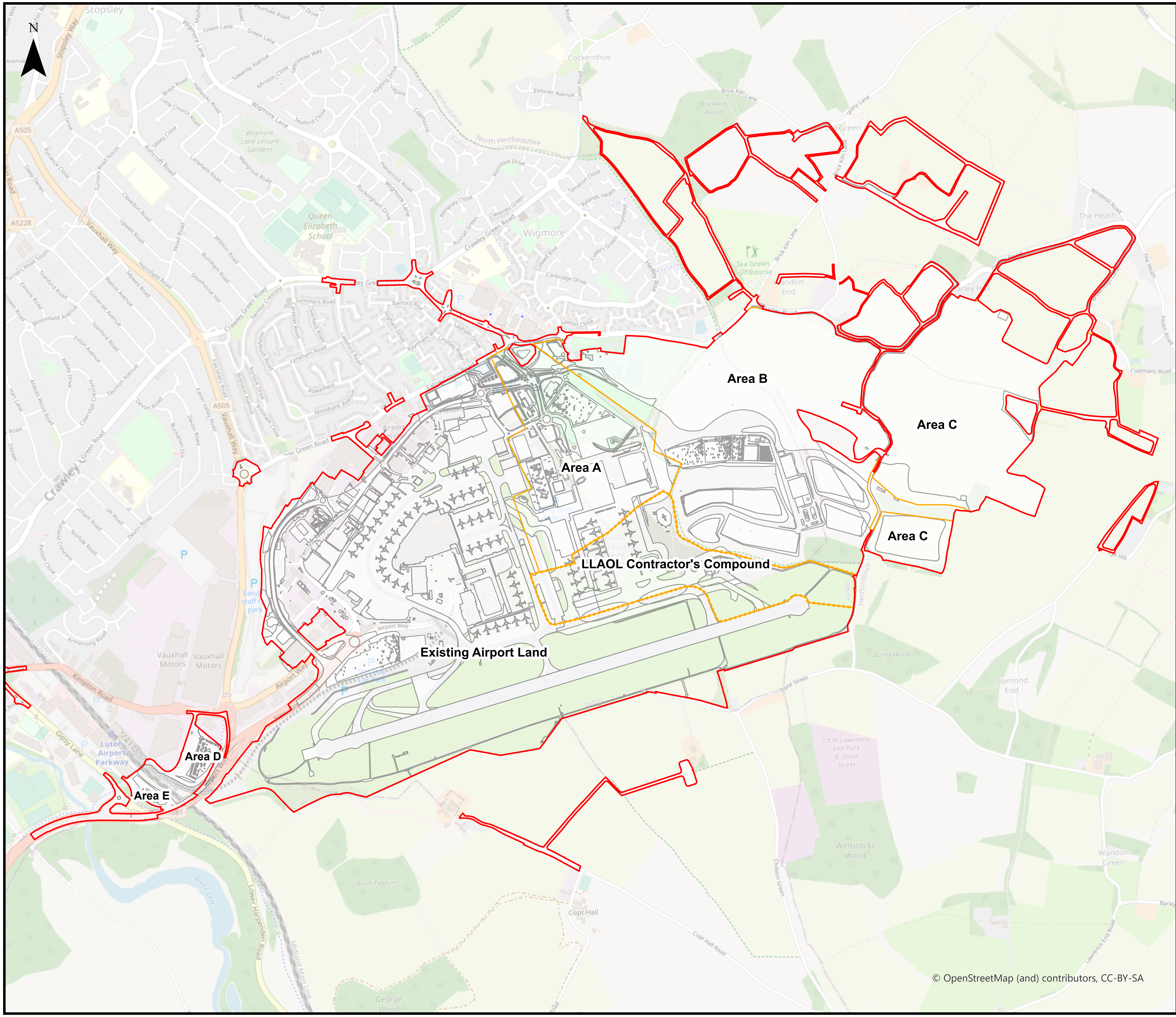
Project - Phase - Originator - Asset/Zone - Sub Asset - Type- Discp. - Number



All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

Legend

- Order Limits
- Site Subdivisions
- Airport Infrastructure Layout - Assessment Phase 2a

Revision History	Drawn	Checked / Approved	Date	Rev.
First Issue	AB	RB / TB	26/09/22	P02

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Drawing Title

Figure 2b
Proposed Masterplan - Assessment Phase 2a

Purpose of issue				Suitability	
SUITABLE FOR INFORMATION				S2	
Drawn	Checked	Approved	Date	Scale	Size
AB	RB	TB	26/09/22	1:15,000	A3

DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001	APFP 5(2)(a)	TR020001/APP/5.03

Drawing Number	Revision
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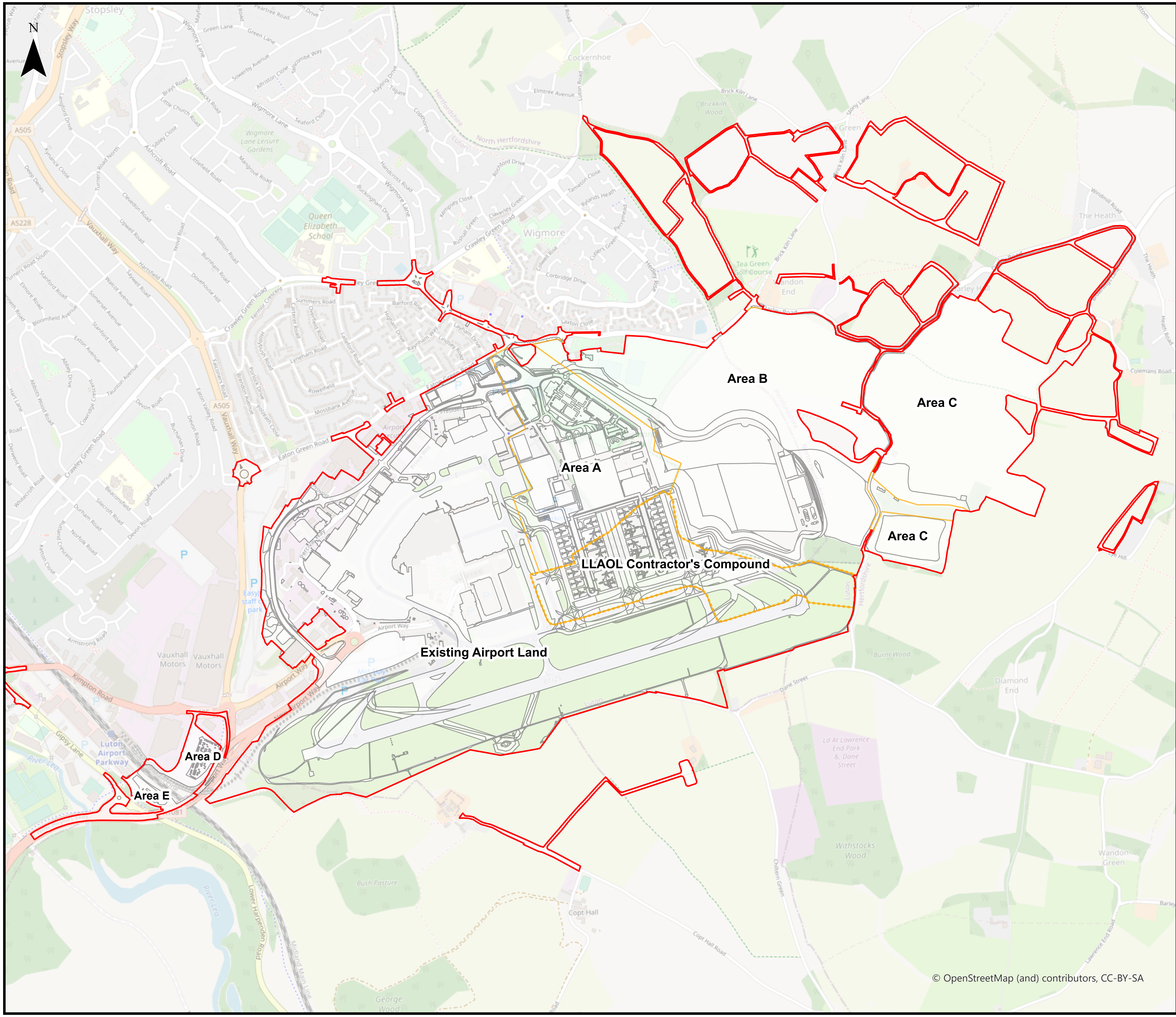
Project - Phase - Originator - Asset/Zone - Sub Asset - Type- Discp. - Number



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Legend

- Order Limits
- Site Subdivisions
- Airport Infrastructure Layout - Assessment Phase 2b

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First Issue	AB	RB / TB	26/09/22	P02
Revision History	Drawn	Checked / Approved	Date	Rev.

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Drawing Title

Figure 2c
Proposed Masterplan - Assessment Phase 2b

Purpose of issue				Suitability	
SUITABLE FOR INFORMATION				S2	
Drawn	Checked	Approved	Date	Scale	Size
AB	RB	TB	26/09/22	1:15,000	A3

DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001	APFP 5(2)(a)	TR020001/APP/5.03

Drawing Number	Revision
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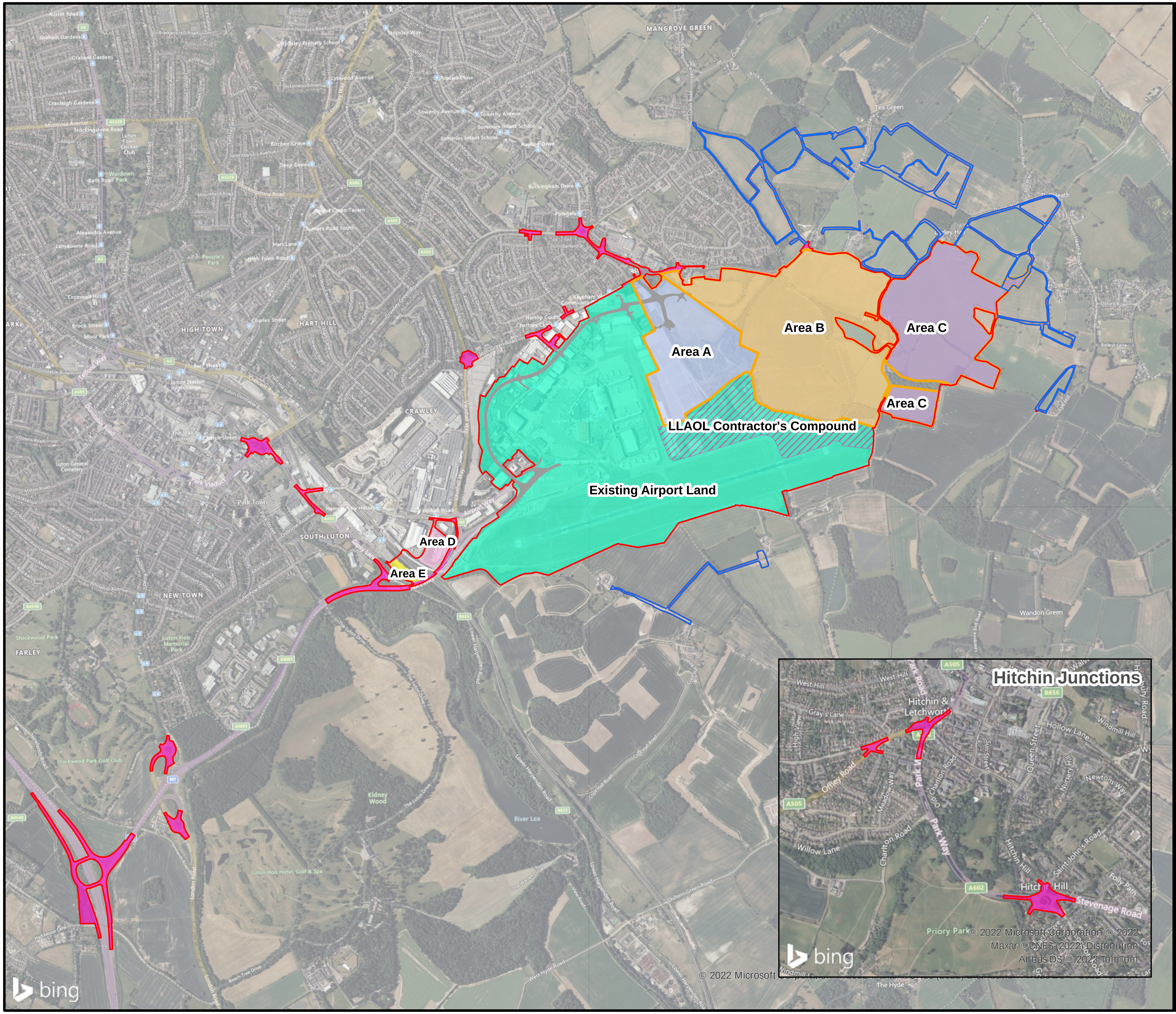
Project - Phase - Originator - Asset/Zone - Sub Asset - Type- Discp. - Number



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Legend

- Order Limits
- Off-site Planting
- Airport Access Road
- Site Subdivisions

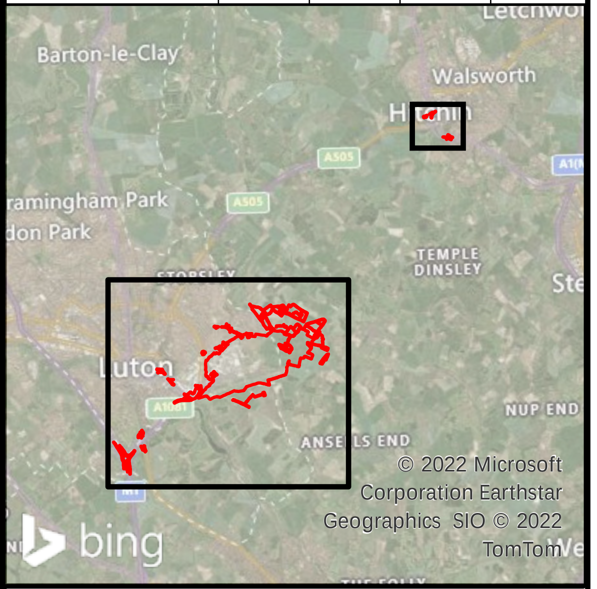
Main Application Site

- Existing Airport Land
- LLAOL Contractor's Compound
- Area A Former Landfill
- Area B Land West of Winch Hill Lane
- Area C Land East of Winch Hill Lane

Other Areas

- Area D Offsite Car Park North
- Area E Offsite Car Park South
- Off-site Highway Interventions

Revision History	Drawn	Checked / Approved	Date	Rev.
First Issue	AB	RB / TB	26/09/22	P02



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Drawing Title

Figure 3
Site Areas

Purpose of issue					Suitability
SUITABLE FOR INFORMATION					S2
Drawn	Checked	Approved	Date	Scale	Size
AB	RB	TB	26/09/22	1:22,500	A3

DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001	APFP 5(2)(a)	TR020001/APP/5.03

Drawing Number	Revision
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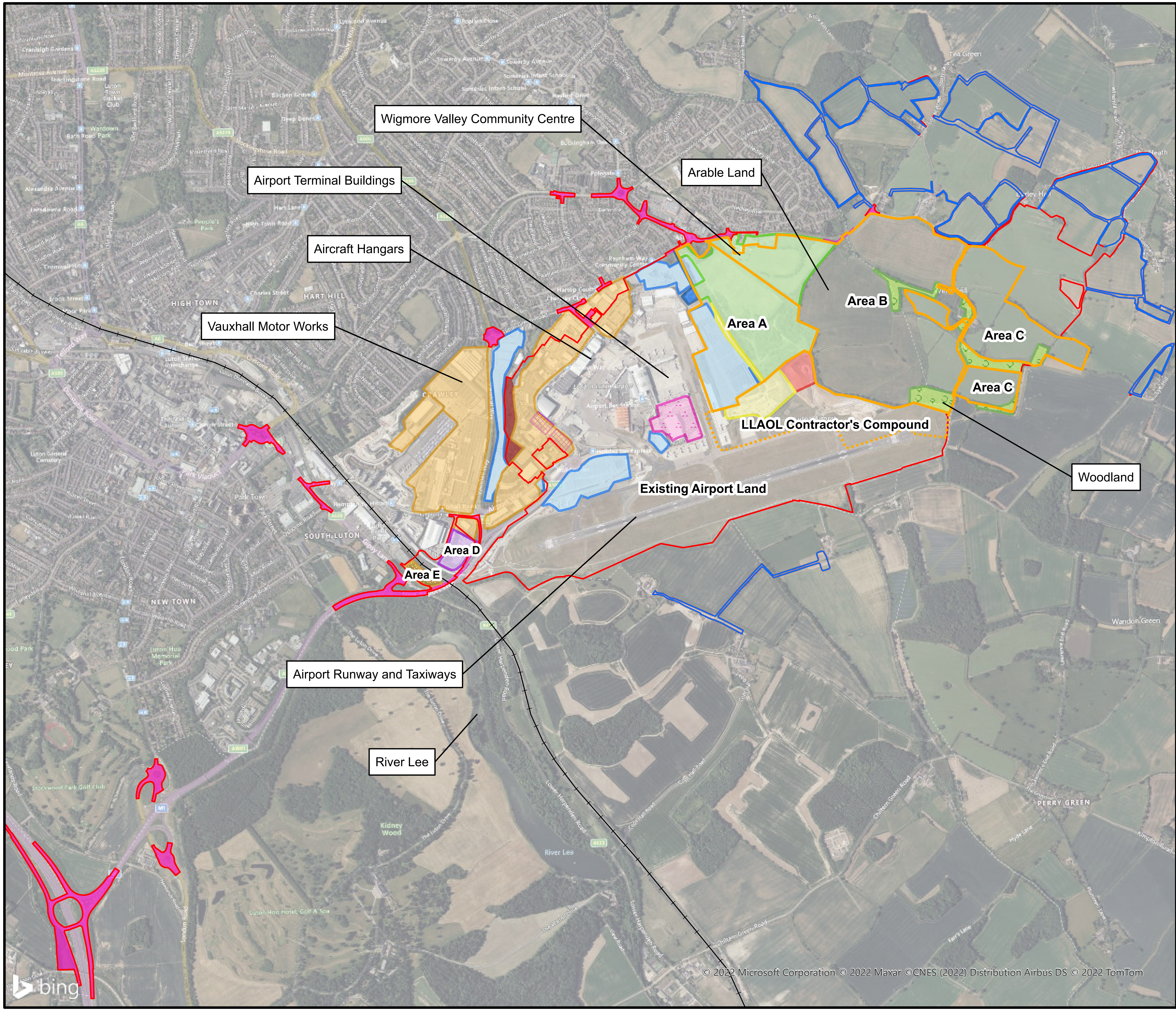
Project - Phase - Originator - Asset/Zone - Sub Asset - Type- Discp. - Number



All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

Legend

- Order Limits
- Off-site Planting
- Site Subdivisions
- Off-site Highway Interventions

Current Land Use

- Car Parking
- Commerical/Industrial
- DART Construction Area
- DART Contractor's Compound
- Tidy Tip
- Fire Training Area
- Wigmore Valley Park
- LLAOL Contractor compound
- Trailer Park, Car Parking, Service Garage
- Woodlands
- Undeveloped Landscape
- Fuel Depots
- Existing Railway

Revision History	Drawn	Checked / Approved	Date	Rev.
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Figure 4
Current Land Uses

Purpose of issue				Suitability	
SUITABLE FOR INFORMATION				S2	
Drawn	Checked	Approved	Date	Scale	Size
AB	RB	TB	26/09/22	1:20,000	A3

DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001	APFP 5(2)(a)	TR020001/APP/5.03

Drawing Number	Revision
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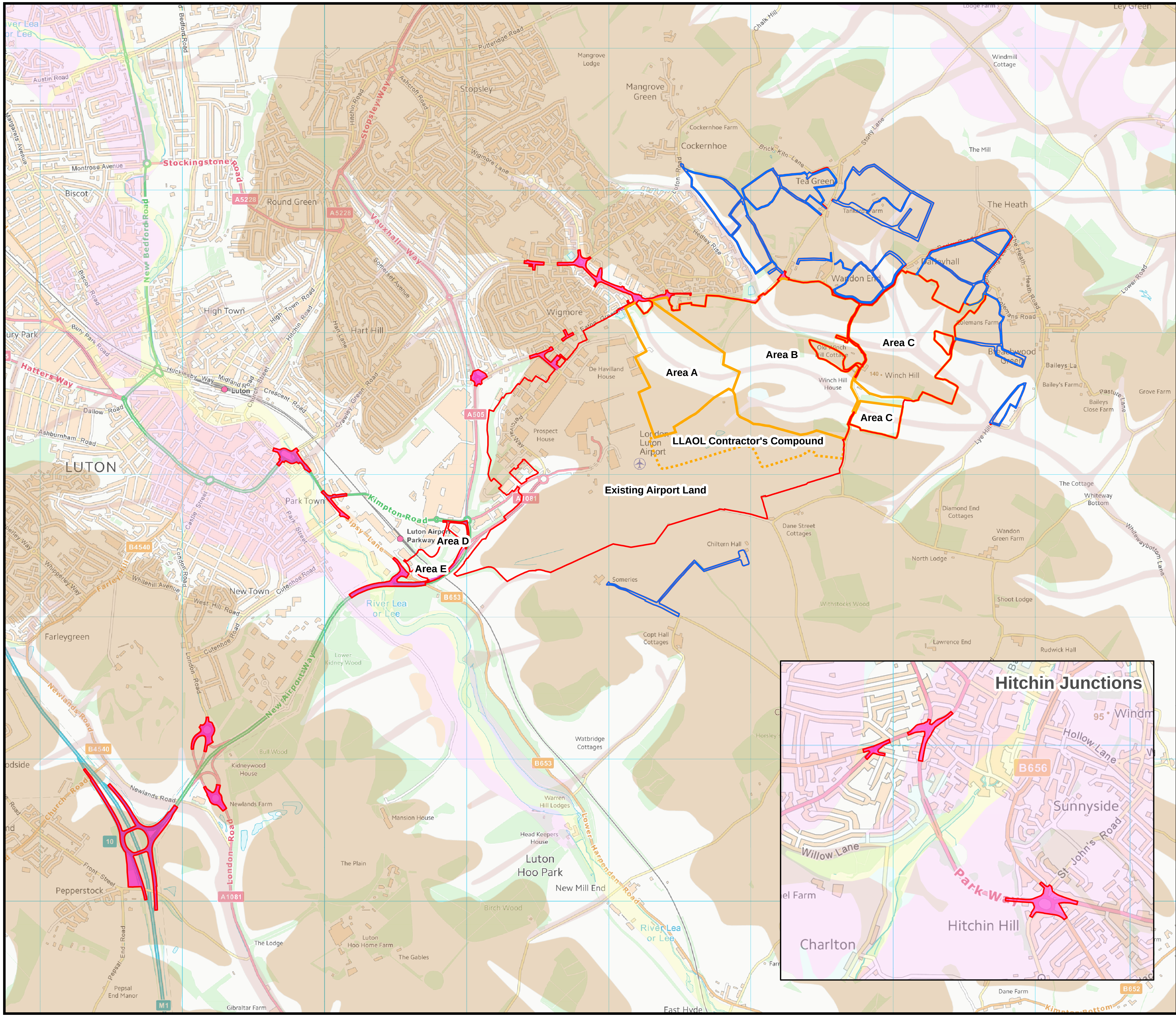
Project - Phase - Originator - Asset/Zone - Sub Asset - Type- Disc. - Number



All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

Legend

- Order Limits
- Off-site Planting
- Site Subdivisions
- Off-site Highway Interventions

Superficial

- Alluvium
- Clay with flints
- Glaciofluvial Deposits
- Head
- Till
- River Terrace Deposits

Revision History	Drawn	Checked / Approved	Date	Rev.
First Issue	AB	RB / TB	26/09/22	P02

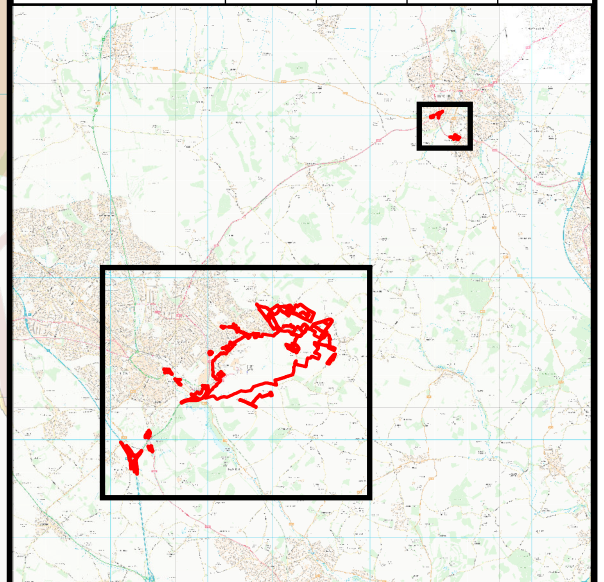


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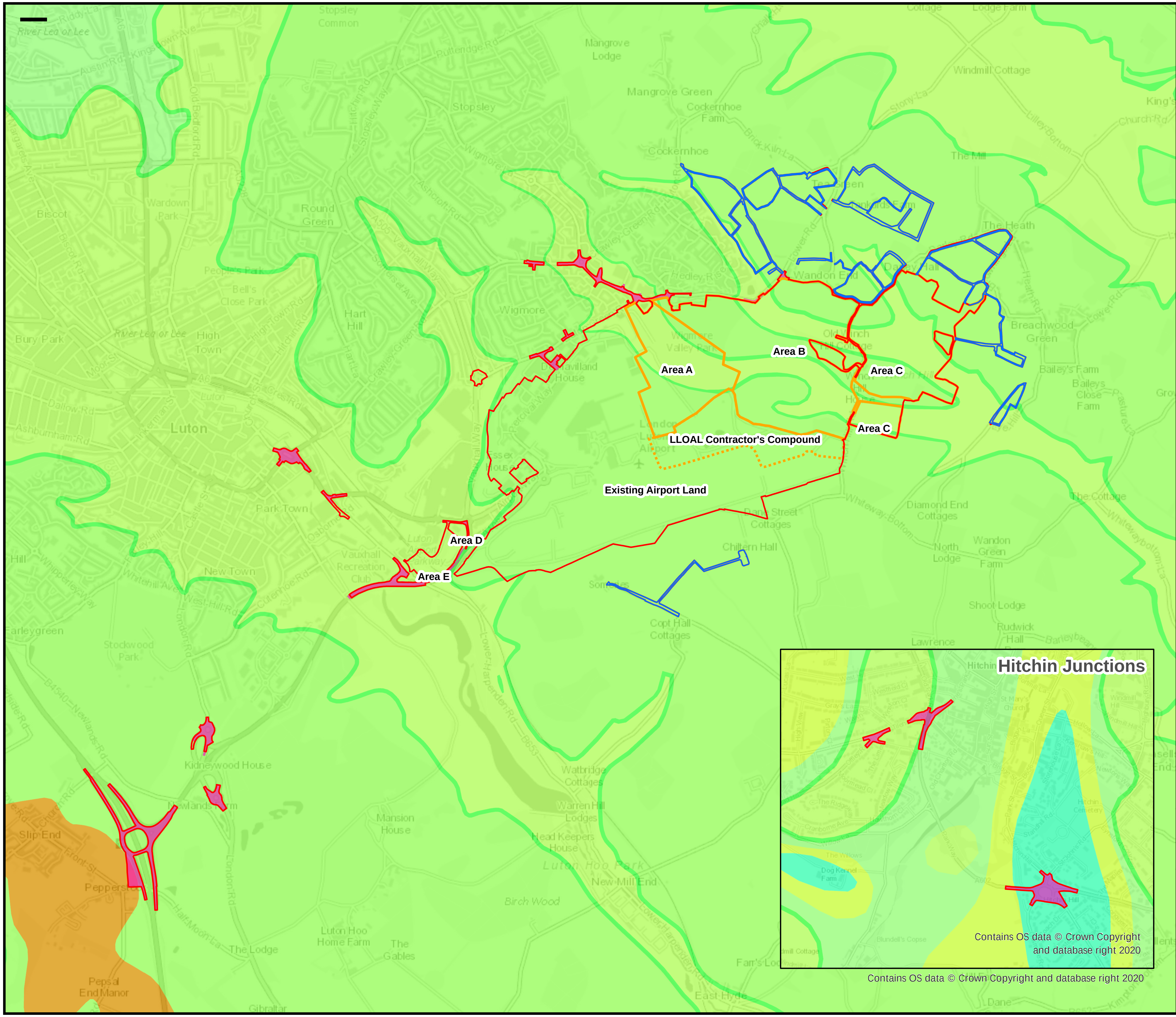
Figure 5
Superficial Geology

Purpose of issue					Suitability
SUITABLE FOR INFORMATION					S2
Drawn	Checked	Approved	Date	Scale	Size
AB	RB	TB	26/09/22	1:25,000	A3

DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001	APFP 5(2)(a)	TR020001/APP/5.03

Drawing Number	Revision
LLADCO-3C-ARP-00-00-DR-YE-0161	P02

Project - Phase - Originator - Asset/Zone - Sub Asset - Type- Discp. - Number



All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

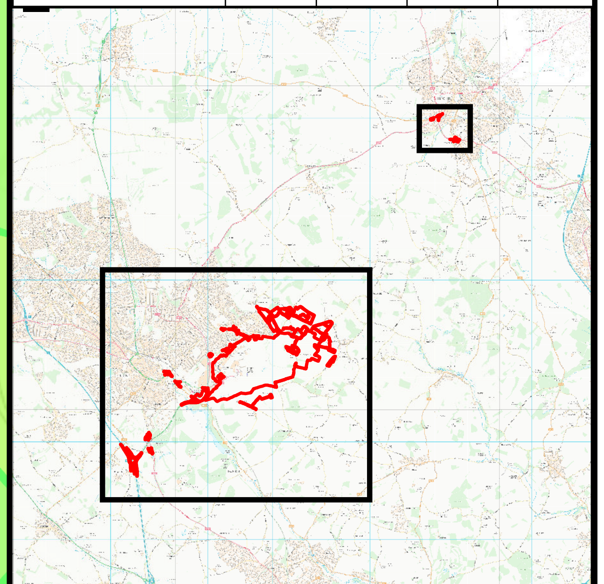
Legend

- Order Limits
- Off-site Planting
- Site Subdivisions
- Off-site Highway Interventions

Bedrock

- Holywell Nodular Chalk formation New Pit Chalk Formation and Undifferentiated
- Zig Zag Chalk Formation
- Lewes Nodular Chalk and Seaford Chalk Formation undifferentiated
- Gault Formation - Mudstone
- West Melbury Marly Chalk Formation
- Lambeth Group - Clay, Silt and Sand

Revision History	Drawn	Checked / Approved	Date	Rev.
First Issue	AB	RB / TB	26/09/22	P02



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Drawing Title

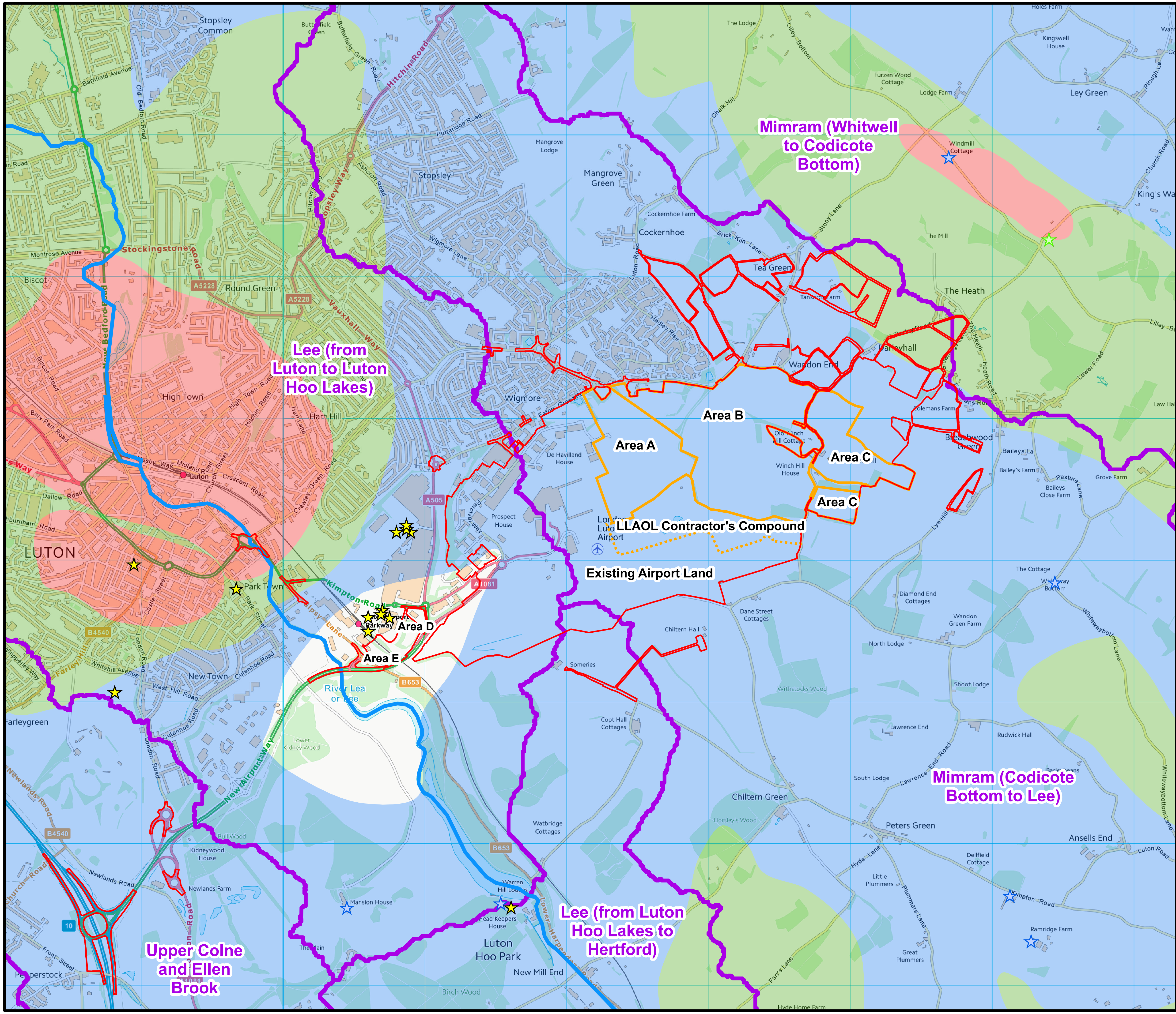
Figure 6
Bedrock Geology

Purpose of issue					Suitability
SUITABLE FOR INFORMATION					S2
Drawn	Checked	Approved	Date	Scale	Size
AB	RB	TB	26/09/22	1:25,000	A3

DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001	APFP 5(2)(a)	TR020001/APP/5.03

Drawing Number	Revision
LLADCO-3C-ARP-00-00-DR-YE-0162	P02

Project - Phase - Originator - Asset/Zone - Sub Asset - Type- Discp. - Number



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Legend

- Order Limits
- Site Subdivisions
- Watercourse
- Affinity Water potable supply
- Licensed groundwater abstractions
- Private groundwater abstractions
- Waterbody Catchment Areas

Source protection zones

- Inner zone
- Outer zone
- Total catchment

First Issue	AB	RB TB	26/09/22	P02
Revision History	Drawn	Checked Approved	Date	Rev.

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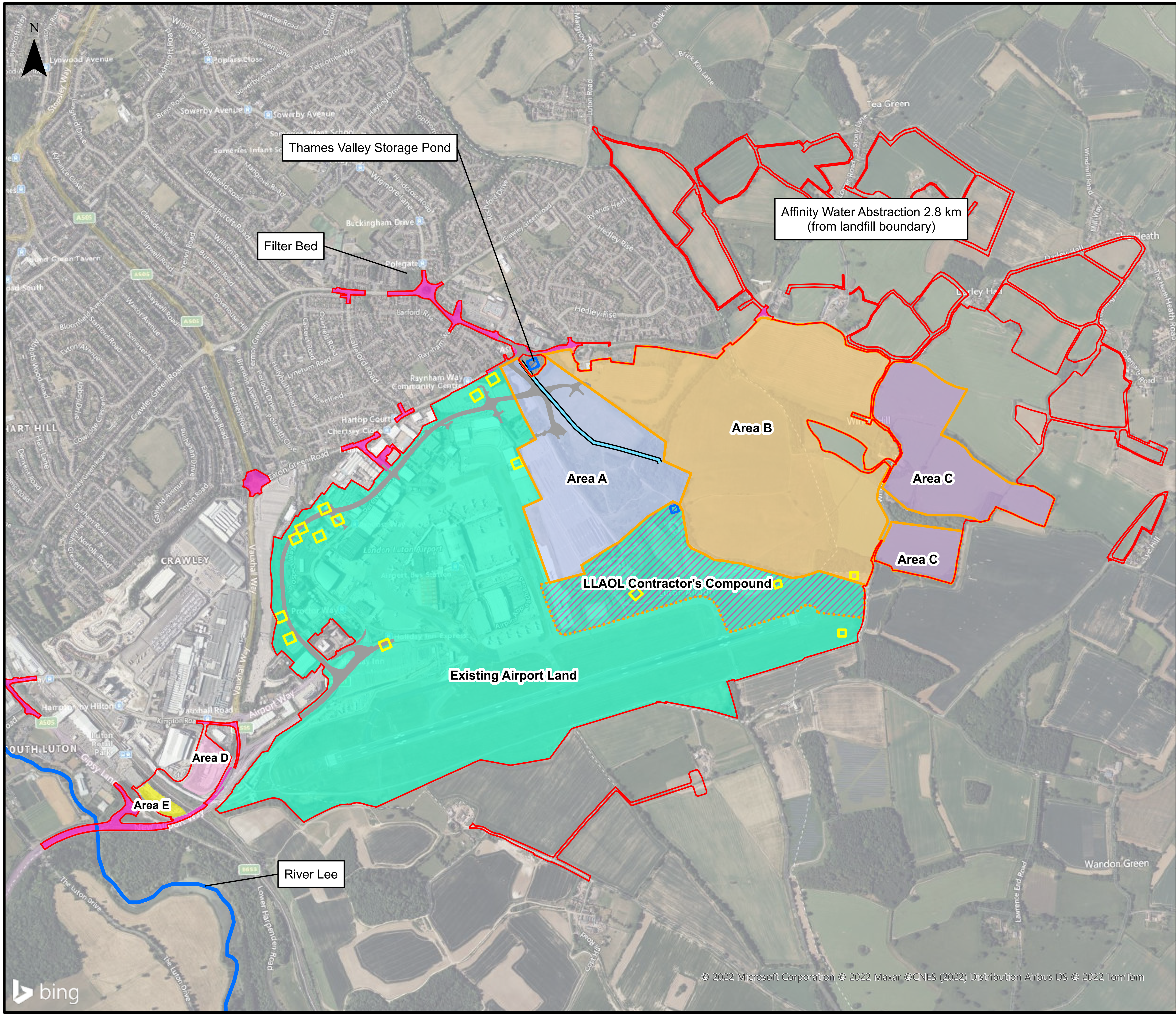
Figure 7
Hydrology & Hydrogeology

Purpose of issue					Suitability
SUITABLE FOR INFORMATION					S2
Drawn	Checked	Approved	Date	Scale	Size
AB	RB	TB	26/09/22	1:25,000	A3

DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001	(APFP 5(2)(a))	TR020001/APP/5.03

Drawing Number	Revision
LLADCO-3C-ARP-00-00-DR-YE-0163	P02

Project - Phase - Originator - Asset/Zone - Sub Asset - Type- Discp. - Number



All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

Legend

- Order Limits
- Site Subdivisions
- Soakaway
- Thames Valley Storage Pond
- Thames Valley Drain
- Airport Access Road
- River Lee

Main Area of New Development

- Existing Airport Land
- LLAOL Contractor's Compound
- Area A Former Landfill
- Area B Land West of Winch Hill Lane
- Area C Land East of Winch Hill Lane

Other Areas

- Area D Offsite Car Park North
- Area E Offsite Car Park South

Revision History	Drawn	Checked / Approved	Date	Rev.
First Issue	AB	RB / TB	26/09/22	P02

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Drawing Title

Figure 8
Existing Water Features within the Proposed Development

Purpose of issue					Suitability
SUITABLE FOR INFORMATION					S2
Drawn	Checked	Approved	Date	Scale	Size
AB	RB	TB	26/09/22	1:15,000	A3

DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001	APFP 5(2)(a)	TR020001/APP/5.03

Drawing Number	Revision
LLADCO-3C-ARP-00-00-DR-YE-0164	P02

Project - Phase - Originator - Asset/Zone - Sub Asset - Type- Discp. - Number

All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

Legend

- Order Limits
- Site Subdivisions
- AECOM 2019 Luton Airport Landfill
- AECOM 2018 Luton Hangar 24
- Structural Soils 2017 Century Park Access Road
- Structural Soil 2017 Landfill and Century Park
- Concept Site 2015 Luton Airport Terminal Extension
- Delta Simmons 2012 Taxiway Foxtrot
- Soil Engineering 2012 Luton Airport FBO
- RSK 2012 Ocean Sky Building and Short Stay Car Park
- Wardell Armstrong 2008 Stirling Place
- RSA 2004 LLA Hangar and Taxiway Extension
- Fugro 2003
- British Geological Society

First Issue	AB	RB TB	26/09/22	P02
Revision History	Drawn	Checked Approved	Date	Rev.

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Drawing Title

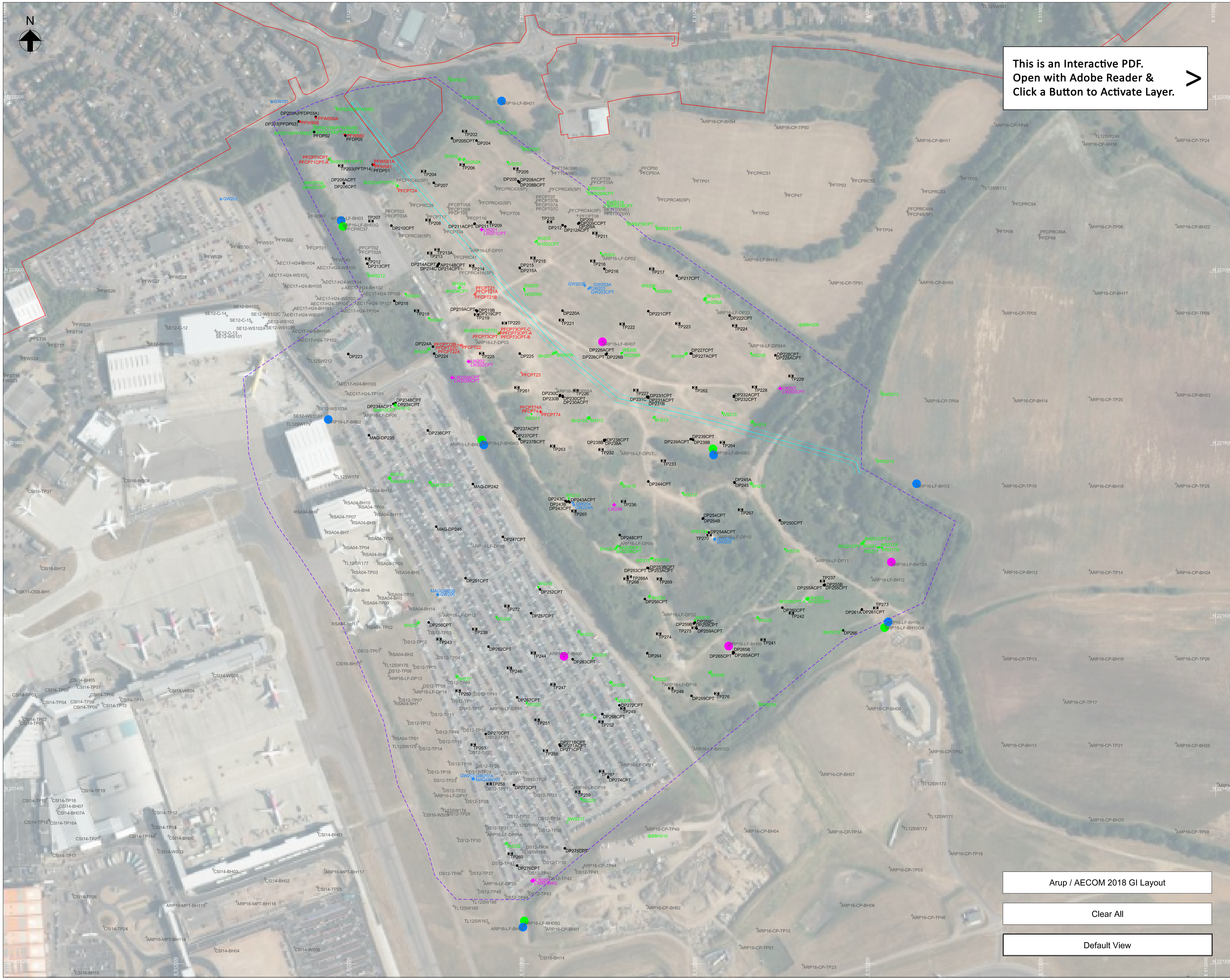
Figure 9
Previous Ground Investigation (GI)
Locations

Purpose of issue					Suitability
SUITABLE FOR INFORMATION					S2
Drawn	Checked	Approved	Date	Scale	Size
AB	RB	TB	26/09/22	1:15,000	A3

DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001	APFP 5(2)(a)	TR020001/APP/5.03

Drawing Number	Revision
LLADCO-3C-ARP-00-00-DR-YE-0165	P02

Project - Phase - Originator - Asset/Zone - Sub Asset - Type- Disc. - Number



This is an Interactive PDF.
Open with Adobe Reader &
Click a Button to Activate Layer.
>

Arup / AECOM 2018 GI Layout

Clear All

Default View

All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

Legend

The Order Limits

Indicative Landfill Extents

Thames Valley Drain (CCTV survey)

Previous GI Location

ARP16-CP-BH55

Hole Location | Consultant / Contractor | Year | Area | Hole Name/Number

Previous Installation Location and Type

Leachate | Gas | Groundwater

GI Location

BH201 - 233	Boreholes
BBH201 - 211	Boundary Borehole
BWS201 - 220	Boundary Window Sample
WS201 - 223	Window Sample
GW201 - 207	Groundwater Hole
LW201 - 205	Leachate Borehole
DP201 - 280	Dynamic Probehole
TP201 - 260	Shallow Trial Pits (max depth 4.5m)
TP261 - 276	Deep Trial Pits (max depth 6m)

Pell Frischmann GI Locations

PFCP49

Install Type

Colour of proposed location denotes the install type:

Green	Gas
Blue	Groundwater
Pink	Leachate

Notes

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2. All levels are in metres above ordnance datum unless noted otherwise.
3. These drawings are primarily intended to be viewed electronically. Some details may not be clear or visible on a printed version.
4. This is an interactive 2D PDF. For Full interactivity it is recommended that the original digitial version is opened and viewed using Adobe Reader 7.0 or higher.

Revision History	Drawn	Checked / Approved	Date	Rev.
Issue	IJ	RB / TB	30/09/22	P02
Issue	IJ	RB / TB	16/12/21	P01

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Drawing Title

Figure 10
Ground Investigation on Area A Former Landfill

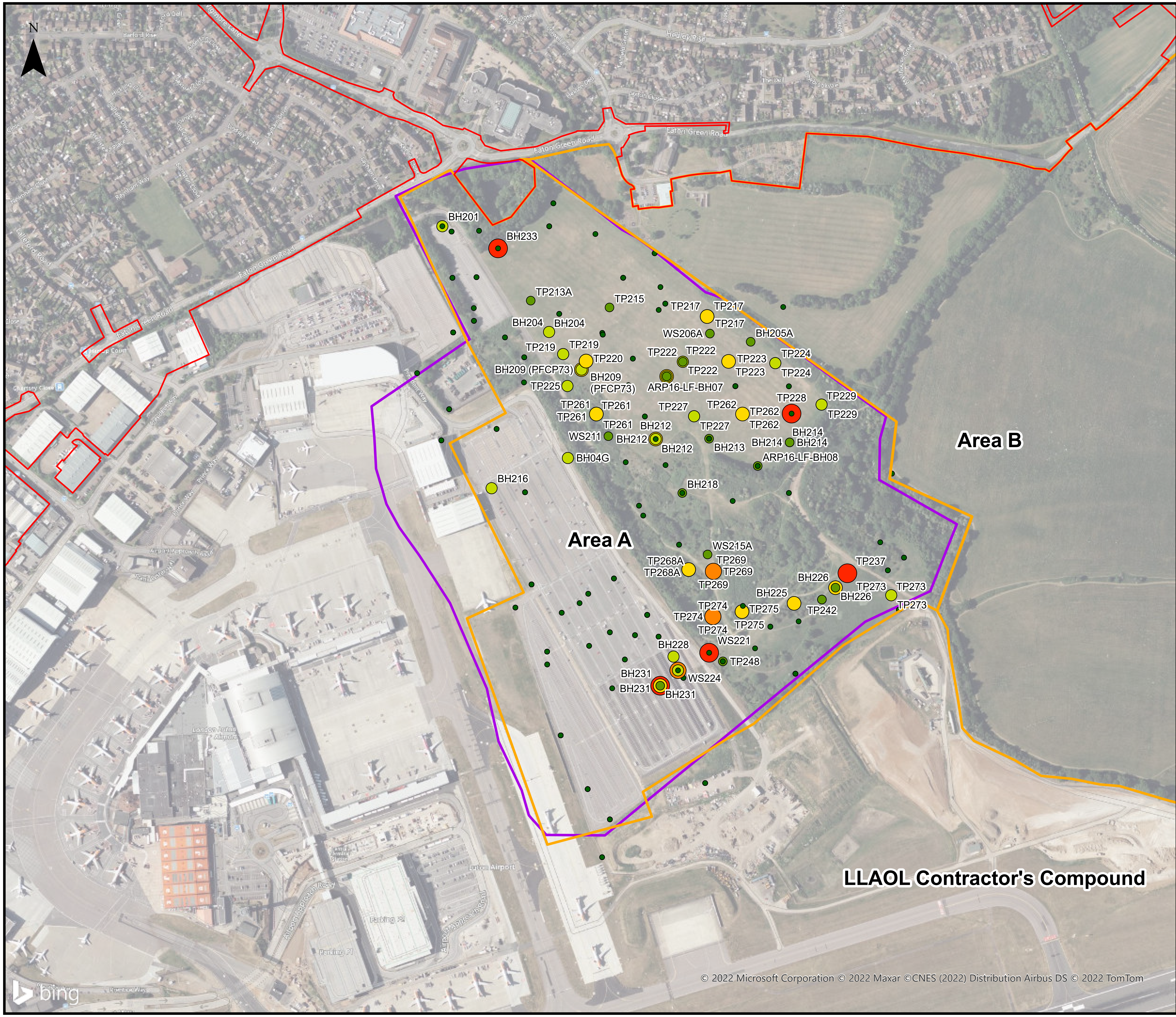
Purpose of issue	Suitability
SUITABLE FOR COORDINATION	S2

Drawn	Checked	Approved	Date	Scale	Size
IJ	RB	TB	30/09/22	1:2000	A1

DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001	APFP 5(2)(a)	TR020001/APP/5.03

Drawing Number	Revision
LLADCO-3C-ARP-00-00-DR-YE-0166	P02

Project – Phase – Originator – Asset/Zone – Sub Asset – Type – Discp. – Number



All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

Legend

- Order Limits
- Site Subdivisions
- Interpreted Landfill Boundary

Max recorded PID Level

- > 0 - 10 ppm
- 10 - 25 ppm
- 25 - 50 ppm
- 50 - 100 ppm
- 100 - 200 ppm
- 200 - 400 ppm

First Issue	AB	RB TB	26/09/22	P02
Revision History	Drawn	Checked Approved	Date	Rev.

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Drawing Title

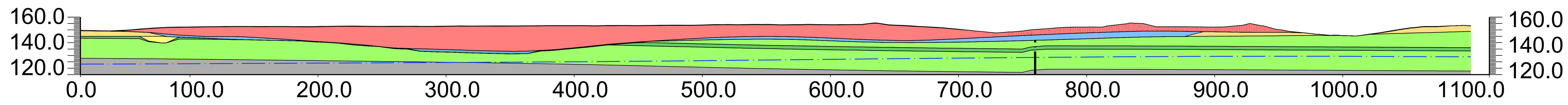
Figure 11
Max Recorded PID Levels and Visual / Olfactory Observations of Contamination

Purpose of issue				Suitability	
SUITABLE FOR INFORMATION				S2	
Drawn	Checked	Approved	Date	Scale	Size
AB	RB	TB	26/09/22	1:5,000	A3

DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001	APFP 5(2)(a)	TR020001/APP/5.03

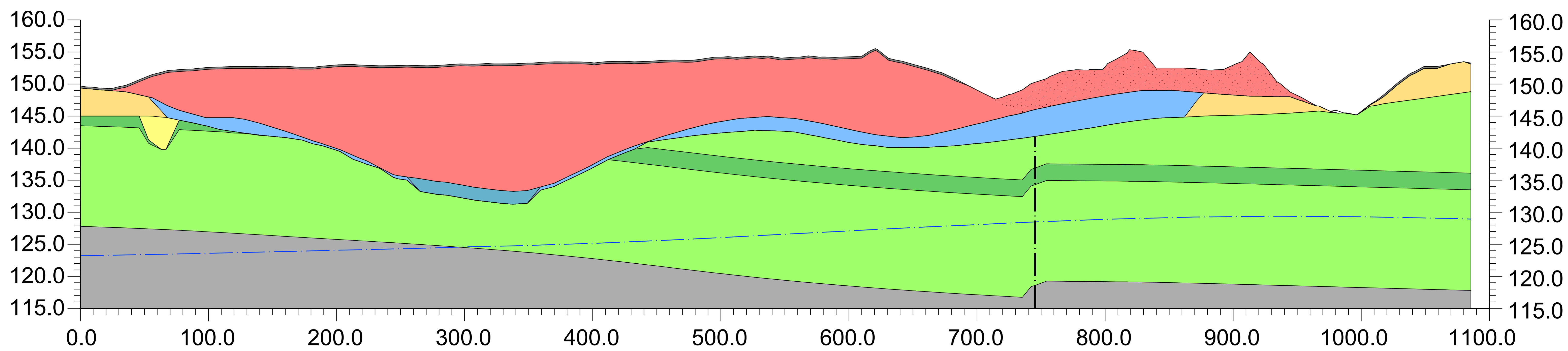
Drawing Number	Revision
LLADCO-3C-ARP-00-00-DR-YE-0167	P02

Project - Phase - Originator - Asset/Zone - Sub Asset - Type- Discp. - Number



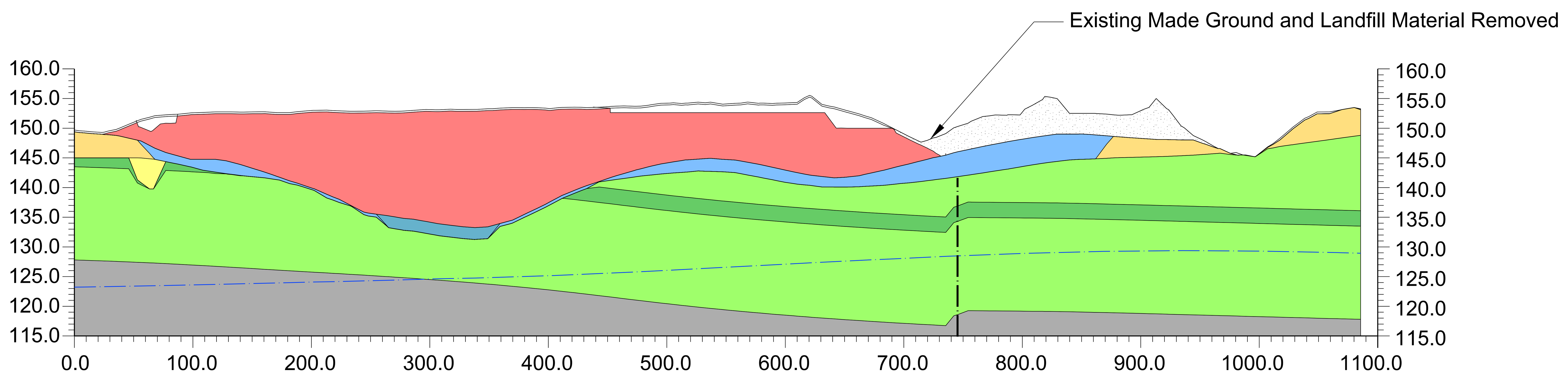
Existing Conditions - Natural Scale

Scale H=1:2500 V=1:2500



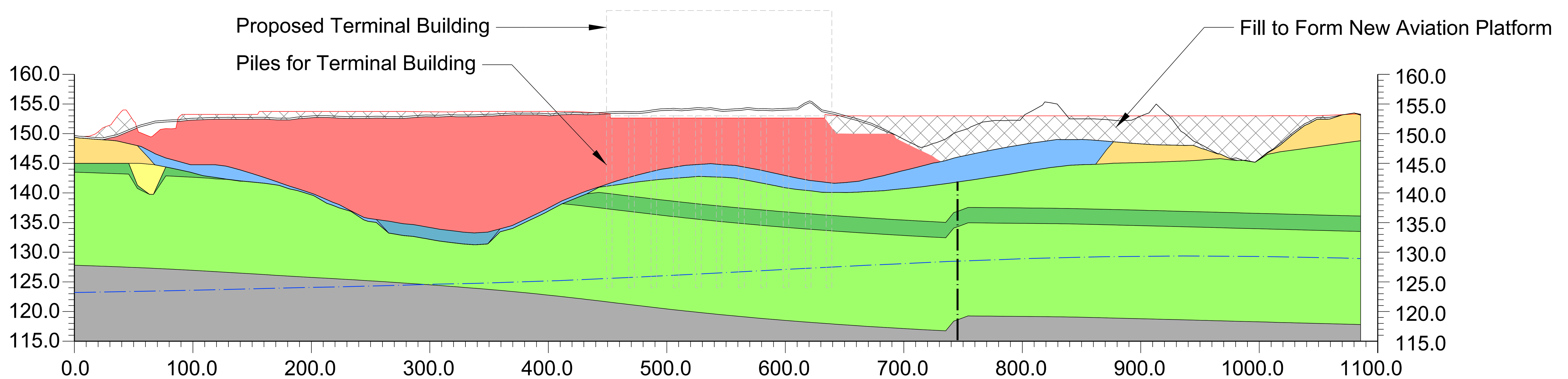
Existing Conditions - Exaggerated Scale

Scale H=1:2500 V=1:500



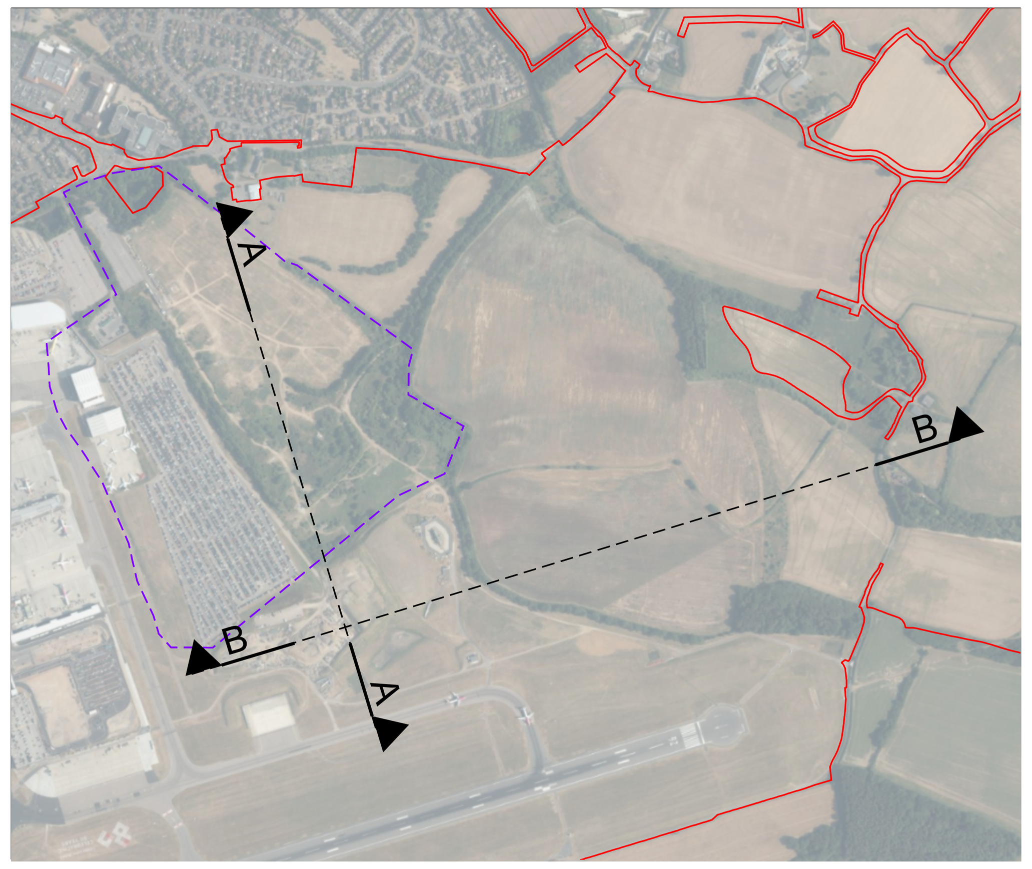
Excavate to Achieve Formation Level

Scale H=1:2500 V=1:500



Proposed Landform

Scale H=1:2500 V=1:500



Key Plan

All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

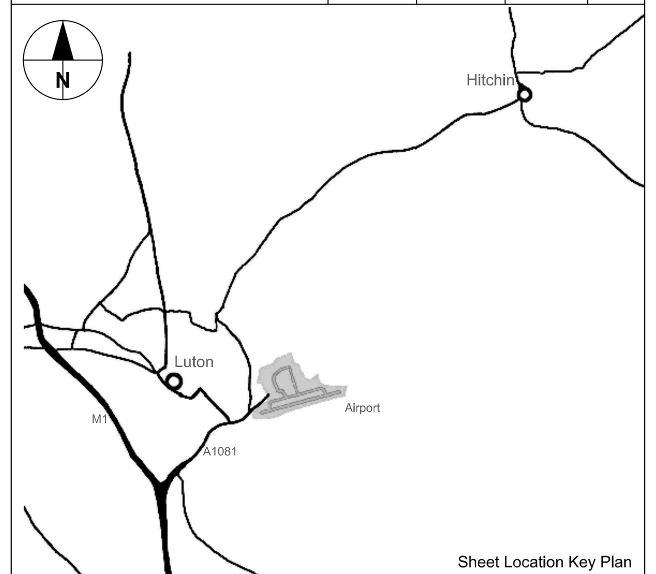
Legend

- The Order Limits
- Indicative Landfill Extents
- Landfill
- Made Ground
- Dry Valley Deposits
- Head
- Clay with Flints
- Solution Feature
- Lewes Nodular Chalk Formation
- Chalk Rock Member
- New Pit Chalk Formation
- Proposed Platform
- Landscape Fill Area
- Interpreted Fault
- 'Worst Case' Groundwater Level for design
- Proposed Finished Surface

Notes

1. Do not scale from this drawing.
2. All levels are in metres above ordnance datum unless noted otherwise.
3. These drawings are primarily intended to be viewed electronically. Some details may not be clear or visible on a printed version.
4. Strata and other levels have been drawn from interpolated 3D models of various boundaries logged in trial pits and boreholes, topographical data and data from geological maps etc.
   It is intended to provide a guide as to likely ground conditions and as such should be regarded as indicative.
   It is recommended that design decisions made on the basis of this information are confirmed by investigation.
5. Bing Maps Aerial - © 2021 Microsoft Corporation © 2021 Maxar ©CNES (2021) Distribution Airbus DS

Revision History	Drawn	Checked / Approved	Date	Rev.
Issue	IJ	RB / TB	30/09/22	P02
Issue	IJ	RB / TB	16/12/21	P01



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Drawing Title

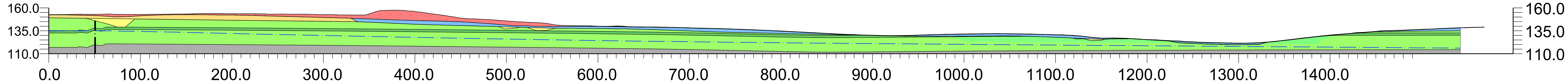
Figure 12
Earthworks Stage 2 Design
Section A-A

Purpose of issue	Suitability
SUITABLE FOR COORDINATION	S2

Drawn	Checked	Approved	Date	Scale	Size
IJ	RB	TB	30/09/22	NTS	A1

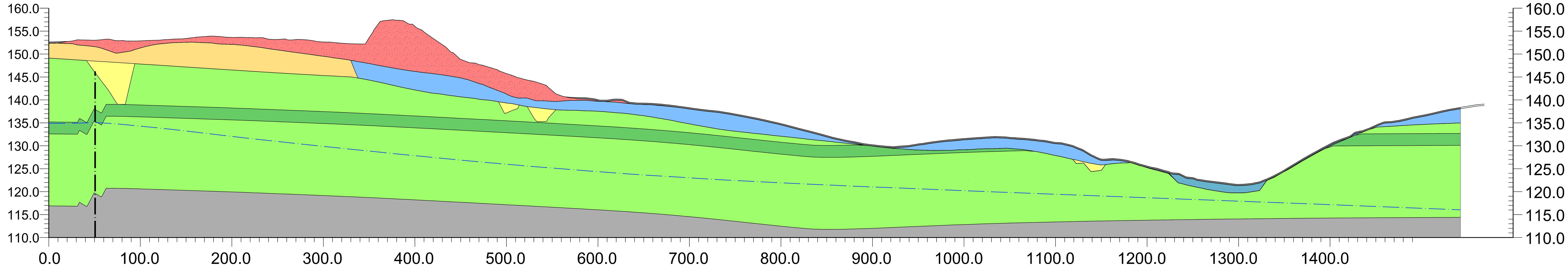
DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001	APFP 5(2)(a)	TR020001/APP/5.03

Drawing Number	Revision
LLADCO-3C-ARP-00-00-DR-YE-0168 Project – Phase – Originator – Asset/Zone – Sub Asset – Type – Discp. – Number	P02



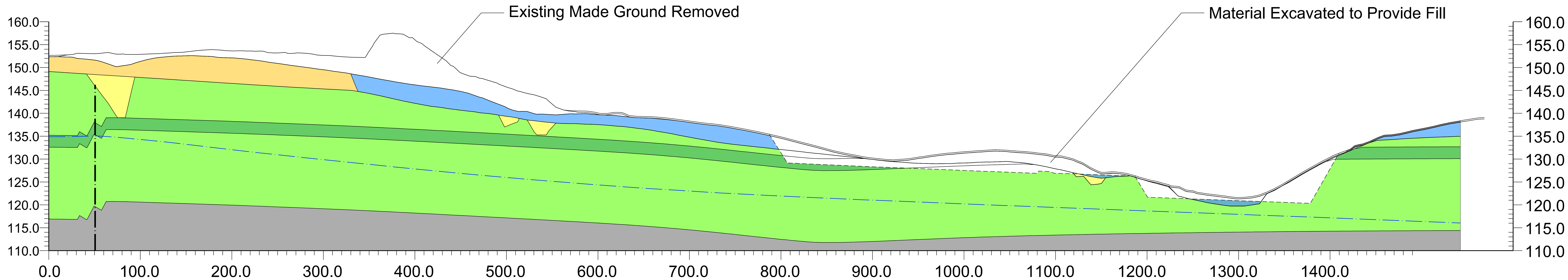
Existing Conditions - Natural Scale

Scale H=1:2500 V=1:2500



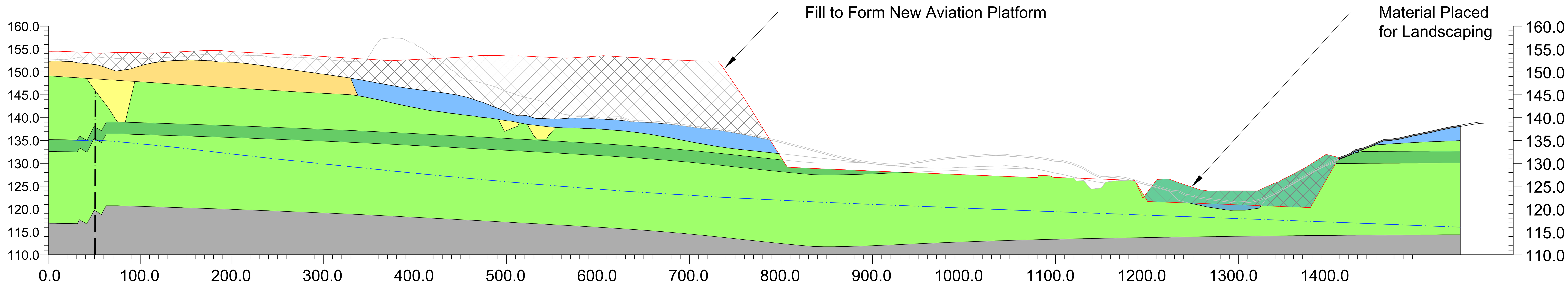
Existing Conditions

Scale H=1:2500 V=1:500



Excavate to Achieve Formation Level

Scale H=1:2500 V=1:500



Proposed Landform

Scale H=1:2500 V=1:500

All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

Legend

- Made Ground
- Dry Valley Deposits
- Head
- Clay with Flints
- Solution Feature
- Lewes Nodular Chalk Formation
- Chalk Rock Member
- New Pit Chalk Formation
- Proposed Platform
- Landscape Fill Area
- Interpreted Fault
- 'Worst Case' Groundwater Level for design
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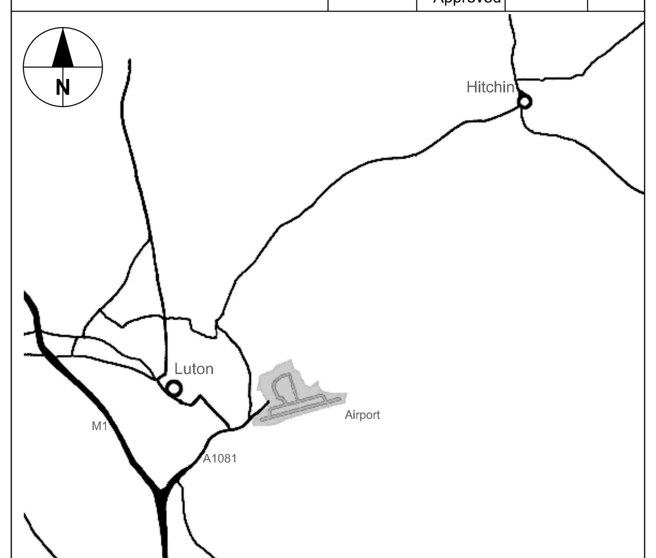
5. Bing Maps Aerial - © 2021 Microsoft Corporation © 2021 Maxar ©CNES (2021) Distribution Airbus DS

Revision History	Drawn	Checked	Approved	Date	Rev.
Issue	IJ	RB	TB	30/09/22	P02
Issue	IJ	RB	TB	16/12/21	P01



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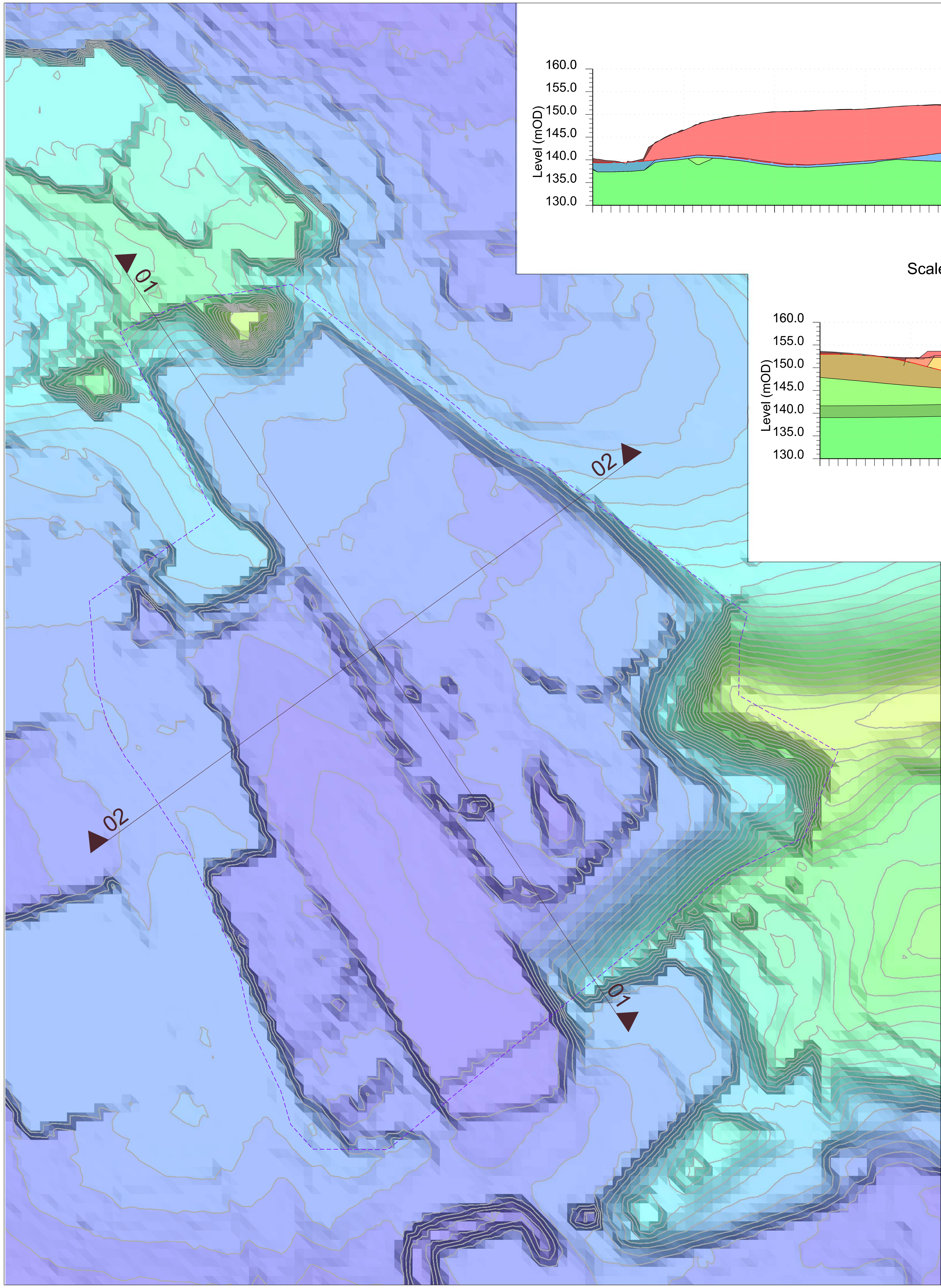
Drawing Title

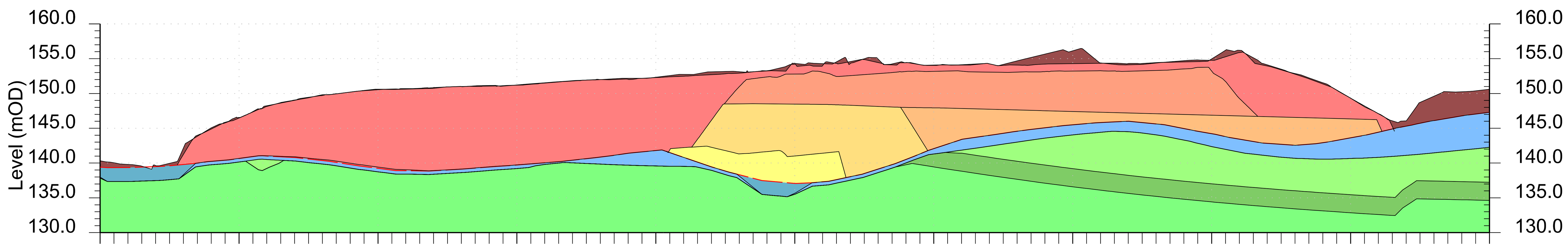
Figure 13
Earthworks Stage 2 Design
Section B-B

Purpose of issue					Suitability
SUITABLE FOR COORDINATION					S2
Drawn	Checked	Approved	Date	Scale	Size
IJ	RB	TB	30/09/22	NTS	A1
DCO Application Ref.	APFP Regulation	DCO Document Ref.			
TR020001	APFP 5(2)(a)	TR020001/APP/5.03			

Drawing Number	Revision
LLADCO-3C-ARP-00-00-DR-YE-0169	P02

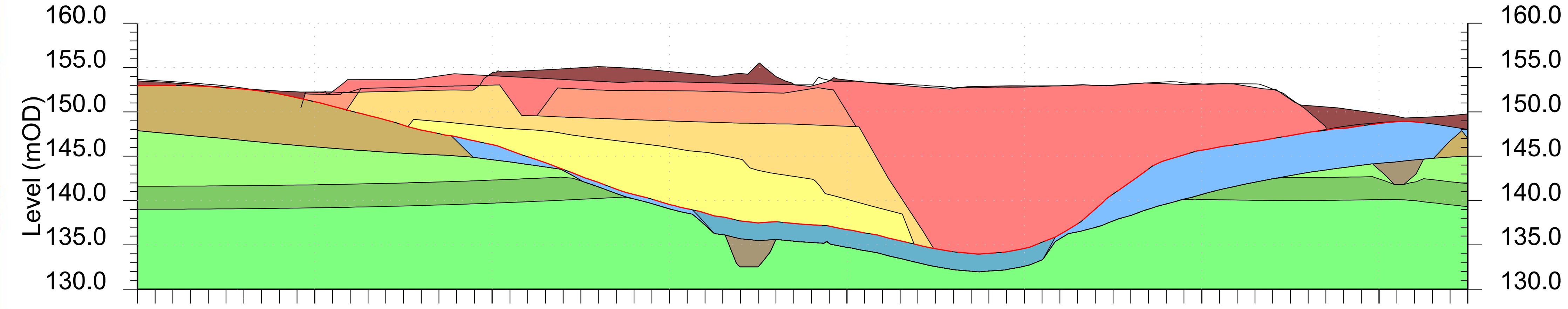
Project – Phase – Originator – Asset/Zone – Sub Asset – Type – Discp. – Number





Section 01

Scale = Horizontal 1:5000 Vertical 1:1000



Section 02

Scale = Horizontal 1:5000 Vertical 1:1000

Interactive Buttons

Click to Cycle through Interpreted Filling Periods

- Before Filling
- Up to 1947
- 1947 - 1955
- 1955 - 1960
- 1960 - 1970
- 1970 - 1980
- Post 1982

Colour Coded Height Map of Historical Levels (mOD)

129.0m, 130.0m, 131.0m, 132.0m, 133.0m, 134.0m, 135.0m, 136.0m, 137.0m, 138.0m, 139.0m, 140.0m, 141.0m, 142.0m, 143.0m, 144.0m, 145.0m, 146.0m, 147.0m, 148.0m, 149.0m, 150.0m, 151.0m, 152.0m, 153.0m, 154.0m, 155.0m

Plan Legend:

Mapped Extent of Landfill from Historical Aerials

Section Legend:

- Base of Made Ground / Top of Natural Ground
- Made Ground Post 1980
- Dry Valley Deposits
- Head
- Clay with Flints
- Pipe
- Lewes Nodular Chalk
- Chalk Rock

Landfill Waste Ages of Filling:

- 1970 - 1980
- 1960 - 1970
- 1955 - 1960
- 1947 - 1955
- Pre 1947

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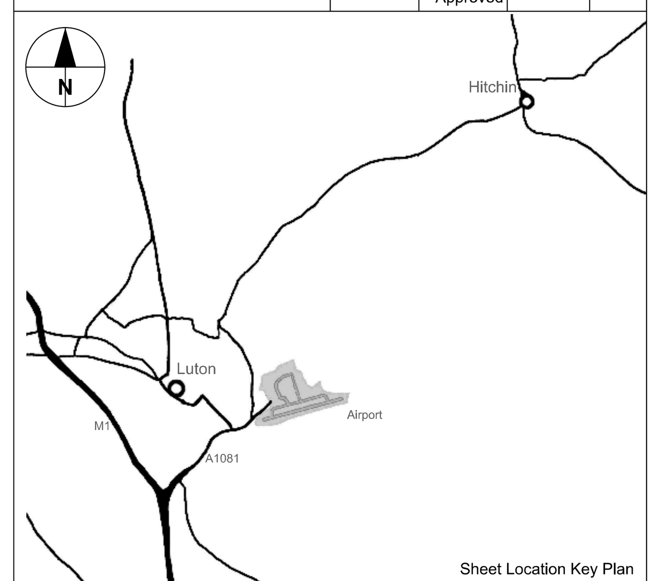
Revision History	Drawn	Checked / Approved	Date	Rev.
Issue	IJ	RB / TB	30/09/22	P02
Issue	IJ	RB / TB	[illegible]	P01



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Drawing Title

Figure 14
Periods of Landfill Filling

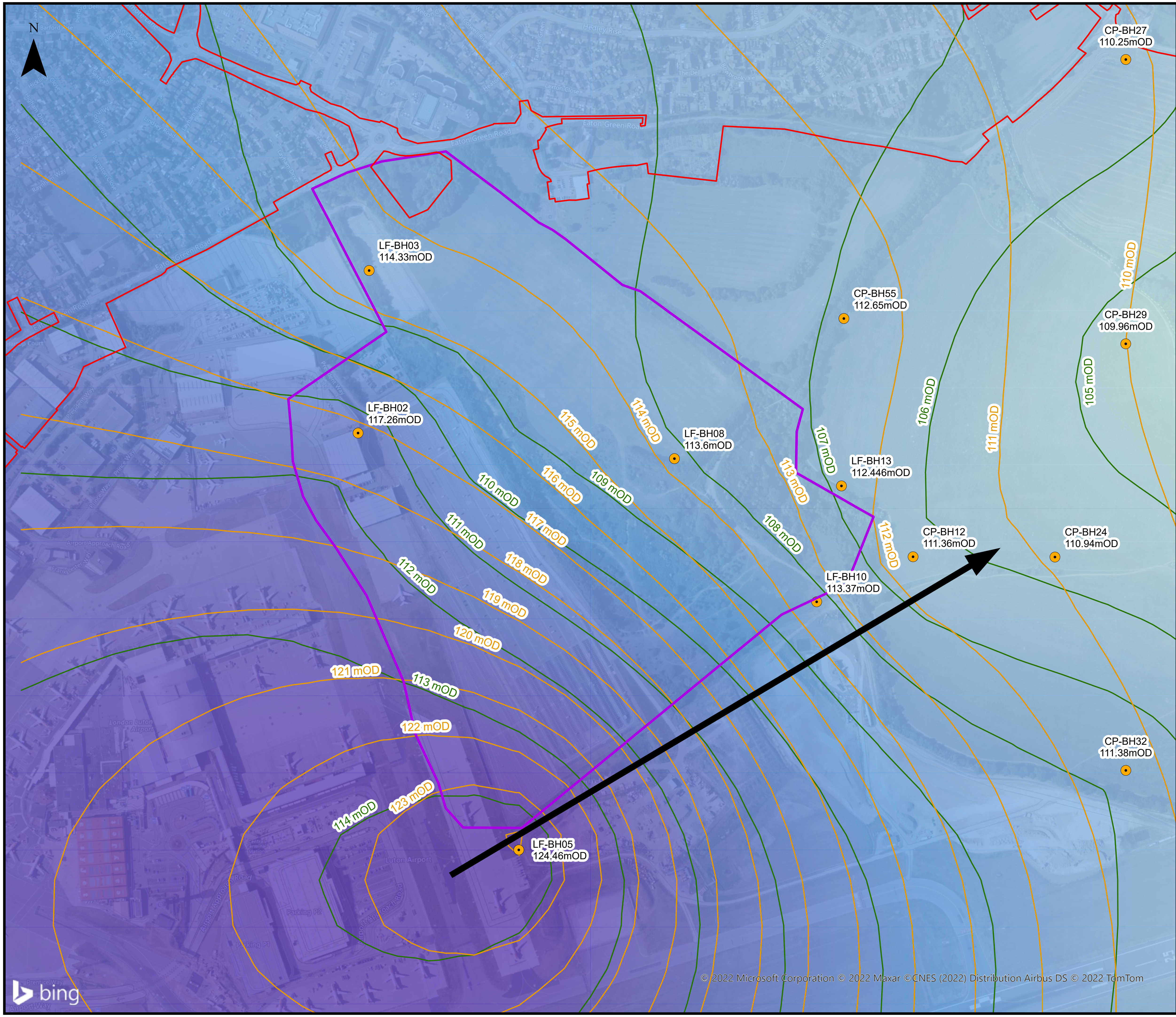
Purpose of issue	Suitability
SUITABLE FOR COORDINATION	S2

Drawn	Checked	Approved	Date	Scale	Size
IJ	RB	TB	30/09/22	1:2500	A1

DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001	APFP 5(2)(a)	TR020001/APP/5.03

Drawing Number	Revision
LLADCO-3C-ARP-00-00-DR-YE-0170	P02

Project – Phase – Originator – Asset/Zone – Sub Asset – Type – Discp. – Number



All structure positions are indicative. The proposed works will be subject to detailed design development. The changes will be within limits of deviation specified in the Development Consent Order.

Legend

- Order Limits
- Interpreted Landfill Boundary
- Reading Location

Minimum and Maximum Groundwater Levels

- Minimum 1m Contour
- Maximum 1m Contour
- High : 114.46
- Low : 85.6
- Interpreted Flow Direction

First Issue	AB	RB / TB	26/09/22	P02
Revision History	Drawn	Checked / Approved	Date	Rev.

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Drawing Title

Figure 15
Minimum and Maximum Groundwater Level

Purpose of issue					Suitability
SUITABLE FOR INFORMATION					S2
Drawn	Checked	Approved	Date	Scale	Size
AB	RB	TB	26/09/22	1:5,000	A3

DCO Application Ref.	APFP Regulation	DCO Document Ref.
TR020001	APFP 5(2)(a)	TR020001/APP/5.03

Drawing Number	Revision
LLADCO-3C-ARP-00-00-DR-YE-0174	P02

Project - Phase - Originator - Asset/Zone - Sub Asset - Type- Discp. - Number