

High Speed 2 - 1MC06 - Stage One C2 - MWCC – North Portal of Chiltern Tunnels to Brackley

Historical Hartwell Landfill Geoenvironmental Assessment Report

1MC06-CEK-EV-REP-CS04_CL18-000001

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Stakeholder review required (SRR)	Purpose of SRR
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☐ LOV	☐ Approval
☐ LUL	☐ No Objection
☐ NRL	☐ Consent
☐ TFL	
☐ Utilities Company	
☐ Other (please specify)	

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1 Introduction

1.1 Terms of Reference

The Arcadis/Setec/COWI Design Joint Venture (ASC) has been appointed by Eiffage Kier Ferroviaire Agroman and BAM Nuttall (EKFB) to provide geoenvironmental assessment for potential contaminated land within Sections C2 and C3 of the Phase 1 High Speed 2 (HS2) development.

This report has been produced in accordance with the HS2 Technical Standard for Land Quality (HS2-HS2-EV-STD-000-000027) and relates to the areas of land between chainage (ch.) 61+700 to ch.62+400 within Section C2, hereafter referred to as “the Site” which encompasses or is near the Land Quality (LQ) constraints listed in Table 1-1 and Figure 1-1/Appendix A.

The Site has been assessed in the Environmental Statement (ES) (Ref. 1 and 2) as part of the screened package of potentially “contaminated” land that potentially poses a contaminative risk to the proposed scheme. The Former Brick Works area was not initially identified as a LQ area in the ES scoping exercise but has subsequently been identified as a potential source of contamination to the scheme.

Table 1-1 List of Land Quality (LQ) Constraints in relation to the Site

LQ Constraints/ Potential Contaminative Source	Interaction with Main Route Asset	Interaction with Non-Route Assets
Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03) *	<u>No interaction.</u> Approx. 160 m east of the proposed Aylesbury North Cutting	Ch.62+100 to 62+275 – the Former Bricks Works area and Landfill is partially within the eastern LOD of the proposed A418 Oxford Road realignment / Embankment.
Historical Hartwell Landfill (LQ 11-04)	Ch.61+870 to 61+985 –the Landfill is within the LOD of Aylesbury North Cutting	Ch.61+870 to 61+985 – the landfill is within the western and eastern Aylesbury North Cutting Landscape Earthworks and partially within the LOD of the proposed non-route asset Footpath SBH/34 Accommodation Overbridge

**Based on historical maps, the Former Brick Works area has been identified which extends beyond the outline of LQ 11-03 originally identified in the ES. The amended outline of the Former Brick Works area is indicated on Figure 1-1 below.*

This report presents a summary of the Site’s setting, history, current uses, and ground investigations undertaken within the Site, it describes the ground conditions encountered and assesses the potential for risk to human health, controlled waters, and infrastructure appropriate to the form of development proposed.

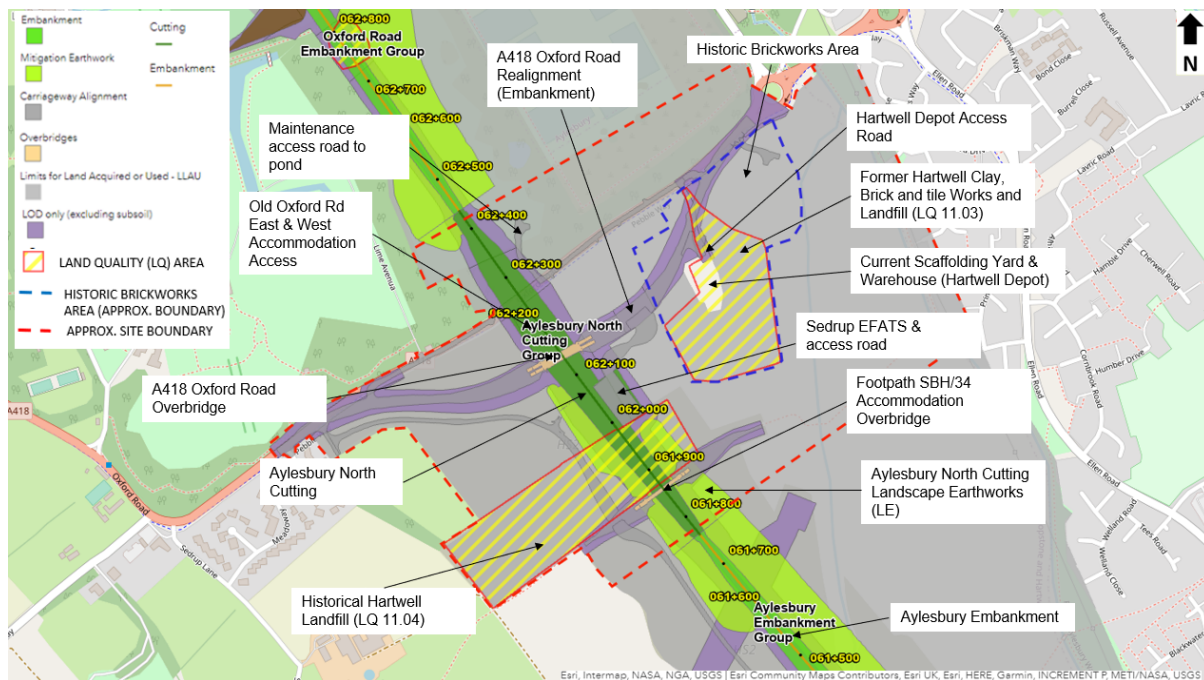


Figure 1-1 Proposed Site layout with land quality constraints and assets highlighted. Extract from ASC Ground Engineering Viewer (Ref. 3).

1.2 Proposed Development

Development of the Site comprises demolition of existing properties/structures and the construction of Main Route (Level 1) and Non-Route (Level 2) assets. The key Level 1 and Level 2 assets are summarised in Table 1-2 and shown on Figure 1-1. A full list of proposed assets within the Site is presented in the Model Production and Delivery Table (MPDT) Scope Level 2 (Ref. 4). Proposed construction details have been summarised from the Aylesbury North Cutting Geotechnical Design Report (Ref. 5), the Supplementary Ground Investigation Report (GIR) for Aylesbury North Cutting (Ref. 6) and the A418 Oxford Road Highways Design Statement (Ref. 7).

Table 1-2 Level 1 and 2 Assets

Asset Name and ID	Interaction with LQ	Proposed Construction Details
Level 1 Assets:		
Aylesbury North Cutting (HS2-000001028)	Historical Hartwell Landfill (LQ 11-04)	Cutting slope gradient of 1V:3.5H and a maximum depth of 7.2 m below existing ground level.
Level 2 Assets:		
Aylesbury North Cutting Landscape Earthworks (LE) (HS2-00002BVFC)	Historical Hartwell Landfill (LQ 11-04)	Landscaping bunds between 4m and 8m in height are proposed on both sides of the cutting which will have a maximum 1V:4H slope inclination.
Footpath SBH/34 Accommodation Overbridge (HS2-000001295)	Historical Hartwell Landfill (LQ 11-04)	Structural design is still being finalised. Non displacement piled structure with minimal excavation (topsoil strip only).

Asset Name and ID	Interaction with LQ	Proposed Construction Details
A418 Oxford Road Overbridge (HS2-000001296)	No Interaction	Seven pre-tensioned concrete U beams with a 250mm thick (minimum) concrete slab supported by piled foundations. Minimal excavation assumed (topsoil strip only).
A418 Oxford Road Realignment (HS2-00002BJSX) / including Embankment	Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03) / Historic Brickworks Area	The road will be realigned to the south of its current route within the Historic Brickworks Area/ Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03) which will provide access to areas on both sides of the HS2 alignment via a new overbridge and embankments. The total alignment length is approximately 1060m in length. Embankment heights vary from at grade to 3.7m with a side slope of 1V:3H. The foundation solution for the embankment comprises the partial removal of Made Ground/landfill material to a maximum depth of approximately 2 mbgl, within the Historic Brickworks area and Former Hartwell Clay, Old Brick and Tile works and Landfill (LQ 11-03) and replacement with a lightweight aggregate, as such minimising the loading upon the Made Ground beneath the asset.
Sedrup Express Feeder Auto Transformer Station (EFATS) (HS2-000000184) and Access Road (HS2-00002BJSR)	No Interaction	The EFATS will be located on a concrete slab/plinth. Assumed to be either an open-air structure or housed within sealed metal cabinet. Minimal excavation anticipated. The access road is a 5.5m wide single carriageway. Minimal excavation anticipated.
Hartwell Depot Access Road (HS2-00002CT5G)	Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03) / Historic Brickworks Area	3.5m single carriageway connecting A418 Oxford Road to the Hartwell Depot. Minimal excavation anticipated.
Maintenance Access Road to Pond (off Old A418 Oxford Road north side of trace) (HS2-000020NC8)	No interaction	3.5m single carriageway connecting the A418 Oxford Road to pond. Minimal excavation anticipated.

1.3 Supplemental Reporting

The recommendations made in this report are based on information contained within the following sources of information completed for the proposed development and surrounding areas, which should be referred to and read in conjunction with this report:

- London-West Midlands Environmental Statement Volume 5 | Map books – Land Quality, HS2, November 2013 (Ref. 1).
- London-West Midlands Environmental Statement Volume 5 | CFA 15 – Technical Appendices – Land Quality, HS2, November 2013 (Ref. 2).

- Aylesbury North Cutting Geotechnical Design Report (Ref. 5)
- Supplementary Ground Investigation Report (GIR) – Aylesbury North cutting (Ref. 6)
- A418 Oxford Road Highways Design Statement (Ref. 7).
- Aylesbury South Cutting to Oxford Road Embankment: Hydrogeological Appraisal Report (Ref. 8)
- Unexploded Ordnance Desk Study, November 2014 (Ref. 9).
- ACD – Amersham to Calvert Area D, Ground Investigation Report – Factual Account, 1G066 – ACD, WP-ACD-001, BAM Ritchies, January 2018 (Ref. 10).

1.4 Limitations

This report has been prepared for HS2 in accordance with the terms and conditions of appointment. ASC cannot accept any responsibility for any use of or reliance on the contents of this report by any third party. The copyright of this document shall remain the property of ASC.

All chainages referred to are approximate with regards to the HS2 route and are based on the ASC Ground Engineering Viewer (Ref. 3).

The Limit of Deviation (LOD) and Limits for Land Acquired and Used (LLAU) boundaries are based on information available at the time of writing. This report will need to be updated in the event of future boundary changes.

A review of historical land uses, published geological, hydrological, and hydrogeological information has been undertaken using information provided by third parties including the records of regulatory and statutory bodies. Information has also been obtained from ASC geotechnical Viewer and ASC Water Viewer.

Data from the ground investigations has been used in the assessment of the ground conditions within the Site (Ref. 10). The exploratory hole locations and rationale behind their positions was undertaken by HS2. This report relies solely on GI data in AGS format, in line with the provisions of HS2 which requires all GI data in AGS format supplied by Contractors to be the same with the pdf copies. The latest AGS data is from the September data drop of 31/09/2022 (Data Drop 25). Arcadis does not warrant, nor does it accept any responsibility or liability for, the accuracy or completeness of the content or for any loss which may arise from reliance on information provided in the BAM Ritchies report and any other third-party information on which this report is based.

Ground investigations by nature only reveal a small percentage of the ground conditions present beneath the Site. The possibility of significant variation in ground conditions existing between sampling locations cannot be discounted. Gas and groundwater conditions are based on observations made at the time of the investigation and during monitoring visits and may be subject to significant variation due to atmospheric, seasonal, or other effects. Depths stated are based on levels at the time of the ground investigation. The data included within this report includes all the data available on the ASC OpenGround database up to the data drop of September 2022 (DD 25).

To inform the geoenvironmental assessment in this report 84 exploratory holes were completed across the site, of which 15 are within the Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03) and 11 within the Hartwell Landfill (LQ 11-04). All scheduled boreholes within the LQ areas and across the wider site have been completed and the results considered in the geoenvironmental assessment.

This is the final iteration of this report, and it is unlikely that outstanding ground investigation information will cause amendment to the Conceptual Site Model (CSM) and findings of this report. Verification assurance will be in place during the construction phase and details of ground conditions encountered during the construction works will be defined within Verification Reporting. Should unforeseen conditions be encountered during construction, this will be managed in accordance with procedures for unforeseen conditions (Ref. 32 and 34) and, if necessary, amended remediation requirements will be designed for agreement with regulators.

2 Desk Study Information

2.1 Site Location

The Site is located between ch.61+775 and ch.62+425 in the Aylesbury (AA) area of the HS2 route, approximately 2.3 km southwest of Aylesbury and 0.5 km east of Hartwell as shown on Figure 2-1.

The National Grid Reference (NGR) for the approximate centre of the Site is SP 80204 12321.



Figure 2-1 Site location plan. Extract from HS2 ASC Ground Engineering Viewer (Ref. 3).

2.2 Site Description

A non-intrusive Site walkover survey was undertaken on 31 March 2021 by two ASC Geoenvironmental Consultants. The photographs from the Site walkover survey are presented in Appendix B and a summary of the Site condition at the time of conducting the walkover is provided below:

A scaffolding yard, warehouse, and several smaller associated buildings (known as Hartwell Depot) were present within a small area in the centre of the Historic Brickworks Area / Former Hartwell Clay, Old Brick and Tile works and Landfill (LQ 11-03). The Scaffolding Yard is accessed from the A418 Road by a concrete road and is covered by concrete hardstanding. Overflowing skips were noted at the scaffolding yard, along with scattered waste materials (pallets, roof sheeting, plastics, gas canisters and drums) (Plates 1 to 4).

Surrounding the scaffolding yard, warehouse and buildings is the former Hartwell Clay, Brick and Tile Works and Landfill (LQ 11-03) and extended Historic Brickworks Area, which comprises rough grassland/ agricultural land that is on higher ground (raised up to approx. 2.5m) than the scaffolding yard (Plates 4 and 5). An area of the ground surface in the south of the former landfill area (LQ 11-03) is exposed due to limited vegetation and grass cover, showing infilled Made Ground containing brick fragments (Plate 6).

Hartwell Landfill (LQ 11-04) in the southwestern portion of the Site comprised a derelict residential dwelling (Glebe House) in the north and agricultural fields surrounded by hedgerows and sparse trees. No evidence of scarring or uneven/disturbed ground was visible from the ground surface that would indicate the presence of an underlying landfill (Plates 7 and 8).

The A418 Road crosses the Site at approx. ch.62+260, and a track intersects the Site at ch.61+850.

Several residential properties were present within the Site adjacent to the A418 road.

Sedrup Ditch was present in the eastern side of the Site which flows from the south towards the northeast within the LLAU towards the edge of Aylesbury before connecting to Stoke Brook present along the eastern LLAU boundary at approx. ch.62+250.

Aylesbury Park Golf Course and Fairford Leys Football Pitches were present to the north of the A418 road from approx. ch.062+300, within the north-eastern LLAU boundary.

The surrounding area, within 250 m west of the Site comprised agricultural fields, farms, Hartwell, and Lower Hartwell town. The land use to the east of the Site comprised the southwest edge of Aylesbury, which predominantly includes residential properties.

There was a gentle upwards topographical gradient towards the west from approx. 80 m AOD at (ch.61+500) to 85 m AOD at (ch.62+400).

2.3 Site History

The history of the Site and surrounding area has been established from Historical Ordnance Survey (OS) maps compiled from the ASC Ground Engineering Viewer (Ref. 3), UXO Desk Study report (Ref. 9) and National Library of Scotland Historical Mapping (Ref. 12).

Table 2-1 summarises the changes which are considered as 'significant,' in land use, both on and adjacent to the Site (up to 250 m). This is not intended as a full summary of the development of the area, but to highlight those features/uses which may have impacted the Site.

Table 2-1 Summary of historic land uses on and around the Site

Site History (within 250 m)

(Potential contamination sources underlined; potential receptors in *italics*)

	Predominantly agricultural land across the Site.
1878	Present day A418 road crosses the Site at ch.62+260. Park Villa, Hartwell Lodge and other residential properties (Glebe House, The Oaks) adjacent to A418. Brickfield (Brick works) present within the LLAU and partially within the LOD approx. ch.62+050 and ch.62+250 which includes 3 kilns and several clay pits. This encompasses the present-day location of the Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03).
1899	<u>Brickworks</u> has slightly expanded (approx. 30 m) to the southeast.
1921	<u>Brickworks</u> has further expanded to the south and east, extending to approx. 100 m northeast of the LOD at ch.61+900 (increased number of kilns and clay pits marked).
1945	<u>WWII Army Training Camp</u> established at Hartwell House, off-Site adjacent to the A418 road and western LOD and LLAU of the proposed A418 Oxford Road Realignment at ch.62+200.
1960	<u>Brickworks</u> now marked as 'Works'. The kilns and several of the smaller clay pits are no longer present.

Site History (within 250 m)

(Potential contamination sources underlined; potential receptors in *italics*)

1980 – 1983	WWII Army Camp demolished and converted to residential area. Brickworks converted to <u>Hartwell Depot</u> . No remaining pits marked.
1984 – 1991	No significant changes evident on Site. Aylesbury town has expanded to the east. Note: the Hartwell Landfill (LQ 11-04) has remained marked as an undeveloped field in all available historic maps.
2021*	Commercial/industrial building and concrete yard remains present at the Hartwell Depot.

*Based on current aerial photography (Ref. 3).

2.4 Physical Setting

Table 2-2 Considers the Physical and environmental setting of the Site, detailing the Hydrological and Geological conditions of the Site.

Table 2-2 Overview of the physical characteristics of the Site

Physical Setting (Ref. 3, Ref. 13, Ref. 14, Ref. 15)

Geology	Artificial Ground: Indicated to be present on Site situated within LQ 11-03- the Former Hartwell Clay, Old Brick and Tile Works and Landfill, which extends towards the eastern section of the A418 Oxford Road (within the LOD). This ground is recorded as “Infilled ground mapped as artificial deposits, worked and Made Ground. No artificial ground has been mapped within the confines of Hartwell Landfill (LQ 11-04). Superficial Deposits (On-Site): Absent across the majority of the Site within the LOD. Present under the eastern section of the A418 Oxford Road (Ch 62+220), with Head and Alluvium deposits of clay, silt sand and gravel. River Terraced deposits are present along the eastern boundary of the Site. Bedrock (On-Site): • The Portland Sand Formation (POSA), predominantly underlying the LOD, and comprises interbedded limestone, fine-grained sandstones, and silty mudstones with variable amounts of calcite and dolomite as well as purer carbonate lithologies. • The Portland Stone Formation (POST) underlies the western LLAU and partially underlies the LOD from ch.61+700 to ch.62+200, and comprises of interbedded limestone and sandstone • The Kimmeridge Clay Formation (KC) underlies most of the LLAU towards the east and north and comprises of a calcareous or kerogen-rich or silty or sandy mudstone.
Hydrogeology	Superficial: Secondary A Aquifer in ALV; Secondary A Aquifer in RTD, Secondary (Undifferentiated) Aquifer in Head.

Physical Setting (Ref. 3, Ref. 13, Ref. 14, Ref. 15)

	Bedrock: Principal Aquifer in POST Secondary A Aquifer in POSA Unproductive Aquifer in KC Aquifer Definitions Secondary A Aquifer, which is defined by the EA as “permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers”. Secondary (Undifferentiated) Aquifer, which is defined by the EA as “cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.” Principal Aquifer, which is defined by the EA as “layers of rock or drift deposits that have high intergranular and/or fracture permeability – meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer.” Unproductive Strata, which is defined by the EA as “rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.” Licensed Groundwater Abstraction Points/Source Protection Zones: None active or historical within 250 m. According to the Hydrogeological Appraisal Report for the area (Ref. 8) interception with the groundwater within the POSA is anticipated at the proposed cutting depth for Aylesbury North Cutting (5.8 m bgl).
Hydrology	Licensed Surface Water Abstraction Points: None active or historical within 250 m. Source Protection Zones: None within 250 m. Surface Water Features: On-Site: Small Pond and Surface water drain located within the Aylesbury Park Golf Course between Ch. 62+400 and 62+500, adjacent to the northern Site boundary. Off-Site: A larger pond is present within the Aylesbury Park Golf Course at approx. ch.62+550 to 62+800, approx. 130m northwest. Sedrup Ditch intersects the proposed Aylesbury Embankment at approx. ch.61+350. The ditch flows from the southwest towards the northeast through the LLAU before connecting to Stoke Brook which is present along the eastern LLAU boundary from approx. ch.61+700 to 62+400. A surface water drain is present adjacent to the A418 road within the LOD at approx. ch.62+250.

2.5 Environmental Setting

Information for the Site and the surrounding area has been obtained from information within the UXO Desk Study report (Ref. 9), Arcadis Ground Engineering Viewer (Ref. 3) and Arcadis Water Viewer (Ref. 11) and is summarised below in Table 2-3.

Table 2-3 Summary of Environmental Data

Information	Summary of Data
Landfill Sites (On-Site)	Historical Hartwell Landfill Site (LQ 11-04) located within the LOD and LLAU between ch.61+870 and ch.61+985 (approx. 430 m x 100 m). Provider: Aylesbury Vale District Council, Environmental Health Waste Type and dates of operation are unknown Historical Old Brickyards Landfill Site (Former Hartwell clay, old Brick and tile works – LQ 11-03). This is a section of the wider historic Brickworks area located within the LLAU and partially within the LOD between ch.62+150 and ch.62+275, approx. 150 m from the route. Operator: Aylesbury Rural District Council (operated from 1935 to 1971) Waste Type: Commercial
Correspondence with statutory bodies regarding Historical Hartwell Landfill (LQ 11-04)	Aylesbury Vale Local Authority (Buckinghamshire County Council): E-mail correspondence with Deborah Ferady from the Environmental Health team on 21 April 2021 notes the following: Information was obtained from the EA and indicates the landfill was pre-1976, was not licensed and has WRC reference 0400/0294. There is no reference to the nature of waste received or operational dates. E-mail correspondence with David Periam from the Minerals and Waste team on 22 April 2021 states that “No records are available of any planning application for mineral extraction or landfill at the location of the former Hartwell Landfill”. Environment Agency: E-mail correspondence with Chris Ford on 03 June 2021 notes the following: There are no recorded details relating to waste type. There are no recorded details relating to active landfill dates other than that the landfill was pre ‘1976’. In correspondence with the EA HS2 Technical Officer for Groundwater and Contaminated Land it was stated that; “it is likely that the polygon shown on the mapping is not accurate”. The information from historical maps, statutory bodies and the Site walkover survey suggest that the Historic Hartwell Landfill (LQ 11-04) may have been mapped erroneously and has in fact remained as an agricultural field.
Pollution Incidents	None recorded within 250 m of the Site.
Discharge Consent	On-Site: 1 discharge consent located within the LLAU approx. 340 m northeast of the LOD at ch.62+000, revoked in July 1995. Effluent Type Description: Miscellaneous Discharges (Surface Water). Off-Site: 1 discharge consent located approx. 90 m northeast of the LLAU at ch.62+400, revoked November 1991. Effluent Type Description: Miscellaneous Discharges (Surface Water)

Information	Summary of Data
Ecological Sensitive Sites	None recorded within 250 m of the Site.
Trade Directories	Aylesbury Park Golf Club (Historical entry) – located within the LOD and LLAU, intersecting the Site from ch.62+325 to ch.62+400 onwards. Fairford Leys Football Pitches – located within the LLAU from ch.62+300 to ch.62+400 onwards approx. 100 m from the LOD at ch.62+300.
Coal mining	The Site is not within an area that may be affected by coal mining.
Unexploded Ordnance (UXO)	The former WWII army training camp (now housing estate) is off-Site, adjacent to the western LOD/LLAU of Oxford Road Realignment. However, according to the Zetica UXO Desk study, the Site is within an area of Low risk, therefore the potential for UXO has not been considered further.
Radon Gas Risk	The Site is predominantly within an intermediate/high probability radon area (3 to 5% of homes are estimated to be at or above the Action Level) (Ref. 16) which is associated with potentially radium rich deposits in the underlying Portland Stone Formation. There are no confined spaces, such as tunnels, proposed within the Site in which radon could accumulate. The Sedrup EFATS will either be an open-air structure or housed within a sealed metal cabinet on a concrete slab/plinth. Therefore, the potential for radon accumulation has not been considered further.
Flood Risk	There is limited potential for groundwater flooding across the majority of the Site, apart from the south and western areas of the Site within the LOD and LLAU. Within the eastern LLAU, towards the city boundary with Aylesbury, the potential for groundwater flooding increases. These risks are associated with Sedrup Ditch and Stoke Brook (Flood zones 2 and 3).

2.6 Preliminary Conceptual Site Model

From the understanding of the Site history, setting, on-Site observations, existing data, and information contained within the previous reports, the following Preliminary Conceptual Site Model and associated potential contaminant linkages were developed.

2.6.1 Potential Contamination Sources

Potential contaminative sources identified are detailed in Table 2-4.

Table 2-4 Potential contamination sources

Potential Sources (On-Site)	Potential Contaminants	Site Area
Localised Made Ground from previously developed areas	Metals, asbestos, poly aromatic hydrocarbons (PAHs), benzene, toluene, ethylbenzene, and xylene (BTEX), phenols, total petroleum hydrocarbon (TPH), volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), ground gas and vapour.	Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03) Historic Brickworks Area (other than the part that is the Landfill) A418 Oxford Road Commercial Land Use – Golf course/Football Pitches.
Historic Landfill Activities	Metals, asbestos, inorganic compounds (e.g., ammoniacal nitrogen, chloride), PAHs, TPH, BTEX, phenols, SVOCs and VOCs, leachate, ground gases, vapour.	Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03) Hartwell Landfill (LQ 11-04)
Geology	Alluvium: Potential ground gas from potential organic materials within Alluvial deposits	Eastern part of the Site within the LLAU.
	Mudstone (Kimmeridge Clay Formation): Potential to include sulphate and sulphide which have the potential to lead to chemical attack on concrete and services.	Site wide
	Potential elevated background concentrations of metals within the natural soils.	
Potential Sources (Off-Site)	Potential Contaminants	Site Area
Historical WWII Army Training Camp (adjacent to the western LOD/LLAU)	Potential contaminants include metals, PAHs, BTEX, phenol, TPH, VOCs/SVOCs, low level radioactive contamination (e.g., from luminescent paints), ground gas and vapour.	Off Site- Ch. 62+100 to 62+250 west of the LOD/LLAU, situated over Hartwell Village

The potential for Site wide ground contamination within the agricultural areas is considered to be very low, although there remains the potential that isolated areas of unforeseen contamination may be present throughout the Site.

2.6.2 Potential Receptors

The identified receptors across the Site are as follows:

Human health:

- Future Site users (employees (within the LOD), farmers and visitors within areas of the LLAU proposed to return to agricultural usage).
- Off-Site Site users (residents, employees, visitors of adjacent housing, farms, and other commercial activities (golf course and football pitches)).

The potential short term risk to human health (construction/maintenance workers and general public during construction) are mitigated specifically through the requirements of the Control of Substances Hazardous to Health Regulations (COSHH) and application of the CDM Regulations and their associated risk assessments and safe systems of work, method statements and adoption of suitable measures such as personal protective equipment (PPE), good hygiene practice and dust control; therefore these receptors are not considered further.

Controlled waters:

- Superficial aquifers:
 - Secondary A Aquifer in ALV and RTD Deposits.
 - Secondary Undifferentiated aquifer in Head Deposits.
- Bedrock aquifers:
 - Principal aquifer in POST Formation
 - Secondary A aquifer in POSA Formation
- Surface waters:
 - Sedrup Ditch, Stoke Brook, drains, ponds.

Property and Utilities:

- On-Site: Proposed HS2 rail system development and associated structures (see Table 1-2).
- Off-Site: Residential areas, utilities, and commercial properties.
- Livestock is not considered.

2.6.3 Pathway Characterisation

The principal exposure pathways include the following:

- Human health
 - Dermal contact or ingestion of contaminated dust, soil and water, or inhalation of dust (within the LLAU in areas proposed to be returned to agricultural usage).
 - Ingestion of contaminated vegetables and soil attached to vegetables (within the LLAU in areas proposed to be returned to agricultural usage).
 - Migration of ground gas & vapours via preferential pathways and accumulation on confined and poorly ventilated spaces. Exposure to low oxygen conditions.
- Controlled waters
 - Mobilisation of contaminants within perched groundwater and/ or leachable contamination during excavation/ construction works and leaching or lateral and vertical migration of contaminants to groundwater (Principal, Secondary A) and surface waters.
 - Leaching or lateral and vertical migration of contaminants to groundwater (Principal, Secondary A, Secondary Undifferentiated).
 - Lateral migration of contaminated groundwater into surface waters.

- Direct runoff of contaminants mobilised or distributed by the works into surface waters.
 - Movement through or migration of contaminated groundwater along engineered structures (services, piles, excavations).
- Property
 - Direct contact of below ground structures and services with contaminated soil or groundwater.
 - Direct contact (sulphate attack or similar) of below ground concrete with aggressive ground conditions.

3 Ground Investigation

3.1 Field Work

Intrusive ground investigation was undertaken at the Site by BAM Ritchies (Contract Area: ACD) between the 4th of April and the 14th of December 2016 and Fugro, from May 2022. The investigation specific to the Site comprised 84 boreholes of which 15 are within LQ 11-03 and the wider brickworks area and 11 within LQ 11-04.

The data included within this report includes all the data available on the ASC OpenGround database up to and including the data drop No. 25 (DD 25), September 2022. The combined works, up to DD 25, comprised a total of 84 exploratory holes as summarised below:

- 19 Cone Penetration (CT) holes to a maximum depth of depth of 15.01 m bgl.
- 4 Pavement Core (PC) holes to a maximum depth of 0.35 m bgl.
- 17 Trial Pits (TP) to a maximum depth of 4.10 m bgl.
- 25 Dynamic Windowless Sample (WS) holes to a maximum depth of 8.00 m bgl.
- 2 Cable Percussion (CP) boreholes to a maximum depth of 15.10 m bgl.
- 9 Cable Percussion borehole with Rotary Cored (CR) follow on to a maximum depth of 45.00 m bgl.
- 2 Rotary Open (RO) hole borehole to a maximum depth of 22.00 m bgl.
- 6 Rotary Cored (RC) boreholes excavated to a maximum depth of 35.00 m bgl.

The exploratory hole plan is presented in Appendix C. The exploratory hole logs are included within the AGS DD 25. This brings the total number of locations between the two phases of investigation at this Site to 84. All ground investigation across the site relevant to this report has been completed and no further ground investigation is scheduled.

Table 3-1 summarises the number of exploratory holes undertaken and chemical data with respect to the individual potential contaminative sources.

Table 3-1 Number of Exploratory Holes and Chemical Testing Undertaken in relation to Contaminative Source Areas

Potential Contaminative Source	No. of Exploratory Holes within/adjacent the Potential Contaminative Source	No. of Exploratory Holes with Chemical Data
Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03) and wider brickworks area	15	8 Soil and Leachate, 5 Groundwater
Historical Hartwell Landfill (LQ 11-04)	11	8 Soil and Leachate; 5 Groundwater

Across the Site, groundwater monitoring has been undertaken at 23 borehole locations, and at 19 gas monitoring locations. At these locations there are up to 14 rounds of groundwater monitoring and up to 11 rounds of gas monitoring, between April 2016 and July 2022.

3.2 Geoenvironmental Laboratory Testing

Contamination testing undertaken on soil, leachate and groundwater samples are summarised in Table 3-2. Surface water data was not available for the Site.

Table 3-2 Summary of Chemical Testing Undertaken on samples across the Site

Type of Test	No. of tests on soil samples	No. of tests on leachate samples	No. of tests on groundwater samples
pH.	49	49	24
Dissolved Organic Carbon (DOC).	-	-	13
cyanide (total).	49	17	20
cyanide (free).	17	-	7
ammoniacal nitrogen, nitrite, nitrate, nitrogen.	10	-	18
sulphate (as S04), phosphate (as PO4)	-	-	7
hardness.	-	-	21
chloride.	11	-	16
Asbestos	39	-	-
arsenic, boron, cadmium, chromium (total), hexavalent chromium, copper, lead, mercury, nickel, selenium, zinc.	49	49	15
barium, beryllium, vanadium, trivalent chromium.	17	17	7
iron, manganese, magnesium.	-	-	5
potassium, sodium.	11	-	18
calcium.	-	-	21
PAHs.	41	-	21
Phenol.	41	-	16
Chlorinated phenols.	11	-	16
Total Petroleum Hydrocarbon Criteria Working Group (TPH CWG).	21	-	22
BTEX.	33	-	23
MTBE.	11	-	16
VOCs.	11	-	14
SVOCs.	29	-	16
PCBS	-	-	-
Total samples analysed	49	49	25

4 Ground Conditions

The ground conditions encountered during the Ground Investigation generally comprised Topsoil or Made Ground, underlain by superficial deposits of Alluvium, Head and River Terrace Deposits followed by bedrock, consisting of the PB, POST, POSA and KC Formations and a single recording of the Ampthill Clay Formation (AMC).

Made Ground was typically localised to the Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03) and the wider Historic Brickworks area. Two instances of Made Ground were encountered within the exploratory holes completed within the mapped Hartwell Landfill (LQ 11-04), albeit these are not linked to any potential landfilling activities. Made Ground has also been identified associated with the A418 Oxford Road, where road surfacing has been encountered in 4 instances.

The geological long section (extract for Aylesbury North Cutting) is provided in Appendix D1. Appendix D2 shows the geological cross section specific to the A418 Oxford Road Realignment, indicating the known depth/ extent of the Made Ground/landfill material and areas of uncertainty.

A summary of the general succession of strata encountered is presented in Table 4-1.

Table 4-1 Summary of Ground Conditions

Strata	Depth to top (m bgl)	Depth to base (m bgl)	Thickness (m)	Description
Topsoil (TOP)	GL	0.05 – 0.70	0.05 – 0.70	Encountered in 51/84 exploratory holes Widespread within the Site within agricultural fields and within the Historic landfill (LQ 11-04). Absent from the historic Brickworks area and Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03). Thickest Topsoil (0.70 m) in ML061-CP011 located within the LLAU, approx. at ch.61+850. Typically, Topsoil appears to be less than 0.30 m thick. Described as a silty, sandy, gravelly clay; a clayey, sandy silt or a clayey sand.
Made Ground (MGR)	GL	0.04 – 7.75	0.20 – 7.75	Encountered in 31/84 exploratory holes Localised to the A418 road, historic Brickworks area and Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03), with minor encounters within the Historic Hartwell Landfill (LQ 11-04). <u>Historic Brickworks Area, and Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03)</u> Identified in 15 exploratory holes (2 of these being pavement cores associated with the A418). Typically described as a clay, with frequent anthropogenic inclusions (metal fragments, plastic, glass, brick, coal, ash, glass bottles, metal pot, plastic food packaging, plaster fabric, clinker, slag, charcoal, burnt timber) between 1.4m thickness at the eastern extent and 7.75m thickness at the western extent (base not proven). Deeper Made Ground is primarily centralised around the structure present on Site. The frequent amount and nature of the anthropogenic material is indicative of landfill material.

Strata	Depth to top (m bgl)	Depth to base (m bgl)	Thickness (m)	Description
				A slight (unknown) odour noted in ML062-WS003 and ML062-CR486. Elevated photoionisation detector (PID) readings were noted at ML062-WS016a (between depths 2-2.5m) when completing the borehole with values ranging between 100 ppm and 125 ppm compared to a background reading of 0.09. Historic Hartwell Landfill (LQ 11-04) Identified in two exploratory holes to limited depths (0.3 and 0.9m bgl). Anthropogenic inclusions have been noted of brick fragments and concrete. These MGR deposits are not thought to indicate any historical landfilling activities. Existing A418 Road Made Ground identified in 4 pavement core holes within the existing A418 Road, typically described as a Macadam of 40 – 90% aggregate of granite or flint gravel up to 0.3m thickness. The PC locations did not extend into the underlying subbase/ Made Ground or natural strata. Strong hydrocarbon odour noted in ML062-PC002 likely to be related to the presence of tarmac. Greenfield Areas: Made Ground identified in 14 locations (2 of these being pavement cores associated with the A418) Made Ground has been identified at limited depths (from GL to 0.4 m bgl). Anthropogenic inclusions have been noted of brick, clinker, and bitumen.
Superficial Deposits				
Alluvium (ALV)	1.40 – 1.50	2.2 – 2.30	0.80	Encountered in 2/84 (ML062-WS006, ML062-WS018) exploratory holes – localised to the eastern area of the Site within the historic Brickworks area and Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03). Underlying Made Ground. Thickest (0.80 m) Alluvium identified in ML062-WS006, located within the LLAU approx. 50 m southwest of the LOD at ch.62+350. Described as a silty, sandy, gravelly clay.
Head	0.05 – 2.95	0.40 – 5.00	0.2 – 2.05	Encountered in 13/84 exploratory holes. Underlying Made Ground and Topsoil. Thickest (2.05 m) in ML062-WS003 located towards the northeast of the Site, approximately 50 m south of the LOD at ch.62+200. Typically, the head deposits appear to be less than 1.4 m thick. Described as a silty, sandy, gravelly clay.

Strata	Depth to top (m bgl)	Depth to base (m bgl)	Thickness (m)	Description
River Terrace Deposits (RTD)	2.20 – 2.30	2.35 – 2.40	0.10 – 0.15	Encountered in 2/84 exploratory holes (ML062-WS006, ML062-WS018) – very infrequent within the Site, both encounters located northeast of the Site within the LLAU, close to the eastern LOD of the proposed A418 re-alignment works. Underlying Alluvium. Described as a clayey, gravelly sand or clayey, sandy gravel.
Bedrock Deposits				
Purbeck Formation (PB)	0.35	3.45	3.10	Encountered in 1/84 exploratory hole (ML061-CR431). Underlying Made Ground. Located Northwest of the Historic Hartwell Landfill (LQ 11-04) at Ch. 62+018, described as a sandy clayey gravel.
Ampthill Clay Formation (AMC)	22.75	25.00	2.25	Encountered in 1/84 exploratory hole (ML061-RC024). Underlying Kimmeridge Clay. Located within the LOD at approx. ch.62+350, described as grey calcareous clay.
Portland Stone Formation (POST)	0.05 – 4.45	0.35 – 9.53	0.14 – 6.08	Encountered in 26/84 exploratory holes, situated across the full extent of the Site (with only one instance noted within LQ 11-03). Underlying Made Ground, Head, Topsoil, Portland Sand and Purbeck Formation. Maximum thickness of 6.08 m was encountered in ML061-CR431 located inside the LOD at approx. ch.62+018. Mixed lithologies (Sand, Gravel, Clays, Silt, Limestone, Sandstone) predominantly soft to firm to very stiff light grey or brown silty sandy gravelly clay (rarely calcareous). Sand is fine to coarse, and gravel is angular to subrounded, fine to coarse of limestone, sandstone and/or mudstone.
Portland Sand Formation (POSA)	GL-9.53	0.45-13.79	0.3 – 6.1	Encountered in 42/84 exploratory holes, situated primarily in greenfield areas with some instances within LQ 11-04 (Historic Hartwell Landfill). Underlying Made Ground, Head, Topsoil and Portland Stone. Maximum thickness of 6.1m found to a depth of 7m (ML061-CP430) located within the confines of LQ 11-04 at approx., ch.061+943. Mixed lithologies (Sand, Gravel, Clays, Silt, Limestone, Sandstone) predominantly described as brownish grey calcareous sandstone. Slightly sandy slightly silty gravel with low cobble and low boulder content. Noted frequently as being distinctly weathered.
Kimmeridge Clay	1.4 – 13.79	1.8 – 45.00	0.65 – >30.00	Encountered in 25/84 exploratory holes. Located across the Site, predominantly in greenfield areas with a few instances

Strata	Depth to top (m bgl)	Depth to base (m bgl)	Thickness (m)	Description
Formation (KC)		(base not proven)		noted within LQ 11-03. Underlying Made Ground, Head, River Terrace Deposits, Portland Stone, and Portland Sand. Maximum thickness of 39.24m was recorded to a depth of 45 m (ML062-CR446) located inside the LOD, at approx. ch.62+139. However, the base was not proven. Predominantly described as a soft to firm to very stiff dark bluish grey silty, sandy, gravelly clay with a plastic behaviour commonly noted. Sand is fine to medium, and gravel is subangular to subrounded, fine to coarse of limestone or mudstone. Occasionally noted to be calcareous and/or locally fossiliferous.

4.1 Hardstanding, Surface Features and Underground Obstructions

Hardstanding was noted in the form of tarmacadam encountered in the 4 Pavement Core boreholes taken from the A418 road.

Obstructions were noted in 2 exploratory holes being ML062-WS005 and ML062-WS005a (both within the Historic Brickworks area) where the boreholes were terminated at 0.55 m bgl and 1.00 m bgl respectively, prior to their scheduled depths due to concrete and brick obstructions.

4.2 Groundwater

4.2.1 Groundwater Strikes

Groundwater strikes were encountered in 18/39 exploratory holes as summarised in Table 4-2

Table 4-2 Summary of Groundwater Strikes

Exploratory Hole ID	Exploratory Hole Elevation (m AOD)	Depth of Water Strike (m bgl)	Depth of Water Strike (m AOD)	Geology (Strike Level)	Depth after 20 minutes observation (m bgl)	Depth after 20 minutes observation (m AOD)
ML061-CP011	81.01	1.20	79.81	HEAD	1.10	79.91
ML061-CR401	84.69	4.40	80.29	POST	4.00	80.69
ML061-WS004	84.33	2.00	82.33	POST	1.70	82.63
ML061-WS011	84.36	2.80	81.56	POST	2.00	82.36
ML061-RO001	85.76	7.10	78.66	POST	1.35	84.41
ML062-RC025	86.18	5.00	81.18	POST	5.00	81.18
ML062-TP442	86.46	0.8	85.66	POST	0.6	85.91
ML062-WS002	81.76	3.00	78.76	MGR	2.00	79.76
ML061-CR419	85.12	0.6	84.52	POST	0.55	84.57

Exploratory Hole ID	Exploratory Hole Elevation (m AOD)	Depth of Water Strike (m bgl)	Depth of Water Strike (m AOD)	Geology (Strike Level)	Depth after 20 minutes observation (m bgl)	Depth after 20 minutes observation (m AOD)
ML061-CP430	85.18	1.2	83.98	POSA	1.1	84.08
ML061-CR431	87.84	0.9	86.94	PB	0.9	86.94
ML062-CR478	86.38	1.2	85.18	POSA	1.15	85.23
ML062-CR486	81.29	5	76.29	MGR	4.8	76.49
ML062-CR449	87.23	0.9	86.33	POSA	0.9	86.33
ML062-TP482	75.72	0.8	74.92	POSA	0.55	75.17
ML062-RO494	86.73	1.19	85.54	POSA	1.16	85.57
ML062-CT497	87.04	1.2	85.84	POSA	0.9	86.14
ML062-RC512	86.76	0.9	85.86	POSA	0.89	85.87

4.2.2 Monitored Groundwater Level

Groundwater level monitoring results are available from a total of 24 exploratory holes within the Site, between 2016 and 2022. For the purposes of the groundwater assessment and consistency with previous versions of this report, groundwater level data has been reviewed from 2017 onwards and does not include the data from 2016 which was collected 1 day after the installation was constructed, because the groundwater level may have been affected by drilling works.

4.2.2.1 Made Ground

Data from ML062-WS005A (MGR, screened 0.20-0.70 mbgl) and ML062-WS018 (MGR, screened 1.00-1.40 mbgl) are not plotted as all monitoring visits recorded the installation as dry. In addition, Data from ML062-CP003 is not plotted due to only having one groundwater level reading and as such not a representative sample of the GW level at the location. Summaries of the groundwater data and a location plan of the monitoring data are presented in Appendix E.

Within the Historic Brickworks Area/ Former Hartwell Clay, Old Brick and Tile works and Landfill (LQ 11-03) in the eastern area, the Site groundwater was recorded within the Made Ground between 0.8 – 5.0 m bgl (74.79 – 80.15 m AOD) as shown in Figure 4-1 and 4-2. Groundwater levels recorded within the Made Ground are highly variable and do not indicate a uniform groundwater table within the Made Ground. In addition, there is limited seasonal variability in groundwater levels. It is considered that groundwater is perched and discontinuous within the Made Ground. Groundwater may be encountered during excavations for the A418 Road Realignment and Hartwell Depot Access Road within LQ 11-03 (maximum depth of excavation to be ~2 m bgl), however, this is expected to be limited and represent discontinuous pockets of groundwater.

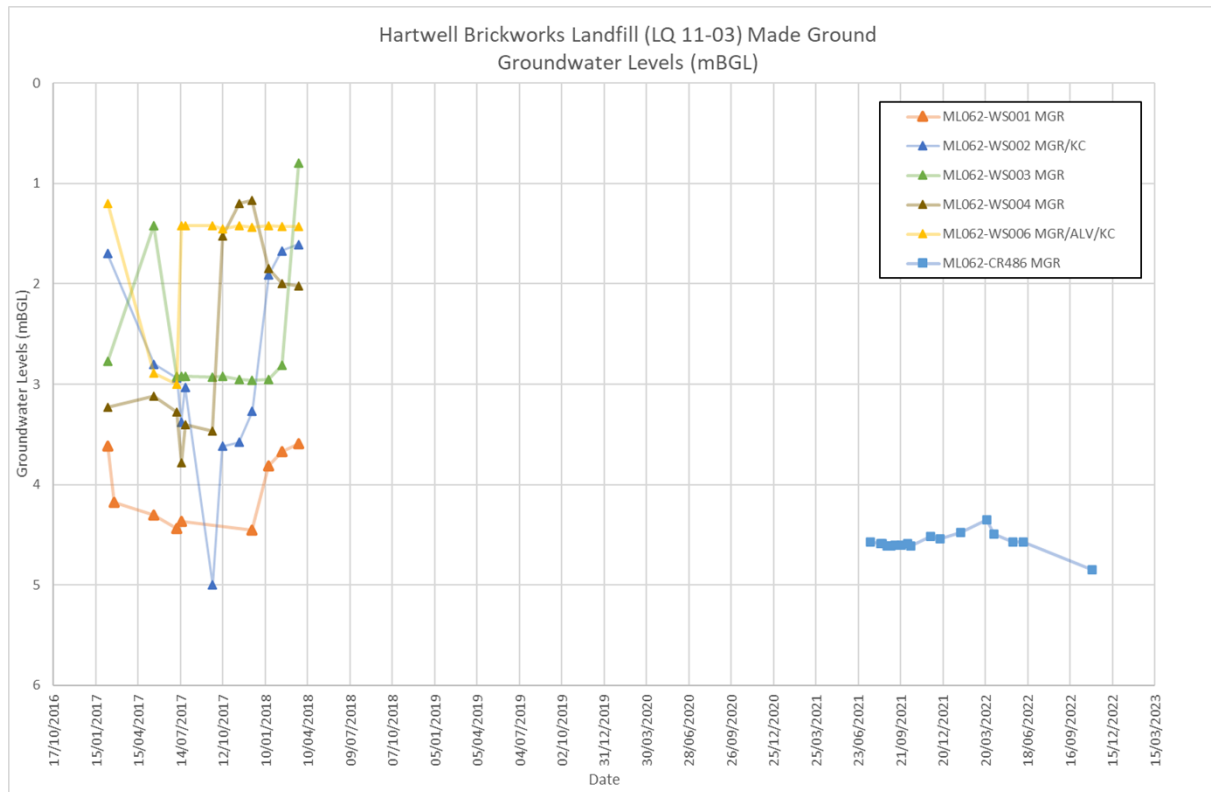


Figure 4-1 Groundwater level readings within Made Ground in LQ 11-03 - below ground level

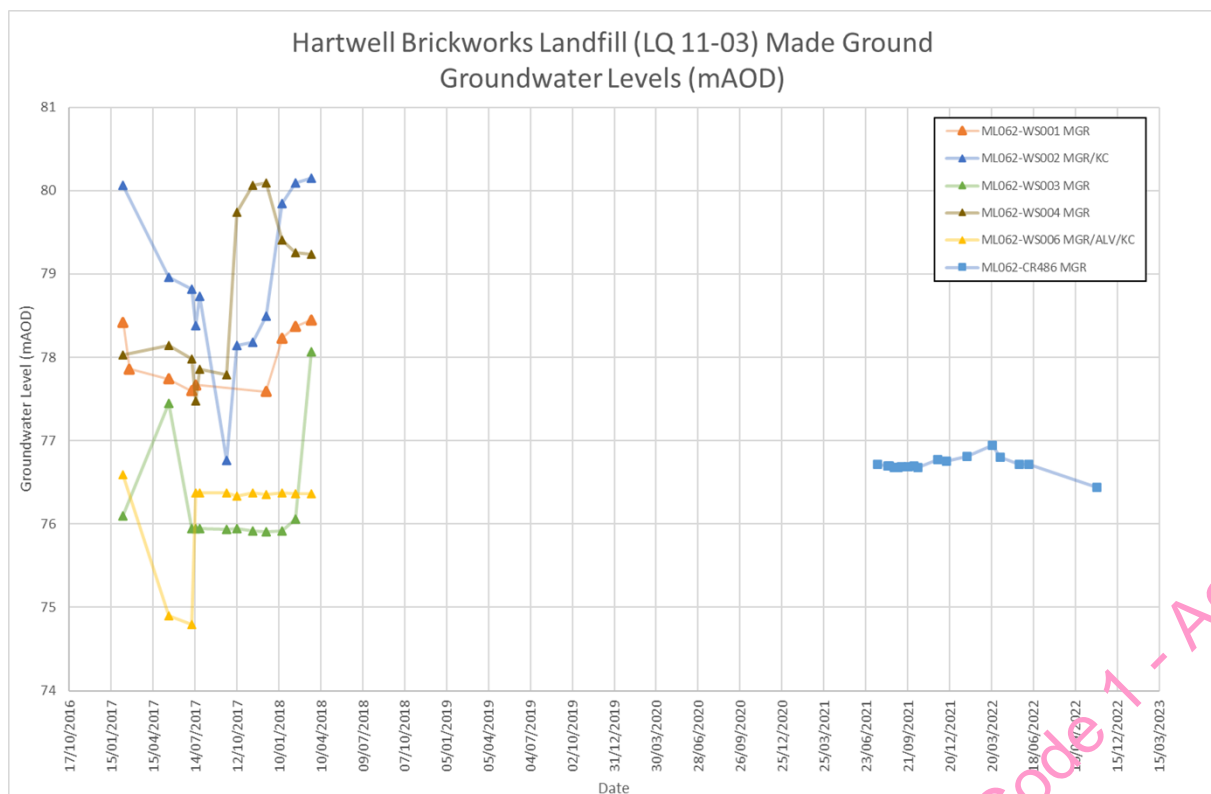


Figure 4-2 Groundwater level readings within Made Ground in LQ 11-03 - elevation

4.2.2.2 Bedrock

Groundwater levels within the POSA/POST Formations were recorded between 0.54 and 5.74 m bgl (87.11 – 80.91 m AOD), across the central and western area of the Site as shown in Figure 4-3 and 4-4. The monitoring shows limited seasonal variability within the POST/POSA. The monitoring data has been examined spatially and temporally and the results indicate that there is poor hydraulic conductivity within the aquifer. The POST/POSA is highly weathered within the Site comprising occasional discontinuous sandstone bands (high permeability) with interbedded clay/silt layers (low permeability). A basal limestone layer is noted in the majority of the boreholes within the POST; however, it is not present in all locations and is variably weathered. Limestone bands are also noted within the POSA within the south of the Site; however, these are below the proposed depth of excavation for Aylesbury North Cutting (discussed further below). It is considered that the limestone strata are likely to provide the majority of the permeability of the aquifer unit.

Aylesbury North Cutting is proposed to be excavated to approx. 83.5 – 81.5 m AOD (up to 7.2 m bgl). It is anticipated that the excavations will partially excavate the POST/POSA between 61+763 and ch.62+050 and progress below the base of the POST/POSA between approximately ch.62+050 and ch.62+400 (Ref. 5) as shown in Figure 4-5. Hence, groundwater within the POST/POSA is expected to be encountered during excavation, however, ingress is expected to be relatively limited due to the area representing a topographic high point, the highly weathered nature of the POST in this area, and the low permeability of the majority of the strata (clays and silts). Temporary dewatering during the works will be required to control groundwater ingress.

The A418 Overbridge will be supported on piles up to 37m in length which terminate in the Kimmeridge Clay Formation. It is anticipated that groundwater will be encountered during piling associated with the POST/POSA however, as detailed above, the ingress is expected to be relatively limited.

The A418 Road Realignment (outside of Hartwell Brickworks Landfill, LQ 11-03) is to be constructed on an earthworks embankment to raise the level to allow it to key into the A418 Overbridge. Minimal excavation (<0.5 m) will be required outside of LQ 11-03 for the construction of the asset; therefore, it is not anticipated that groundwater will be encountered during construction of the asset.

Excavations of up to 3.1 m deep are expected during the construction of the Sedrup ATS Access Road. It is anticipated that groundwater will be encountered during excavation associated with the POST/POSA however, as detailed above, the ingress is expected to be relatively limited.

Groundwater present within Kimmeridge Clay (Unproductive Stratum) is likely to be limited to poorly connected pore spaces, with no significant regional groundwater flow within the bedrock due to clay dominated and cohesive nature of this strata. The groundwater that is observed within the monitoring boreholes is likely to represent seepages from the surrounding muds and clays and not a continuous flowing water table. Whilst groundwater is likely to be encountered during excavation of the KC this groundwater is very localised and is not representative of a true groundwater table and will reach a point of equilibrium.

Shallow groundwater within the KC is expected to be present within pore spaces, fissures and weathered sections and is likely to be encountered during excavation works. Groundwater collected from dewatering of the Cutting excavations will be collected and tested prior to discharge.

As stated in the Aylesbury South Cutting to Oxford Road Embankment Hydrogeological Appraisal Report (HAR) (Ref. 8), post construction impacts to groundwater at Aylesbury North Cutting have been determined (through assessment as part of the HAR) to impact groundwater locally to the cutting only, and not likely to cause major changes to the regional hydrogeology due to the limited groundwater anticipated. Seepages from within the cutting will need to be accommodated in the track drainage design.

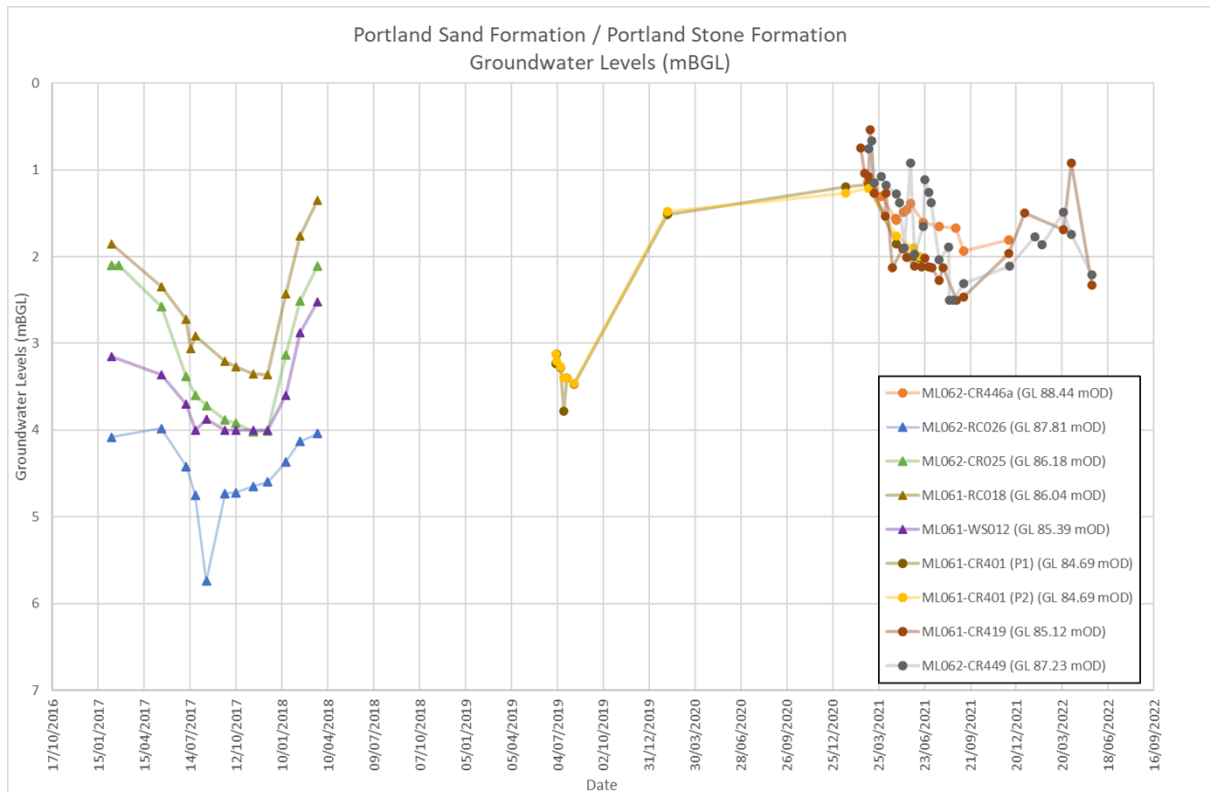


Figure 4-3 Groundwater level readings within POST/POSA - below ground level

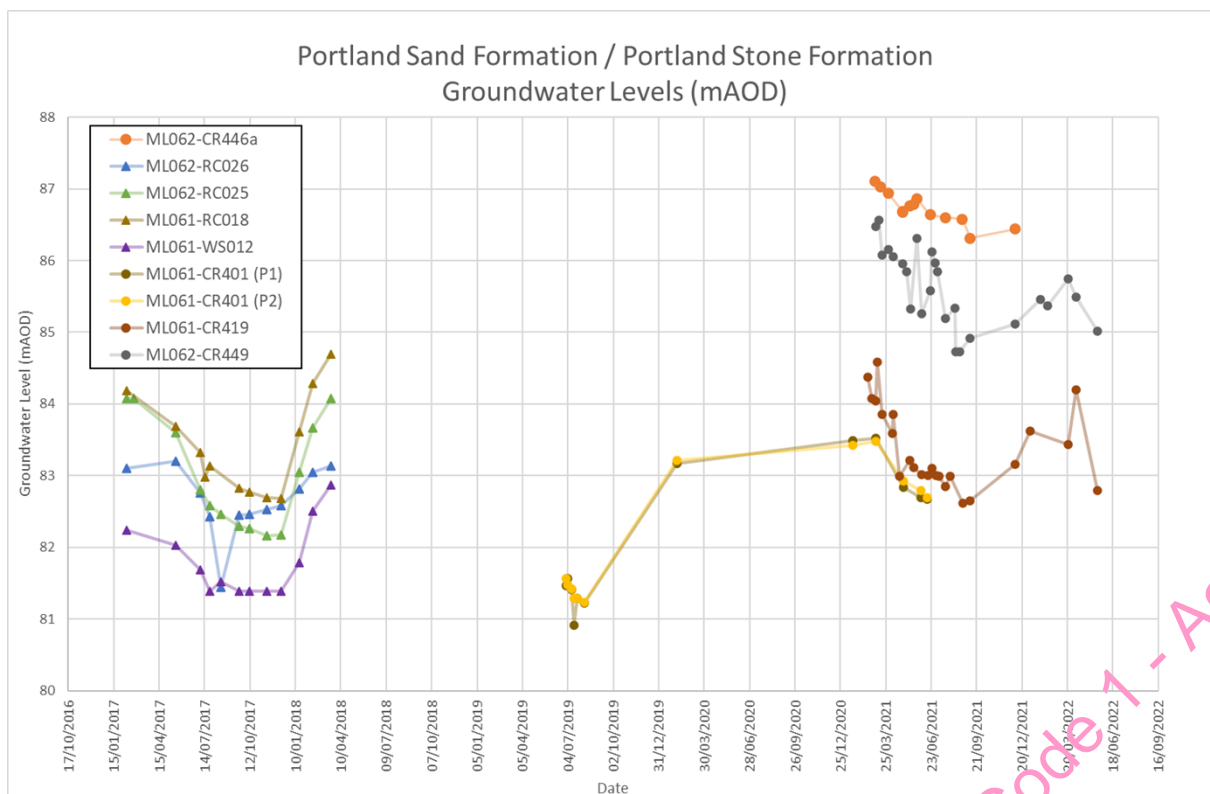


Figure 4-4 Groundwater level readings within POST/POSA - elevation

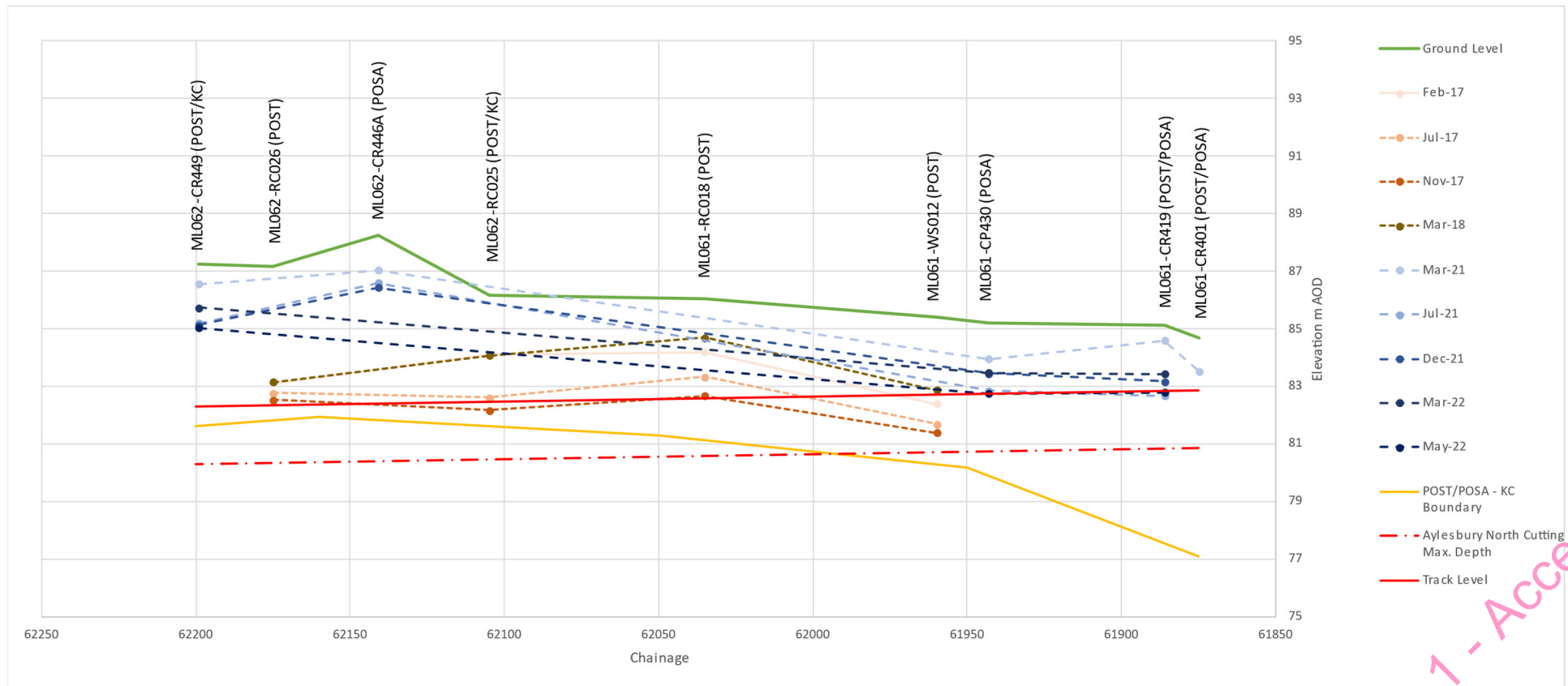


Figure 4-5 Section showing groundwater level monitoring within installations screened within POST/POSA

4.3 Visual and Olfactory Evidence of Contamination

Evidence of suspected anthropogenic material was noted in 30 exploratory holes within Made Ground which were primarily situated within the Historic Brickworks area/ Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03), there were two instances located within the Historic Hartwell Landfill (LQ 11-04) area. A Strong hydrocarbon odour was noted in ML062-PC002 which is associated with the presence of tarmac within the A418 Road. In addition to this, organic odours were also noted in ML062-CR486 and ML062-WS003.

PID Headspace testing was conducted across the Site during ground investigation works. Generally, across the Site values recorded were low with only two instances within ML062-WS016a, demonstrating elevated readings at 100 ppm and 125 ppm, this borehole also demonstrated numerous anthropogenic inclusions and as such the contamination present is likely the cause of these readings. Within LQ 11-04; Historic Hartwell Landfill the maximum reading noted was 0.2 ppm.

A summary of visual/olfactory evidence encountered within Made Ground is presented in Table 4-4 below.

Table 4-3 Summary of Visual and Olfactory Contamination

Exploratory Hole ID	Area	Range of depths observed (m bgl)	Visual and Olfactory Observation
ML062-CR486	11-03	0.00 – 7.75	Ceramic, lignite, brick fragments, burnt wood, plastic bags, ash, glass fragments, metal fragments and clinker. <i>Slight organic odour.</i>
ML062-PC002	A418 Oxford Road	0.00 – 0.35	Tarmacadam and granite gravels. Strong hydrocarbon odour.
ML062-WS004	11-03	0.00 – 5.00	Tile, brick fragments, coal, plastic, ash, fabric, and metal fragments.
ML062-WS002	11-03	0.00 – 4.35	Brick fragments, coal, gravels of various lithologies, metal pieces, concrete fragments, and glass.
ML062-WS016a	11-03	0.00 – 3.30	Coal, glass fragments, brick fragments, metal pieces, coal, and ash. Elevated headspace PID readings were noted (between depths 2.00 – 2.50m) when completing the borehole with values ranging between 100 ppm and 125 ppm.
ML062-WS003	11-03	0.00 – 2.95	Brick fragments, glass fragments, plasterboard fragments, gravels of various lithologies and plastic (household waste). Slight odour noted.
ML062-WS006	11-03	0.00 – 1.50	Ash, glass fragments, clinker, slag, charcoal, burnt timber, metal pieces and plastic fragments.
ML062-WS018	11-03	0.00 – 1.40	Coal, tile fragments, brick fragments, glass fragments, metal pieces and ash (household waste)

5 Contamination Assessment

The analytical results of the soil, leachate and groundwater samples collected and tested have been assessed to determine the potential risk to human health, controlled waters, and property/structures. The following sections provide a screening assessment of the suite of contaminants analysed against appropriate screening values.

5.1 Human Health Risk Assessment

5.1.1 Soil Screening Values

Soil screening values have been adopted from LQM/CIEH Suitable for Use Levels (S4ULs) (Ref. 17) and Category 4 Screening Levels (Ref. 18) for Human Health Risk Assessment, using a soil organic matter (SOM) content of 1% as a precautionary approach (see below). Based on the proposed land uses within the Site and to provide flexibility in the assessment, the following screening criteria have been considered:

- Commercial/Industrial end-use – i.e., for the proposed HS2 railway infrastructure within the Limit of Deviation (LOD).
- Public Open Space (POS) _(park) end-use within the LLAU to be restored to public open spaces (i.e., the golf course, football field(s) and landscape areas where public access may be granted).
- Allotment end-use within the LLAU/ LOD – based on areas of the LLAU proposed to be restored to agricultural usage.

Note: The SOM within the Hartwell Landfill (LQ 11-04) ranged from <0.35 – 1.76% and the SOM within and adjacent to the Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03) ranged from 0.91 – 19.70%. Hence, the most conservative S4UL criteria relating to a SOM content of 1% has been adopted for this assessment.

In the absence of a published screening criteria for Extractable Petroleum Hydrocarbons (EPH), the most conservative S4UL for TPH CWG for the appropriate aliphatic/ aromatic fractions have been used, respectively.

5.1.2 Soil Results

A total of 49 soil samples (2 Topsoil, 26 Made Ground, 1 ALV, 3 HEAD and 17 Bedrock (5 POST and 8 POSA, 1 PB and 3 KC)) collected across the Site were analysed for asbestos, metals, inorganic, and organic compounds. 10 of the soil samples were collected from within the Hartwell Landfill (LQ 11-04), 19 from within the Historic Brickworks area and Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03), and the remaining 20 samples from Greenfield Site. A summary of the soil assessment is presented in Appendix F.

5.1.2.1 Asbestos Screening

38 soil samples were screened for asbestos, with no asbestos detected.

Given the former use of the eastern side of the Site as a landfill (which was over 7.75m thick in the western extent and included anthropogenic materials representative of domestic landfill material), the potential presence of asbestos cannot be discounted and will need to be considered during the works.

5.1.2.2 Metals

Outside of LQ areas/ greenfield

Metal or inorganic exceedances were not recorded in the 8 Made Ground samples and 12 natural soil samples collected against all screening criteria.

Historic Hartwell Landfill (LQ 11-04)

Metal and inorganic exceedances were not recorded from 2 Made Ground samples and 8 natural soil samples against appropriate screening criteria.

Historic Brickworks Area / Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03)

Metals exceedances of the S4UL Allotment criteria were recorded within 11 samples of Made Ground, within the Historic Brickworks Area/ Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03), as shown in Table 5-1. No exceedances of the POS_(park) or Commercial/Industrial criteria were identified within this area.

Table 5-1 Summary of Metal Exceedances above the Allotment S4UL Criteria within the Historic Brickworks Area/ Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03)

Determinand	LQM S4UL (1%SOM)			Result (mg/kg)	Exploratory Hole and Depth (m bgl)
	Allotment	Park (POS)	Commercial / Industrial		
Arsenic	43	170	640	93.2 93.2	ML062-WS003 (0.5) ML062-WS006 (1)
Boron	45	46,000	240,000	114 121	ML062-WS003 (0.5) ML062-WS006 (1)
Cadmium	1.9	190	532	4.1 3.1 13 3.49 18.8 4.38	ML062-CR486 (0.5, 2) ML062-WS003 (0.5) ML062-WS006 (1) ML062-WS016a (0 & 1)
Copper	520	44,000	68,000	757 539	ML062-WS005 (0.2) ML062-WS006 (1)
Lead	80	1300	2300	100 130 310 228 962 80.6 213 791 465 86.3 120	ML062-CR486 (0.5, 2 & 4) ML062-WS003 (0.3 & 0.5) ML062-WS004 (0.2) ML062-WS005 (0.2) ML062-WS006 (1) ML062-WS016a (0 & 1) ML062-WS485 (0.2)

	LQM S4UL (1%SOM)			Results	Exceedance Location
Nickel	53	800	980	58 76 57 235 211 191 77.6	ML062-CR486 (0.5, 2 & 4) ML062-WS003 (0.5) ML062-WS006 (1) ML062-WS016a (0 & 1)
Zinc	620	170,000	730,000	1190 2430 970 2500	ML062-WS003 (0.3, 0.5) ML062-WS005 (0.2) ML062-WS006 (1)

The exploratory hole logs for the locations of exceedances above indicated the presence of anthropogenic materials including metal fragments, household waste, coal, ash, clinker, slag, charcoal and burnt timber, which is likely to be related to the recorded exceedances.

5.1.2.3 Inorganics

Exceedances of inorganic contaminants were not noted.

5.1.2.4 Organics

The results for organics in soil samples were assessed against the relevant generic assessment criteria detailed in Section 5.1.1.

Outside of LQ areas/ greenfield

Organic exceedances were not recorded from the 20 samples taken from outside of the LQ areas (8 Made Ground and 12 Natural soil samples); against relevant screening criteria.

Historic Hartwell Landfill (LQ 11-04)

Organic exceedances were not recorded from the 10 natural soil samples within parts of the Historic Hartwell Landfill (LQ 11-04) in the LOD and LLAU; against relevant screening criteria.

Historic Brickworks Area / Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03)

Exceedances of the POS_(park) or Commercial/Industrial screening criteria were not identified. Exceedances of the allotment screening criteria were identified for 4 PAHs and 4 EPH/TPHs in 6 Made Ground samples from 4 exploratory holes within the Historic Brickworks Area / Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03) as presented in Table 5-2.

Table 5 2 Summary of Organics Exceedances above the Allotment S4UL Criteria within the Historic Brickworks Area/ Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03)

Determinand	LQM S4UL (1%SOM)			Result (mg/kg)	Exploratory Hole and Depth (m bgl)
	Allotment	Park (POS)	Commercial / Industrial		
PAHs					
Naphthalene	4.1	1200	190	112	ML062-WS005 (0.2)
Benzo(b)fluoranthene	0.99	13	44	2.28 1.94 1.18 3.9	ML062-WS003 (0.3 & 0.5) ML062-WS016a (0) ML062-WS485 (0.2)
Benzo(a)pyrene	0.97	5.7	35	1.82 1.34 4	ML062-WS003 (0.3 & 0.5) ML062-WS485 (0.2)
Dibenz(a,h)anthracene	0.14	1.1	3.5	0.346 0.282 0.144 0.159 0.7	ML062-WS003 (0.3 & 0.5) ML062-WS005 (0.2) ML062-WS016a (0) ML062-WS485 (0.2)
EPH/TPHs					
>C ₁₀ -C ₁₂	*13	*9200	*16,000	20.6	ML062-WS005 (0.2)
>C ₁₂ -C ₁₆	*23	*10,000	*26,000	26.3	ML062-WS003 (0.5)
>C ₁₆ -C ₂₁	*46	*7600	*28,000	68.1 275	ML062-WS003 (0.5) ML062-WS005 (0.2)
>C ₂₁ -C ₄₀	*370	*7800	*28,000	451 999 1,390 720	ML062-WS003 (0.3 & 0.5) ML062-WS005 (0.2) ML062-WS006 (1)

* In the absence of screening criteria for EPH, the most conservative S4UL values for TPH-CWG are adopted

The logs of the 4 exploratory holes where exceedances were identified (ML062-WS003, ML062-WS005, ML062-WS006, ML062-WS016a) within the Historic Brickworks Area / Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03), which recorded anthropogenic materials including coal, clinker, slag, charcoal and burnt timber which are likely to be related to the above exceedances. ML062-WS003 also recorded a slight odour between 2.60 and 2.95 m.

The exceeded PAHs were all marginally above their respective Allotment criteria apart from Naphthalene (112 mg/kg) in ML062-WS005_{0.20 m} which was significantly above the Allotment criteria (4.1 mg/kg).

Exceedances noted for EPH/TPHs were also slightly exceeded above the Allotment guideline value. However, it should be noted that the screening values used for EPH were not specified, hence, the assessment should be considered indicative.

5.1.3 Summary of Results

Exceedances for metals/inorganics and organics were not recorded within the LOD when assessed against the POS (park) end-use and the Commercial/Industrial end use values, therefore the excavated materials are not considered to pose a significant risk to human health following the construction of the cutting or landscape embankments/bunds.

Concentrations of metal, PAH, and EPH/TPH determinands were noted to exceedance the Allotment end use criteria within the Made Ground in the Historic Brickworks Area / Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03). The majority of this area is within the LLAU where minimal excavation is anticipated (i.e., proposed to be used for temporary stockpiles, compounds etc only), however some of this material is potentially to be excavated for the proposed A418 Oxford Road Realignment as it is unlikely to be a suitable founding stratum for the road and will need to be removed. Excavated landfill material from the A418 Oxford Road Realignment is likely to require remediation to make it suitable for re-use within the scheme.

Contaminants of concern were not recorded within the Historical Hartwell Landfill (LQ 11-04), or greenfield areas of the Site.

5.2 Controlled Water Assessment

5.2.1 Water Quality Standards

Potential impacts to Controlled Waters have been assessed by reviewing the chemical results for leachate and groundwater samples. Each contaminant concentration is compared against appropriate Water Quality Standards (WQS), comprising Environmental Quality Standards (EQS) (Ref. 20) and UK Drinking Water Standards (DWS) (Ref. 21). EQS are considered protective of surface water and DWS are protective of groundwater which may be used as a potable supply.

In the absence of UK WQS for TPH, the appropriate World Health Organisation (WHO) guideline values for TPH CWG fractions in drinking water (Ref. 22) have been adopted as an indicative screening value.

The toxicity of copper, nickel, zinc, manganese, and lead is heavily influenced by bioavailability. An initial screening of leachate and groundwater samples identified exceedances of these metals against the EQS. Where there are exceedances, the Water Framework Directive (WFD) Metal Bioavailability Assessment (m-BAT) (Ref. 23) has been used to calculate a Site-specific screening value for these metals. The parameters used in the MBAT comprise the mean pH (7.37 pH units), mean dissolved organic carbon (8.93 mg/l) and mean dissolved calcium (223 mg/l) values from groundwater samples collected within the natural bedrock strata on Site (Ref. 23).

5.2.2 Leachate Assessment

49 soil leachate samples (2 Topsoil, 26 Made Ground, 3 HEAD, 1 ALV, 1 PB, 8 POSA and 5 POST and 1 KC) were scheduled for leachate analysis for metals/inorganics (determinants are listed in Table 3-3). The analytical results are screened against the relevant WQS, presented in Appendix G.

The soil leachate analysis comprised BSEN 12457 – 1 Single Stage 2:1 Leachate prep.

It should be noted that the limit of detection for total cyanide (50 µg/l) is higher than the EQS guideline value (1 µg/l). Therefore, the assessment of leachable cyanide with respect to Controlled Water risk was not undertaken.

It should be noted that the WQS for these contaminants are very stringent, and the soil leachate test undertaken within the laboratory environment may not be a true reflection of actual Site condition.

Outside of LQ areas / greenfield

20 leachate samples taken from 8 Made Ground and 12 natural soil samples from outside of the LQ areas. Exceedances outside of LQ areas were noted for only pH, with exceedances seen in 8 of the samples taken, ranging from 5.9-6.5.

Historic Hartwell Landfill (LQ 11-04)

10 samples were taken from within LQ 11-04 (2 MGR and 8 Natural soils). One exceedance was noted within a natural soil sample (TOP, ML061-WS003) for chromium III, however this was a minor exceedance against the more stringent EQS screening value.

Historic Brickworks Area / Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03)

19 samples were taken and analysed from within the Historic Brickworks Area / Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03), with 16 of these being Made Ground. Exceedances were recorded for metals in 5 locations against WQS within the Historic Brickworks Area and Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03), and for pH in one location (ML062-WS485). These exceedances are summarised in Table 5-3.

Table 5-2 Summary of leachate exceedances against WQS

Determinand	DWS (µg/l)	EQS (µg/l)	Result	Exploratory Hole and Depth (m bgl)
Arsenic	10	50	13.2	ML062-WS016a (0)
Boron	1,000	2,000	1590 1430	ML062-WS003 (0.5) ML062-WS006 (1)
Cadmium	5	0.25	2.09 0.368 1.19 0.23	ML062-WS003 (0.5) ML062-WS006 (1) ML062-WS016a (0,1)
Chromium VI	50	3.40	4.1	ML062-WS016a (1)
Copper	2,000	42.23 (PNEC)	74.40	ML062-WS016a (0)
Mercury	1	0.07	0.115	ML062-WS016a (0)
Nickel	20	23.12 (PNEC)	278 20.7 35.3 89.3	ML062-WS003 (0.5) ML062-WS004 (2.25) ML062-WS006 (1) ML062-WS016a (0)
Selenium	10	-	14.10	ML062-WS006 (1)
Zinc	3,000	35.65 (PNEC)	976 40.7 634	ML062-WS003 (0.5) ML062-WS005 (0.2) ML062-WS006 (1)

Anthropogenic material indicative of landfill material (comprising of metal fragments, plastic fragments, coal, ash, clinker, slag, charcoal and burnt timber) were identified within the Made Ground, where exceedances have been identified.

Based on the results, metals are potentially leachable to concentrations that would exceed the WQS within the Historic Brickworks Area / Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03), and hence this area is considered as a potential source of leachable contamination to Controlled Waters, if disturbed or mobilised by the works.

5.2.3 Groundwater Assessment

25 groundwater samples from 16 exploratory holes were collected from two groundwater regimes beneath the Site (comprising 4 perched groundwater samples from the Made Ground; and 21 groundwater samples within the underlying aquifers on Site; 8 of these from the principal aquifer in the POST Formation). The samples were analysed for the determinants listed in Table 3-4 including metals, inorganic and organic contaminants. The results were screened against the relevant WQS as presented in Appendix H of this report. Groundwater sampling locations with exceedances summarised in Tables 5-3, 5-4, 5-5 and 5-6 below.

5.2.3.1 Metals

Note: The limit of detection for chromium VI (15 and/or 7 µg/l) is higher than the EQS guideline value (3.4 µg/l) for 10 samples taken across the Site. Therefore, the assessment of chromium VI in samples taken from these locations was not undertaken.

Outside of LQ Areas / greenfield

12 groundwater samples, from 6 borehole locations (ML061-RC018, ML062-CR446A, ML062-CR449, ML062-RC025, ML062-RC512, ML062-RC513) with response zones within the POST, POSA and KC were collected from agricultural land within the LOD between ch.61+890 and ch.62+100. Exceedances of arsenic and, iron were noted within samples obtained from ML062-CR446A against the respective WQS.

Historic Hartwell Landfill (LQ 11-04)

8 groundwater samples (ML061-CP430, ML061-CR401, ML061-CR419, ML061-RC018, ML061-RO001, ML061-WS012), with response zones within the POSA and POST within the mapped Hartwell Landfill (LQ 11-04). Minor exceedances of cadmium (0.32 µg/L) and chromium III (3.8 µg/L) were noted within the sample obtained from ML061-CR401.

Historic Brickworks Area / Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03)

Five groundwater samples were collected and tested from parts of the LOD and LLAU within the Former Hartwell Clay, Old Brick and Tile Works, Landfill (LQ 11-03) and wider brickworks area.

Exceedances were recorded for metals in 4 exploratory holes (ML062-WS001, ML062-WS002, ML062-CR486, ML062-WS485) within the extended Historic Brickworks area with response zones within the Made Ground and KC (see Table 5-4 below).

Note: a small section – 0.65 m of the response zone in ML062-WS002 also extends into the KC bedrock).

Table 5-3 Summary of Metal Exceedances in Groundwater above the WQS within the Historic Brickworks Area

Determinand	UK DWS (µg/l)	EQS (µg/l)	Result (µg/l)	Exploratory Hole and Depth (m bgl)	Geology
Arsenic	10	50	19 40.70	ML062-CR486 (5) ML062-WS002 (3)	MGR MGR
Boron	1,000	2,000	1700	ML062-CR486 (5)	MGR
Cadmium	5	0.08	10.60	ML062-WS002 (3)	MGR
Chromium III	50	4.7	9.24 61.40	ML062-WS001 (4.2) ML062-WS002 (3)	MGR MGR
Chromium VI	-	3.4	15	ML062-WS485 (3.5)	KC
Copper	2000	42.23 (PNEC)	99.40	ML062-WS002 (3)	MGR
Lead	10	10.72 (PNEC)	531	ML062-WS002 (3)	MGR
Nickel	20	23.12 (PNEC)	226	ML062-WS002 (3)	MGR
Vanadium	-	60	148	ML062-WS002 (3)	MGR
Zinc	3000	35.65 (PNEC)	1,980	ML062-WS002 (3)	MGR

Minor exceedances against DWS were noted for arsenic and boron within ML062-CR486, whilst minor exceedances of the EQS have been noted for ML062-WS001 and ML062-WS485 (for chromium III and chromium VI, respectively). All other metal exceedances were noted within ML062-WS002, with exceedances of both DWS and EQS being noted for 8 metals. Exceedances from three (ML062-WS001, ML062-WS002 and ML062-CR486) of the boreholes indicated numerous anthropogenic inclusions including brick, tiles, coal, plastic, metal fragments, clinker, glass, and concrete. This anthropogenic material within the Made Ground/landfill material is likely to be the source of the identified exceedances.

Temporary groundwater control (such as dewatering) is likely to be required for excavation works for the A418 Oxford Road Realignment works (proposed excavation depths to be determined) and during the excavation for Aylesbury North Cutting which will be up to 5.8 m bgl. The GI data indicates that groundwater is present from as shallow as 0.8 m bgl, therefore it is likely that contaminated groundwater will be encountered during dewatering and will need to be collected, tested, and disposed off-Site/treated under a Schedule 33 Environmental Consent.

5.2.3.2 Inorganics

Outside of LQ areas/ greenfield

Exceedances were recorded in 2 boreholes (ML062-CR446A & ML062-CR449) across the Site (not within LQ areas). The exceedances were associated with total cyanide, nitrate as NO₃ and phosphorous), from response zones within the POST, POSA and KC formations. These boreholes are situated primarily centred on the route trace around the A418 Oxford Road.

Historic Hartwell Landfill (LQ 11-04)

Exceedances of the DWS were recorded for nitrate (as NO₃) and phosphorus, and the EQS for total cyanide. Minor exceedances of the EQS for cyanide, and DWS for nitrate (NO₃) were seen in ML061-CP430 and ML061-CR419 (within the POSA and POST). Phosphorous exceedances were noted from ML061-WS012 which has a response zone targeting the POST Formation within the Historic Hartwell Landfill (LQ 11-04) within agricultural land. The results from this screening is shown below in Table 5-4.

Table 5-4 Summary of inorganic contaminant exceedances within LQ 11-04

Determinand	UK DWS (µg/l)	EQS (µg/l)	Result (µg/l)	Exploratory Hole and Depth (m bgl)	Geology
Cyanide (Total)	50	1	1.6 2	ML061-CP430 (2.5) ML061-CR419 (4.5)	POSA POST
Nitrate (as NO ₃)	50	-	150 53	ML061-CP430 (2.5) ML061-CR419 (3)	POSA POST
Phosphorous	2200	-	40,100	ML061-WS012 (3.1)	POST

Historic Brickworks Area / Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03)

Exceedances were recorded for ammoniacal nitrogen, phosphorus, calcium, and potassium in 5 groundwater samples (ML062-WS001, ML062-WS002 and ML062-WS003, ML062-CR486 and ML062-WS485) taken from installations with response zone targeting the Made Ground (and one response zone of KC) in parts of the Historic Brickworks area within the LOD and LLAU.

A summary of inorganic exceedances is presented in Table 5-5.

Table 5-5 Summary of Inorganics exceedances in groundwater above the WQS

Determinand	UK DWS (mg/l)	EQS (µg/l)	Result (mg/l)	Exploratory Hole and Depth (m bgl)	Geology
Ammoniacal Nitrogen	600	300	12000 4360 11800 86600 2400	ML062-CR486 (5) ML062-WS001 (4.2) ML062-WS002 (3) ML062-WS003 (2.92) ML062-WS485 (3.5)	MGR MGR MGR MGR KC
Calcium	250000	-	345000 901000 270000	ML062-WS001 (4.2) ML062-WS002 (3) ML062-WS485 (3.5)	MGR MGR KC
Cyanide (Total)	50	1	2.2 6.9	ML062-CR486 (5) ML062-WS485 (3.5)	MGR KC
Phosphorous	2200	-	24000 5990	ML062-WS001 (4.2) ML062-WS002 (3)	MGR MGR
Potassium	12000	-	32000 18000	ML062-CR486 (5) ML062-WS002 (3)	MGR MGR

The exceedances of ammoniacal nitrogen in groundwater samples are likely to be associated with the presence of landfill material within the Historic Brickworks Area / Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03). Exceedances of Cyanide are considered to be minor.

The exceedances of phosphorous and potassium in the groundwater samples are likely to be related to agricultural activities (within greenfield areas) and/ or from the landfill/ Made Ground within the Historic Brickworks area/ Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03).

Exceedances of calcium within groundwater collected from the Historic Brickworks area (response zone within the Made Ground) may be due to background geology from the underlying POST formation.

Ammoniacal nitrogen, phosphorous and potassium are considered as contaminants of concern within the groundwater.

5.2.3.3 Organics

Outside of LQ Areas/ Greenfield

No exceedances of organic criteria (including the WHO speciated screening criteria for TPHs (Ref.22)) has been noted outside of LQ areas/within Greenfield locations.

Historic Hartwell Landfill (LQ 11-04)

No exceedances of organic criteria (including the WHO speciated screening criteria for TPHs (Ref.22)) has been noted within the confines of LQ 11-04, Historical Hartwell Landfill.

Historic Brickworks Area / Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03)

Exceedances of the WHO screening criteria for TPH (Ref. 22) were recorded for TPH Aromatic C₂₁-C₃₅ in 2 groundwater and 2 PAHs in 2 groundwater samples (ML062-WS001, ML062-WS002) and one exceedance of SVOCs from (ML062-WS001) taken from the perched groundwater regime in the Made Ground within the LOD and LLAU within LQ 11-03 and the wider Historic Brickworks area, as presented in Table 5-6.

Table 5-6 Summary of Organic Determinands in Groundwater above the WQS

Determinand	UK DWS (µg/l)	EQS (µg/l)	Result (µg/l)	Number and Location of Exceedances
Aromatics C ₂₁ -C ₃₅	90 (WHO)	-	110 189	ML062-WS001 (4.2) ML062-WS002 (3)
Fluoranthene	1	0.10	1.31 4.50	ML062-WS001 (4.2) ML062-WS002 (3)
Benzo(b) fluoranthene	0.10	0.30	1.10	ML062-WS001 (4.2)
Bis(2-ethylhexyl) phthalate	1.3	-	3.77	ML062-WS001 (4.2)

The exceedances in groundwater samples (perched within Made Ground) are likely to be associated with the presence of leachable contaminants sourced from the Historic Brickworks area / Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03). The PAHs, TPH, and Bis(2-ethylhexyl) phthalate are therefore considered to be contaminants of concern to controlled waters. Contaminated groundwater is likely to be encountered during temporary works dewatering for Aylesbury North Cutting and within excavations proposed for the A418 Oxford Road Realignment.

5.3 Ground Gas Assessment

Ground gas was monitored in 19 standpipes across the Site, between May 2017 and April 2022.

Five of the monitored exploratory holes (ML061-CP430, ML061-CR401, ML061-CR419, ML061-RO001, ML061-WS012) are located within and adjacent to the Historic Hartwell Landfill (LQ 11-04), 9 within the Historic Brickworks and LQ 11-03 area (ML062-CR486, ML062-WS001, ML062-WS002, ML062-WS003, ML062-WS004, ML062-WS005a, ML062-WS006, ML062-WS018, ML062-WS485). 5 Boreholes were conducted outside of LQ areas in greenfield Sites (ML061-RC018, ML062-CR446a, ML062-CR449, ML062-RC512, ML062-RC513).

The monitoring undertaken has had some rounds of data discounted due to the standpipes being saturated at the time of monitoring. Overall, across the Site 64% of the monitoring rounds were unsaturated, with 68/87 monitoring rounds within LQ 11-03 and the wider Historic Brickworks area being unsaturated, thus considered to present a representative assessment of the ground gas regime across the Site.

The maximum and minimum steady state gas concentrations from these rounds have been summarised in Table 5-7.

Table 5-7 Summary of ground gas monitoring data

Location	No. of monitoring rounds	CO ₂ Range (% v/v)	CH ₄ Range (% v/v)	O ₂ Range (% v/v)	Flow Rate Range (l/hr)	Response Zone (m bgl)	Geology
Greenfield Areas	1-10	1-6.0	0-4.0	10.6-21.1	0-0.4	0.50 – 9.00	POST/ POSA
Historic Brickworks Area / LQ 11-03	6-11	0.5-15.8	0-31.2	0.1-21.3	-0.3-0.4	0.50 – 5.00	MGR
LQ 11-04	3-11	0.2-2.0	0-4.0	16.8-21.4	0-0.4	0.50 – 4.00	POST

The monitoring results for the Site area have been assessed using the current guidance CIRIA C655 Assessing Risks Posed by Hazardous Ground Gases to Buildings (Ref. 24) and BS8485 Code of Practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings (Ref. 25).

Atmospheric pressure during the gas monitoring visits ranged between 989 and 1027 mb.

The following rounds of ground gas monitoring were undertaken when the response zone was flooded and has therefore been excluded from ground gas assessment:

- ML061-CR401: 3 rounds saturated
- ML061-CR419: 3 rounds saturated
- ML061-RC018: 1 round saturated
- ML062-CR449: 5 rounds saturated
- ML062-RC513: 2 rounds saturated
- ML062-WS002: 3 rounds saturated
- ML062-WS003: 2 rounds saturated
- ML062-WS006: 9 rounds saturated
- ML062-WS018: 2 rounds saturated

The gas flow rate varied between 0.00 – 0.4 l/hr across the Site, throughout the monitoring period.

Carbon dioxide (CO₂) was detected in all installations between 0.20 and 15.80 % v/v. The maximum value of 15.80 % v/v was recorded within the Made Ground in ML062-WS003 in the Historic Brickworks area. CO₂ levels greater than 5% were recorded in 8 boreholes, with 7 of these within the Historic Brickworks area (LQ 11-03). It is considered likely that the Made Ground/landfill material within the Historic Brickworks is the source of the elevated CO₂ concentrations.

Flammable gas (methane) was detected in all installations (but for ML062-RC513), between 0.10 – 31.2% v/v, with the maximum recorded value in ML062-WS003 (within the Historic Brickworks Area), however, whilst all boreholes (but for one) during monitoring highlighted the presence of Methane, some rounds did not detect any Methane.

Oxygen concentrations varied from 21.40 to 0.30 % v/v with the lowest recorded value noted at ML062-WS003. 5 boreholes (ML062-WS001, ML062-WS002, ML062-WS003, ML062-WS004 and ML062-CR486) recorded low oxygen concentrations (0.30 – 6.50 %) within Made Ground in the Historic Brickworks area and Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03).

Carbon monoxide (CO) was reported below the detection limit (<0.1) to 1 ppm (in 9/14 locations). Hydrogen sulphide (H₂S) ranged from below the detection limit (<0.1) to 3 ppm (in 13/14 locations). The concentrations of CO and H₂S are below the long- and short-term Health and Safety Executive Workplace Exposure limits (Ref. 26) and are therefore not considered to be of concern.

Calculation of the GSV

In accordance with the CIRIA C665 Guidance (Ref. 24) the GSV is calculated using the following equation:

GSV = borehole flow rate (l/hr) x gas concentration (% v/v)

Taking the “worst case” scenario (highest recorded CO₂, CH₄ and gas flow rates) in Table 5-7, GSV/hazardous gas flow rates for methane and carbon dioxide have been calculated and are summarised in Table 5-8.

Table 5-8 Summary of maximum gas concentrations and GSVs from steady state gas concentrations

Potential Contaminative Source	Max. CO ₂ (v/v %)	Max. CH ₄ (v/v %)	Max Flow Rate (l/hr)	Max CO ₂ GSV (l/hr)	Max CH ₄ GSV (l/hr)	Characteristic CH ₄ & CO ₂ Gas Situation	Risk Classification (Ref. 24)
Greenfield Areas	6.0	4.0	0.40	0.024	0.016	2 (CO ₂ >5% & CH ₄ >1%)	Low Risk
Historic Brickworks Area / Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03)	15.8	31.2	0.40	0.0632	0.1248	2 (CO ₂ >5% & CH ₄ >1%)	Low Risk
Historic Hartwell Landfill (LQ 11-04)	2.0	4.0	0.40	0.0008	0.016	2 (CH ₄ >1%)	Low Risk

The calculated GSVs for CH₄ for the Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03) and Historic Brickworks Area were above the 0.07 l/hr threshold, as such they fall under the classification of Characteristic Situation 2 (Low risk). Within the Historic Hartwell Landfill (LQ 11-04) and Greenfield areas the calculated GSVs for CO₂ and CH₄ are below the 0.07 l/hr threshold for

Characteristic Situation 1, however the maximum CO₂ concentration is over 5% (in both areas), and CH₄ is over 1% (for LQ 11-04) Hence, they fall under a classification of Characteristic Situation 2 (Low Risk), given that there are viable sources of ground gases within the area.

The Made Ground/ landfill material within the Historic Brickworks area/ Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03) is considered to be the likely sources of ground gas (CS2) identified within these areas. Limited Made Ground was encountered within the mapped Historic Hartwell Landfill (LQ 11-04), and data suggests a CS2 (low risk) is present within this area, however, there remains a potential for further unforeseen Made Ground and landfill material to be present.

Whilst the presence of ground gases has been detected, the low flow rates detected particularly within the Historic Brickworks Area / Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03) suggests that migration of ground gas from this area is unlikely. There are no structures or buildings proposed on Site in which ground gas would be likely to accumulate. The Sedrup EFATS will either be an open-air structure or housed within a sealed metal cabinet on a concrete slab/plinth. However, the presence of carbon dioxide and depleted levels of oxygen may present a potential risk to construction workers entering confined spaces such as deep excavations (proposed for the A418 Oxford Road and Aylesbury North Cutting) and unsealed services conduits/connections.

5.4 Risk to Property

5.4.1 Aggressive Ground Conditions

The assessment of potential sulphate attack to below ground concrete is discussed within the Aylesbury North Cutting Geotechnical Design Report (Ref. 5), with further data for the Portland Formation and Kimmeridge Clay formations being analysed in the latest iteration. Despite this the Sulphate data available specific to the Aylesbury North Cutting is limited and as such, route-wide data from across C2 were used to determine the Design sulphate (DS) DS-2 and Aggressive Chemical Environment for Concrete (ACEC) classifications, in accordance with Table C1 of British Research Establishment Special Digest 1: Concrete in Aggressive Ground (Ref. 27). The following DS and ACEC classifications were determined:

- Head: DS-2, AC-2.
- Kimmeridge Clay: DS-4, AC-4.
- Ampthill Clay Formation: DS-4, AC-4.
- Portland Stone and Portland Sand: DS-1, AC-1.
- The Made Ground/landfill material is also a likely source of aggressive ground conditions to below ground concrete.

5.4.2 Ground gas

As stated in Section 5.3, a Characteristic gas situation 2 (Low risk) was determined from monitoring data. There are no proposed buildings in which gas would be likely to accumulate and cause a potential explosive risk, however ground gas could accumulate within deep excavations and unsealed services conduits/connections.

5.4.3 Below ground services

Gross hydrocarbon contamination capable of impacting the built environment has not been identified, however owing to the presence of landfill material within the Historic Brickworks area/ Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03), the potential for encountering such contamination cannot be discounted, which could impact proposed below ground services such as the proposed Thames Water Main Diversion for potable water supply (permanent and temporary diversions) proposed in the central and eastern areas of the Site, and a such appropriate barrier piping should be employed in accordance with UK WIR Guidance (Ref. 30).

5.4.4 A418 Oxford Road Realignment

The proposed A418 Oxford Road Realignment will be raised on an embankment over part of the Historic Brickworks area and Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03), see *Figure 5-1*. The underlying Made Ground/ landfill material (>5 m thickness in areas) is likely to be variable and compressible, and therefore unlikely (in its current state) to be a suitable founding stratum for the proposed realignment/embankment.

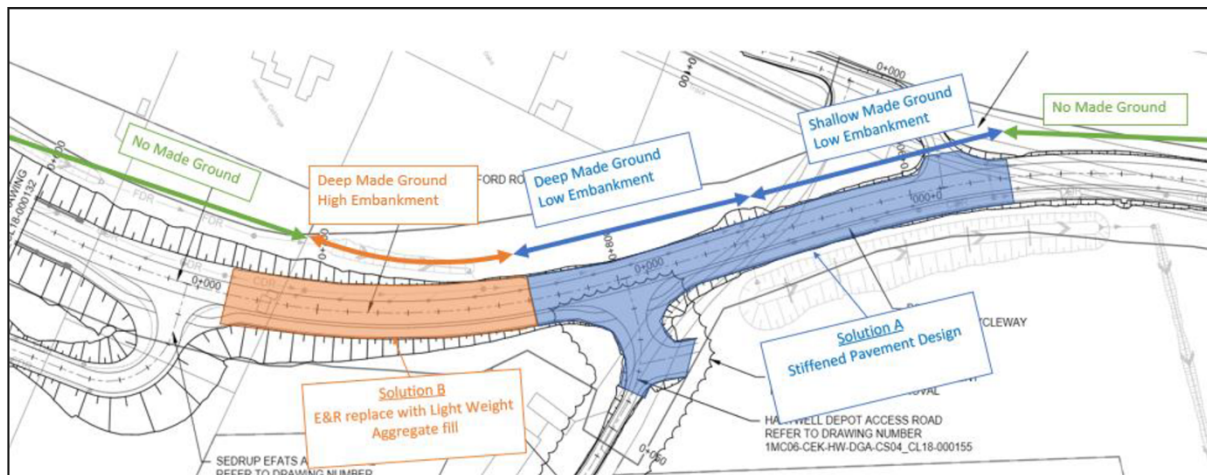


Figure 5-1 Summary A418 Oxford Road Design

The current design proposed is a partial excavation of Made Ground within the confines of the A418, and replacement with a lightweight aggregate (LWA) substitute within the core of the road beneath a reinforced road surface (see figures 5-4), as such minimising the loading upon the Made Ground beneath the asset, thus managing the risks associated with post construction settlement. Further information regarding the proposed design can be found within Appendix I of the Aylesbury North Cutting GDR (Ref. 5)

As exceedances of the Allotment Human Health screening criteria were identified in samples of the Made Ground/landfill material, the arisings of Made Ground /landfill material excavated from this area will need remediating to make them suitable for re-use within the scheme. The remediation strategy for dealing with this material is presented in the Historical Hartwell Landfill Remediation Outline Strategy (Ref. 19).

6 Conceptual Site Model – Contaminant Linkages

6.1 Introduction

Based on the assessment of soil, leachate, groundwater and surface water chemical test results, the potential risk to the identified receptors has been evaluated in accordance with the Land Contamination Risk Management (LCRM) guidance (Ref. 28) which has superseded the CLR 11 guidance and CIRIA guidance C552 (Ref. 29), to identify the 'contaminant linkages' (contaminant source-pathway-receptor relationships) that may be present at the Site.

6.2 Risk Assessment Methodology

Risk assessment is the process of collating known information on a hazard or set of hazards (to determine the potential severity of any impact) along with details on the likelihood of impact on identified receptors. Risks are generally managed by isolating the sensitive receptor or by intercepting or interrupting the exposure pathway, thus no pollutant linkages are formed and there is no risk. The following risk assessment focuses on the potential contaminants identified on the Site and the proposed development.

CIRIA C552 guidance states that the designation of risk is based upon a consideration of both:

- The likelihood of an event (probability); (takes into account both the presence of the hazard and the receptor and the integrity of the pathway).
- The severity of the potential consequence (takes into account both the potential severity of the hazard and the sensitivity of the receptor).

Under such a classification system the following categorisation of risk has been developed and the terminology adopted as presented in Table 6-1.

Table 6-1 Summary of Risk Classification Categories

Term	Description
Very High Risk	There is a high probability that significant harm could arise to a designated receptor from an identified hazard at the Site without appropriate remedial action.
High Risk	Significant Harm is likely to arise to a designated receptor from an identified hazard at the Site without appropriate remedial action.
Moderate Risk	It is possible that without appropriate remedial action, harm could arise to a designated receptor, but it is relatively unlikely that any such harm would be severe and if any harm were to occur, it is likely that such harm would be relatively mild.
Low Risk	It is possible that significant harm could arise to a designated receptor from an identified hazard, but it is likely that at worst this harm if realised would normally be mild.
Very Low Risk	There is a low possibility that harm could arise to a receptor. In the event of such harm being realised, it is not likely to be severe.

6.3 Contaminant Sources

Based on the results from the contamination assessment of the Site, the following revised contaminative sources have been identified to be contaminants of concern:

Table 6-2 Contaminative sources with contaminants of concern

Contamination Source	Contaminants	Site Area
Made Ground/ landfill material from Historic Brickworks area / Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03)	Exceedances of allotment criteria for Metals, PAH and TPH within Made Ground	Historic Brickworks area, Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03)
	Leachate – exceedances of WQS for metals	
	Exceedances of WQS for metals, inorganics, TPH and PAH within perched groundwater within Made Ground	
Contaminated Groundwater perched within the Made Ground/ landfill and in underlying bedrock (POST/KC)	Exceedances of WQS for metals, inorganics, TPH and PAH within perched groundwater within Made Ground and POST/KC Formations.	Historic Brickworks area, Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03), Hartwell Landfill (LQ 11-04) Central area of the Site (outside of LQ Areas/ Greenfield)
Ground Gas	CS2 (low risk) relating to CO2 and CH4 and depleted oxygen.	Historic Brickworks Area, Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03) Hartwell Landfill (LQ 11-04) Central area of the Site (outside of LQ Areas/ Greenfield)
Geology	Aggressive ground conditions (sulphates and low pH) within Made Ground, soil, and bedrock	Site-wide

It should be noted that the GI has not identified Made Ground or any contaminants of concern within the soil from the historical Hartwell Landfill (LQ 11-04). Desk based information, the Site walkover survey and local authority records indicate that it may have been mapped as a landfill erroneously and has remained as undeveloped land. Therefore, it has not been included further within the Geoenvironmental assessment.

The historical WWII army training camp is off-Site, adjacent to the LOD/LLAU associated with the western edge of the A418 Oxford Road Realignment, and over 350m away from the cutting. The works planned for the western edge of the A481 realignment comprises shallow topsoil/ surface material strip only, therefore it is unlikely that potentially contaminated groundwater and/ or ground gas would be encountered. Therefore, this potential source has not been considered further in the risk assessment.

Construction of Aylesbury North Cutting and its associated assets will involve importing natural soils from other areas of C2 which are of a different geology to the Hartwell Area. The risk assessment for the re-use of natural soils (Ref. 32) has indicated that there is a low risk associated with the proposed

placement of natural materials on Site, and any imported materials will have undergone testing (geotechnical and chemical) to confirm their suitability within the construction works.

6.4 Potential Receptors

The potential receptors identified across the Site include:

Human Health

- Future Site users (employees (within the LOD), farmers and visitors within areas of the LLAU proposed to return to agricultural usage).
- Off-Site Site users (residents, employees, visitors of adjacent housing, farms, and other commercial activities (golf course and football pitches)).

The potential short term risk to human health (construction/maintenance workers and general public during construction) are mitigated specifically through the requirements of the Control of Substances Hazardous to Health Regulations (COSHH) and application of the CDM Regulations and their associated risk assessments and safe systems of work, method statements and adoption of suitable measures such as personal protective equipment (PPE), good hygiene practice and dust control; therefore these receptors are not considered further.

Controlled waters

- Superficial aquifers:
 - Secondary A aquifer in ALV and RTD Deposits.
 - Secondary Undifferentiated aquifer in Head Deposits.
- Bedrock aquifers:
 - Principal aquifer in POST Formation
 - Secondary A aquifer in POSA Formation
- Surface waters:
 - Sedrup Ditch, Stoke Brook, drains, ponds.

Property

- On-Site - Proposed HS2 rail system development and associated structures (see Table 1-2).
- Proposed below ground services including Thames Water main diversion and services connections/conduits.

6.5 Pathway Characterisation

The potential exposure pathways include the following:

- Human health
 - Dermal contact or ingestion of contaminated dust, soil and water, or inhalation of dust (within the LLAU in areas proposed to be returned to agricultural usage).
 - Ingestion of contaminated vegetables and soil attached to vegetables (within LLAU in areas proposed to be returned to agricultural usage)
 - Migration of ground gas via preferential pathways and accumulation on confined and poorly ventilated spaces. Exposure to low oxygen conditions.
- Controlled waters
 - Mobilisation of contaminants within perched groundwater and/ or leachable contamination during excavation/ construction works and leaching or lateral and vertical migration of contaminants to groundwater (Principal, Secondary A) and surface waters.
 - Lateral migration of contaminated groundwater into surface waters.

- Direct runoff of contaminants mobilised or distributed by the works into surface waters.
- Movement through or migration of contaminated groundwater along engineered structures (services, piles, excavations).
- Drawdown of contaminated groundwater into excavations (i.e., Aylesbury North Cutting) during dewatering.
- Property
 - Direct contact of below ground structures and services with contaminated soil or groundwater (including sulphate attack).
 - Accumulation of explosive gases in poorly ventilated/ confined spaces (such as unsealed services connections/conduits).

6.6 Contaminant Linkages

Based on the contaminant sources and the potential receptors and pathways identified in previous sections, Table 6-2 provides an assessment of the identified Contaminant Linkages (CL) to establish the potential risk to the sensitive receptors.

Table 6-3 Summary of Contaminant Linkages associated with the proposed assets

Contaminant Source	CL	Sensitive Receptor	Pathway	Hazard (Severity)	Likelihood	Pre-Mitigation Risk	Further Assessment and/or Remedial Action	Post Mitigation Risk	Asset Interaction
Made Ground/ landfill material from Historic Brickworks area / Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03)	CL1	Human Health (Site Users)	Inhalation/ ingestion / dermal contact with contaminants / contaminated vegetables.	Chronic Damage (Medium)	Likely. Soil exceedances of Allotment criteria within Made Ground/landfill material for metals, PAH and TPH. Leachable elevated concentrations of metals above WQS have also been identified in Made Ground soils. Some of this material is proposed to be excavated from the A418 Oxford Road and re-used within the works within the LLAU. Further contamination is likely to be present within Made Ground which may be disturbed/ mobilised during the works.	Moderate	Watching brief will be required to ensure that the risk from any encountered contamination is mitigated. Excavated landfill/ Made Ground from the A418 Oxford Road will be remediated, tested, and appropriately placed / re-used within the works in accordance with the Remediation Outline Strategy (Ref. 19), which is protective of Human Health and Controlled Waters and also in accordance with the EKFB Construction Environmental Management Plan (CEMP) (Ref. 34). Adopt appropriate mitigation during construction works to prevent contact between Made Ground and controlled waters, control groundwater levels and prevent uncontrolled releases to ground and via overland flow.	Low	A418 Oxford Road Realignment. (HS2-00002BJSX) Hartwell Depot Access Road (HS2-00002CT5G)
	CL2	Controlled Waters (underlying Aquifers, Sedrup Ditch & Stoke Brook)	Lateral and vertical migration of contaminants to groundwater and surface waters via leaching, surface runoff and movement along preferential pathways (piled foundations)	Reduction in Water Quality (Medium)	Likely. Exceedances of WQS for metals in leachate samples and metals, inorganic, TPH and PAH within perched groundwater within Made Ground. Potential impact to Controlled Waters from re-use of excavated Made Ground/ landfill materials within the works and potential for mobilising/ disturbing material during excavation.	Moderate / low	1.2m of clean cover (restored topsoil) is proposed within areas to be returned to agricultural usage which will sever the pathway for human exposure. Soils at greater than 1.2m depth will meet the S4UL Allotment Screening Criteria to be protective of human health and the Zone 2a/2C screening criteria to be protection of Controlled Waters. Use of appropriate PPE, dust suppression measures including damping down excavations and arisings and general good hygiene/ working practices when working on Site. Topsoil to be stripped and re-used in line with Soil Resource Plans.	Low	
	CL3	Property (Thames Water Main Diversion)	Direct contact with contaminants (hydrocarbons) in Made Ground/ landfill and perched groundwater.	Damage to drainage pipes/ systems (Mild)	Likely. Gross organic contamination has not been recorded within the vicinity of the proposed utility; however there maybe potential impact to the proposed Thames Water Main in direct contact with hydrocarbon contaminated perched groundwater within the Made Ground/landfill material.	Moderate/ low	Appropriate barrier piping should be adopted for water supply piping, in accordance with UK WIR Guidance (Ref. 30). Replacement of Made Ground with clean fill within services trenches.	Low	Thames Water Main Diversion

Contaminant Source	CL	Sensitive Receptor	Pathway	Hazard (Severity)	Likelihood	Pre-Mitigation Risk	Further Assessment and/or Remedial Action	Post Mitigation Risk	Asset Interaction
Contaminated Groundwater perched within the Made Ground/landfill and in underlying bedrock (POST)	CL4	Controlled Waters (underlying Aquifers, Sedrup Ditch & Stoke Brook)	Vertical/ horizontal migration of groundwater, drawdown of contaminated groundwater into excavations during dewatering and uncontrolled release/ discharge of collected groundwater	Reduction in Water Quality (Medium)	Likely. Exceedances metals, inorganics, TPH and PAH within perched groundwater within the Made Ground and the POST/KC Formations (Principal Aquifer). Contaminated groundwater is likely to be encountered during excavation/dewatering for Aylesbury North Cutting and the A418 Oxford Road Realignment.	Moderate	Groundwater collected from dewatering the cutting excavation will be collected and tested prior to discharge. Where this exceeds the relevant screening values it may require treatment prior to discharge or off-Site disposal, in accordance with the appropriate Schedule 33 Environmental Consent. Uncontrolled discharges of groundwater will not be permitted. Piling Risk Assessments should be undertaken for any piles proposed for the A418 Overbridge.	Low	Aylesbury North Cutting (HS2-000001028) A418 Oxford Road Realignment (HS2-00002BJSX) and Overbridge (HS2-000001296)
	CL5	Property (Thames Water Main Diversion)	Direct contact with contaminated perched groundwater	Damage to drinking water pipes and services (Mild)	Likely. Gross organic contamination has not been recorded within the vicinity of the proposed utility; however there maybe potential impact to the proposed Thames Water Main in direct contact with hydrocarbon contaminated perched groundwater within the Made Ground/landfill material.	Moderate/low	Below ground drinking water pipes to be designed in accordance with the UK WIR Guidance (Ref. 30). Replacement of Made Ground with clean fill within services trenches.	Low	Thames Water Main Diversion
Ground Gases (CO ₂ , CH ₄)	CL6	Human Health (Site Users)	Migration via permeable strata and accumulation in confined and poorly ventilated /confined spaces.	Asphyxiation/ Explosion (Severe)	Low. The presence of elevated concentrations of CO ₂ / CH ₄ and depleted levels of O ₂ detected in the ground gas presents a potential risk to construction workers entering unsealed manholes, drains or deep excavations. No other confined spaces such as buildings are proposed.	Moderate / low	Standard health and safety practices with respect to monitoring and verifying the absence of ground gas, vapour and depleted oxygen, prior to man entry and during the excavation works should be adopted in accordance with the recommendations of HSE guidance for working safely in confined spaces (Ref. 31).	Low	A418 Oxford Road Realignment (HS2-00002BJSX) & Aylesbury North Cutting (HS2-000001028) (excavations)
	CL7	Property Deep excavations & services trenches	Migration via permeable strata and accumulation in confined and poorly ventilated /confined spaces	Explosion (Severe)	Low: No structures (such as buildings) are proposed in which ground gas could accumulate. The proposed Sedrup EFATS is either an open-air structure or housed within a sealed metal cabinet on a concrete plinth/footing, therefore the potential risk relates to unsealed services connections/ conduits only.	Moderate	All connections and joints within drains, manholes and service trenches to be fully sealed to prevent pathway for gas migration.	Low	Unsealed services conduits / connections
Aggressive Ground Conditions within Made Ground, soil and bedrock	CL8	Property (below ground concrete)	Direct Contact with Aggressive Ground Conditions	Damage to concrete foundations (Medium)	Likely: Sulphate testing has indicated that aggressive ground conditions can be present within the natural strata. The Made Ground/ landfill material is also a potential source of sulphates. Potential impact to below ground concrete foundations in direct contact.	Moderate/low	Design of below ground concrete will be undertaken in accordance with BRE SD1 requirements (Ref. 27).	Low	All Assets

7 Conclusion and Recommendations

7.1 Conclusions

Proposals for this section of the route (LOD and LLAU) include the main route assets (Aylesbury North Cutting) and non-route assets including the A418 Oxford Road Realignment shown in Table 1-2.

Potential constraints identified are predominantly associated with the Historic Brickworks Area/ Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03) in the north-eastern side of the Site which partially intersect the LOD associated with the re-alignment of the A418 Oxford Road. The Historic Hartwell Landfill (LQ 11-04) is partially within the LOD of the proposed Aylesbury North Cutting in the western area of the Site.

84 Boreholes have been completed across the Site, 15 situated within the Historic Brickworks Area/ Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03), and 11 within the Historic Hartwell Landfill (LQ 11-04). Testing was carried out on soil, leachate, and groundwater, and up to 11 rounds of gas and groundwater monitoring was undertaken.

Ground conditions encountered during the investigation mainly comprised topsoil underlain by superficial deposits of Alluvium, Head, or River Terrace Deposits, underlain by the Portland Stone Formation, Portland Sand Formation, Purbeck Formation, Kimmeridge Clay Formation and Ampthill Clay Formation.

Made Ground was encountered in 15 locations within the Historic Brickworks area /Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03) up to 7.75m in thickness. The Made Ground comprised frequent anthropogenic material (such as metal, plastic, fabric, glass, ash, coal etc.) indicative of landfill material.

2 instances of Made Ground were encountered within the mapped area of the Historic Hartwell Landfill (LQ 11-04) to the eastern side closest to the route trace, however these are likely to be reworked natural materials with limited anthropogenic inclusions (brick and concrete fragments). Desk study-based information; the Site walkover survey and Local Authority records, indicate that it is likely to have been mapped as a landfill erroneously and has remained as undeveloped land. However, the potential further presence of Made Ground and contamination cannot be discounted completely.

A total of 49 geoenvironmental soil samples, 26 of these being from within the Made Ground samples were tested as part of the Ground Investigation. There were no exceedances of Human Health Screening Criteria against the POS (park) end-use or Commercial/Industrial end use, indicating the materials are not considered to pose a significant risk to human health following the construction of the proposed assets or landscape embankments/bunds within the LOD.

Exceedances of the Allotment Criteria were identified for metals, PAHs and EPH/TPH within the Made Ground from the LLAU in the Historic Brickworks Area / Former Hartwell Clay, Old Brick and Tile Works and Landfill. The majority of this area is within the LLAU where minimal excavation is anticipated (i.e., used for stockpiles, compounds etc only), however some of this material is proposed to be excavated for the proposed A418 Oxford Road Realignment/embankment. The foundation solution is a partial excavation of Made Ground within the confines of the A418, and replacement with a lightweight aggregate substitute beneath a reinforced road surface, as such minimising the loading upon the Made Ground beneath the asset. Material excavated from the A418 Oxford Road Realignment is proposed to be re-used within the scheme, however it will be likely to require remediation to make it suitable for re-use, followed by testing and placement within an appropriate area within the works.

The Historic Brickworks Area / Former Hartwell Clay, Old Brick and Tile Works and Landfill was identified as a source of leachable contamination to groundwater. Exceedances of WQS were identified in perched groundwater (metals, inorganics, TPH and PAH) within the Made Ground/ landfill material. Exceedances of

WQS were identified in other areas of the Site within the underlying POST/KC Formation, likely to be sourced from the Made Ground/ landfill material and/ or agricultural activities.

Groundwater is likely to be encountered during the excavation works relating to the proposed Aylesbury North Cutting within the POST/POSA Formations. Perched groundwater within the Made Ground is also likely to be encountered in the Historic Brickworks area / Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03) area during excavation works proposed for the A418 Oxford Road Realignment. Hence, temporary groundwater control measures such as dewatering are likely to be required during excavation works.

The ground gas risk assessment indicates that a CS2 (low risk) is present. A potential risk to construction workers was identified from low oxygen and CO₂ within deep excavations and unsealed services connections/ conduits.

On the basis of the available testing and contamination risks assessments completed to date, the pre-mitigation risks to human health are considered to be Moderate to Moderate/low with regard to ground gas and exposure to contaminants in areas proposed to be returned to agricultural usage. The risks to Controlled Waters are considered to be Moderate to Moderate/Low with regard to mobilising contamination during the works and encountering contaminated groundwater. The risk to property is considered Moderate/ Moderate/low with regard to direct contact with contaminated soil/water and accumulation of ground gases.

7.2 Recommendations

The following recommendations are made with regard to the proposed development:

- Verification assurance will be in place during the construction phase and details of ground conditions encountered during the construction works will be defined within Verification Reporting. Should unforeseen conditions be encountered during construction, this should be managed in accordance with procedures for unforeseen conditions (Ref. 35) and, if necessary, amended remediation requirements should be designed for agreement with regulators.
- The current foundation solution for the A418 Oxford Road is a partial excavation of Made Ground within the confines of the A418, and replacement with a lightweight aggregate substitute beneath a reinforced road surface, as such minimising the loading upon the Made Ground beneath the asset. In the first case, the volume anticipated to be excavated is estimated to be between 28,000 m³ and 35,000 m³ (based on full excavation of the material down to bedrock). The excavated arisings of Made Ground /landfill material will need remediating to make them suitable for re-use within the scheme (pending agreement of this approach with the Environment Agency). Further details are provided in the Remediation Outline Strategy (Ref. 19).
- Groundwater monitoring data has indicated contaminants within perched groundwater within the Made Ground and in groundwater within the POST Formation, likely to have originated from the Historic Brickworks and Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11-03). Dewatering proposed to be undertaken for Aylesbury North Cutting and for the Oxford Road Realignment/embankment is likely to cause drawdown of potentially impacted groundwater into the excavations, where it will need to be collected and tested prior to discharge. Where this exceeds relevant screening values it may require treatment prior to discharge or off-Site disposal, in accordance with the Schedule 33 Environmental Consent.
- Appropriate construction management practices outlined in the EKFB Construction Environmental Management Plan (Ref. 34) should be adopted during construction works to intercept run off, prevent cross contamination of controlled waters, minimise potential favourable conditions that can cause leaching of contamination and to include dust suppression measures to damp down excavations and arisings.

- Suitable PPE and health and safety procedures should be used on Site during the proposed development works to adequately mitigate the potential risk of contamination to construction workers. The presence of contamination should be relayed to construction workers so that appropriate procedures can be enforced during Site works.
- A watching brief procedure will be put in place during construction, to ensure that if any unforeseen contamination including asbestos is encountered it is dealt with appropriately. This may involve additional chemical analysis and assessment to ensure that the appropriate action is undertaken, and verification of absence upon completion in working areas.
- Standard health and safety practices with respect to monitoring and verifying the absence of ground gas, depleted oxygen and vapour during the excavation works should be adopted in accordance with the recommendations HSE guidance. Excavations and confined spaces should be monitored for gas and depleted oxygen prior to man entry. All connections and joints within services connections/ conduits should be fully sealed to prevent a pathway for gas migration.
- Excavated arisings should be segregated during excavation to maximise volumes for re-use. Natural soil is likely to be suitable for re-use within the scheme without chemical testing. Full details including the material management, placement and re-use measures for natural soil are set out in the Routewide Risk Assessment for re-use of natural soils (Ref. 32).
- Made Ground will be tested to verify that it complies with the appropriate Made Ground Material Re-Use Criteria (Appendix I) to be protective of Controlled Waters (Zone 2a/2c) and the appropriate Human Health screening criteria for the proposed land use, as outlined in the Remediation Outline Strategy (Ref. 19).
- Below ground concrete will be designed in accordance with the specifications of BRE Special Digest 1 (Ref. 27).
- A utilities appraisal must be undertaken for all below ground water supply pipes. Any proposed water supply pipes (such as the proposed Thames Water Main Diversion) within areas of Made Ground/ landfill material or within existing roads should be designed with appropriate barrier piping, as per the UK WIR Guidance (Ref. 30). Made Ground/landfill material within proposed services trenches should be excavated and replaced with engineering fill.

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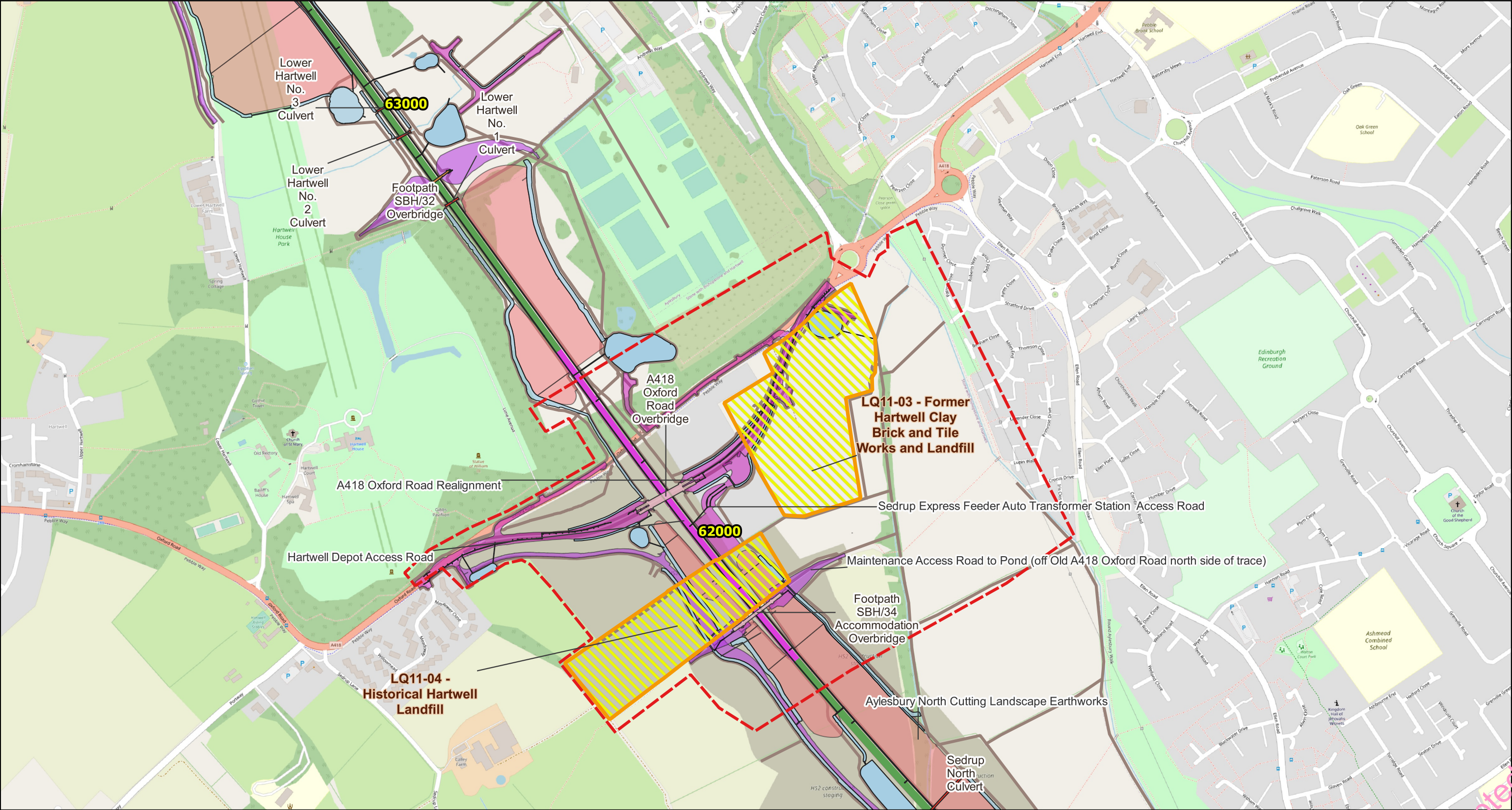
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33. Aylesbury North Cutting Earthworks Specification, ASC, (to be issued).
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Appendix A

Proposed Development Plans

Number of Pages: 01

HS2 Ltd - Code 1 - Accepted

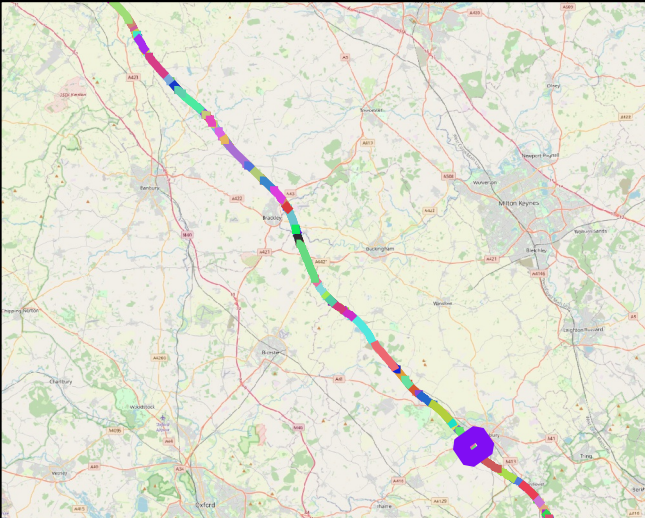


1MC06-CEK-EV-REP-CS04_CL18-000001

Revision : C04

Historical Hartwell Landfill
Geo-environmental Assessment Report

Figure A - Proposed Development Plan



Legend

- Site Boundary
- Land Quality (LQ) Areas
- Extent of Hartwell Landfill
- HS2 Route Chainage (m)

Engineering Design :

- Cutting
- Embankment
- Mitigation Earthwork
- Overbridges
- Culverts, Open Drain and Piped Drain
- Road Realignment

0 0.1 0.2 0.3 km

Scale at A3: 1:7,000

Appendix B

Site Walkover Photos

Number of Pages: 04

HS2 Ltd - Code 1 - Accepted

Photograph	Description
	Plate 1 – Scaffolding Yard, Warehouse and smaller associated buildings in the centre of the Former Hartwell Clay, Old Brick and Tile Works (LQ 11.03) covered with hard standing.
	Plate 2 – Overflowing skips and scattered waste materials within the Scaffolding Yard within LQ 11.03.

Photograph	Description
	Plate 3 – Gas canisters located within the Scaffolding Yard within LQ 11.03.
	Plate 4 – Concrete access road to the Scaffolding Yard within LQ 11.03. Raised area of landfill noted either side of the road.

Photograph	Description
	Plate 5 – Former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11.03) comprising rough grassland on higher land than the Scaffolding Yard.
	Plate 6 – Exposed area of Made Ground/ landfill within the Historic Brickworks Area/ former Hartwell Clay, Old Brick and Tile Works and Landfill (LQ 11.03)

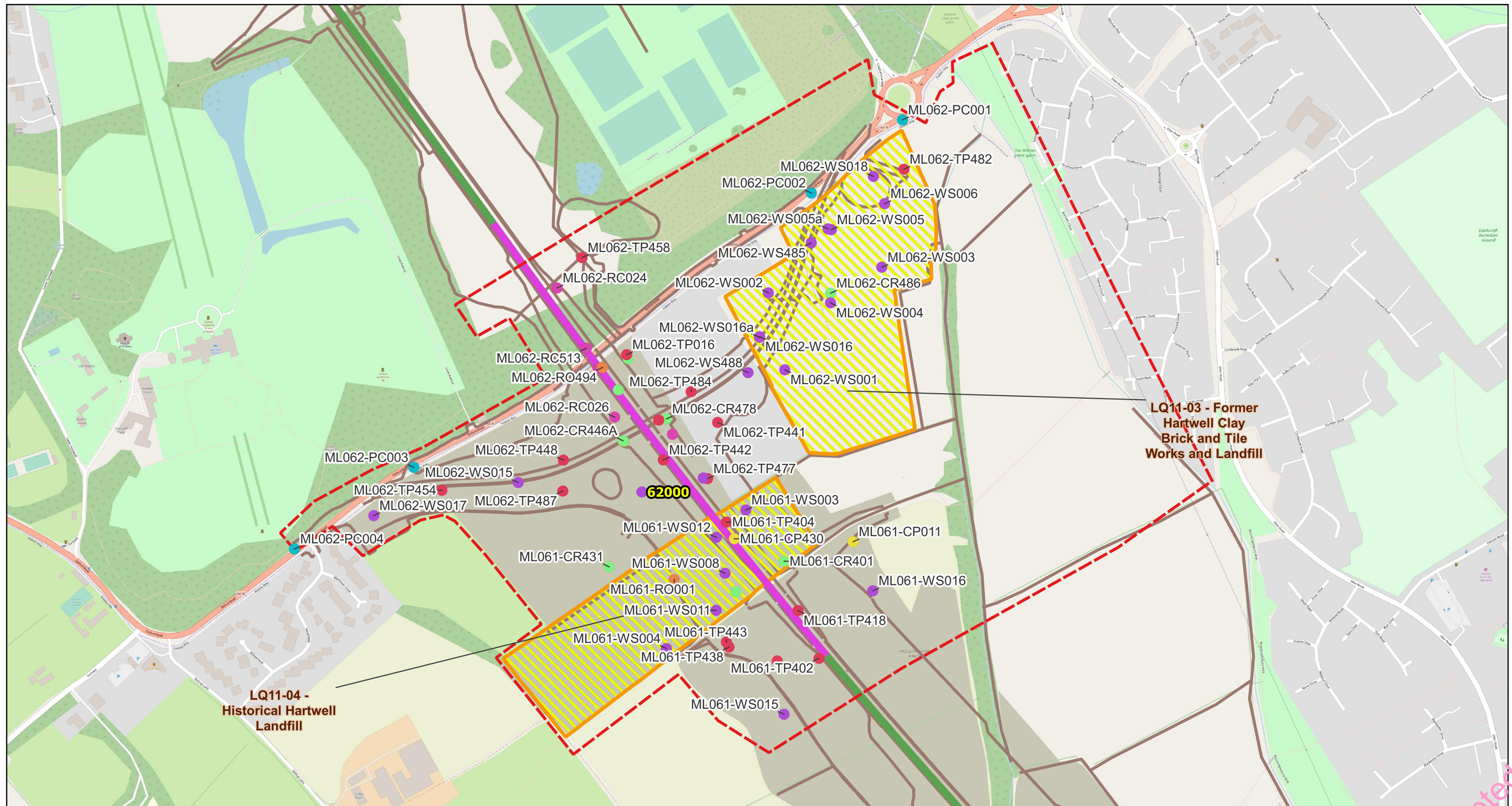
Photograph	Description
	Plate 7 – Hartwell Landfill (LQ 11.04) with the derelict residential dwelling (Glebe House) in the background.
	Plate 8 – Historical Hartwell Landfill (LQ 11.04) comprising grassland /agricultural fields.

Appendix C

Exploratory Hole Location Plan

Number of Pages:01

HS2 Ltd - Code 1 - Accepted

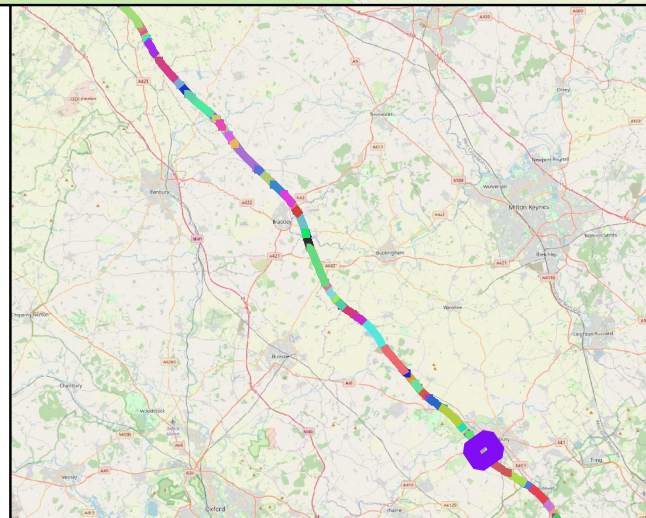


1MC06-CEK-EV-REP-CS04_CL18-000001

Revision : C04

Historical Hartwell Landfill Geo-environmental Assessment Report

Figure C- Exploratory Hole Location Plan



Legend

-  **Site Boundary**
 **Land Quality (LQ) Areas**
 **Extent of Hartwell Landfill**
 **HS2 Route Chainage (m)**

Engineering Design :

- Cutting
- Embankment

Ground Investigation Holes

- Cable percussion borehole
- Cable percussion borehole with rotary cored follow on
- Pavement Core
- Rotary core borehole
- Rotary open borehole
- Trial pit (mechanically dug)
- Windowless sampling

0 0.05 0.1 0.15 km

Scale at A3: 1:5,000

Appendix D

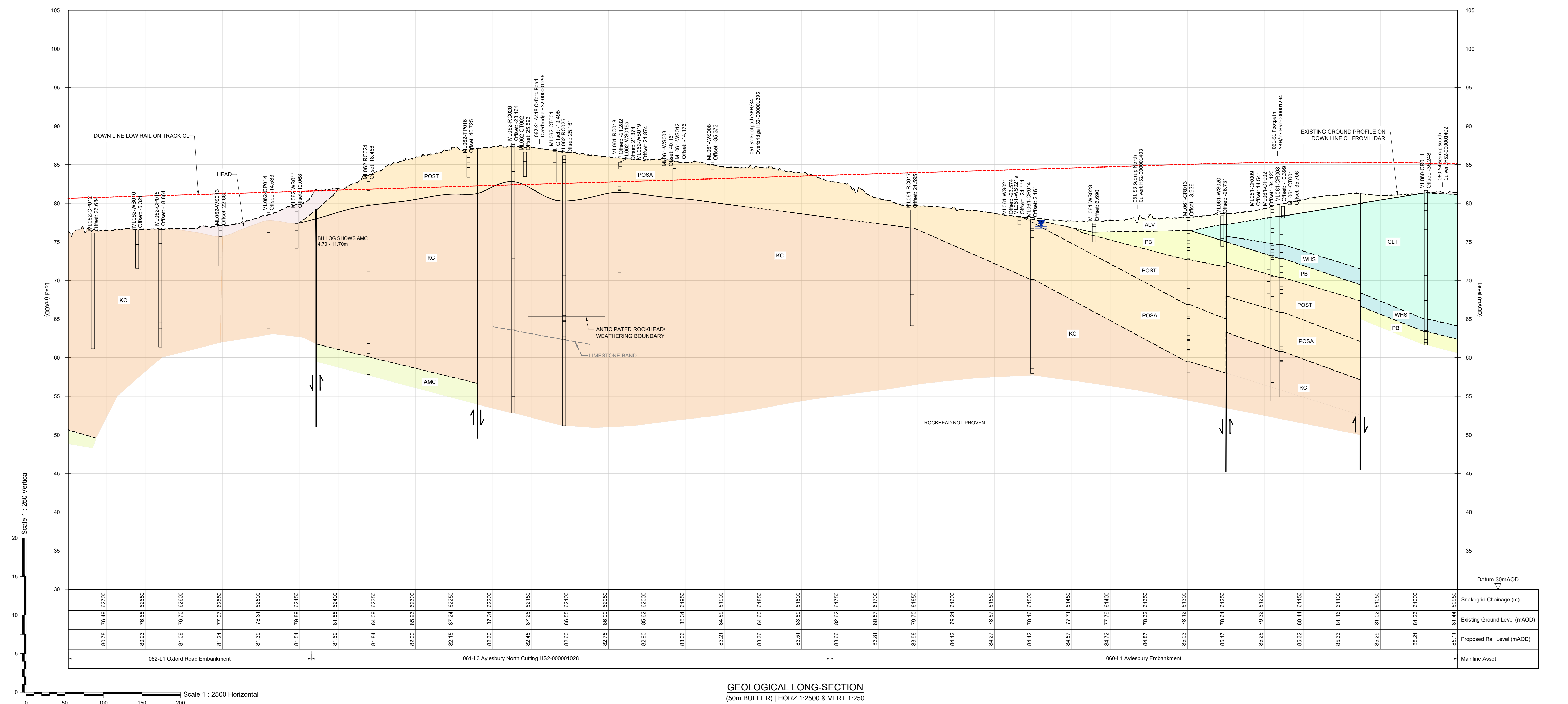
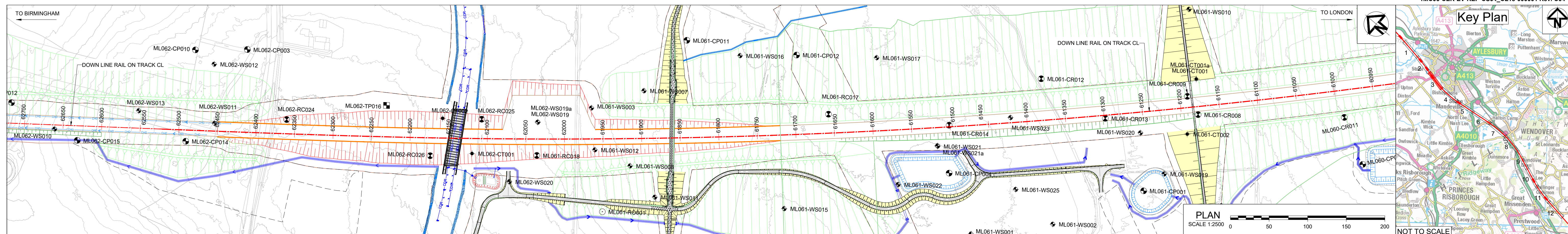
Geological Cross Sections

D1: Extract for Aylesbury North Cutting

D2: Extract for A418 Oxford Road Realignment

Number of Pages:02

HS2 Ltd - Code 1 - Accepted

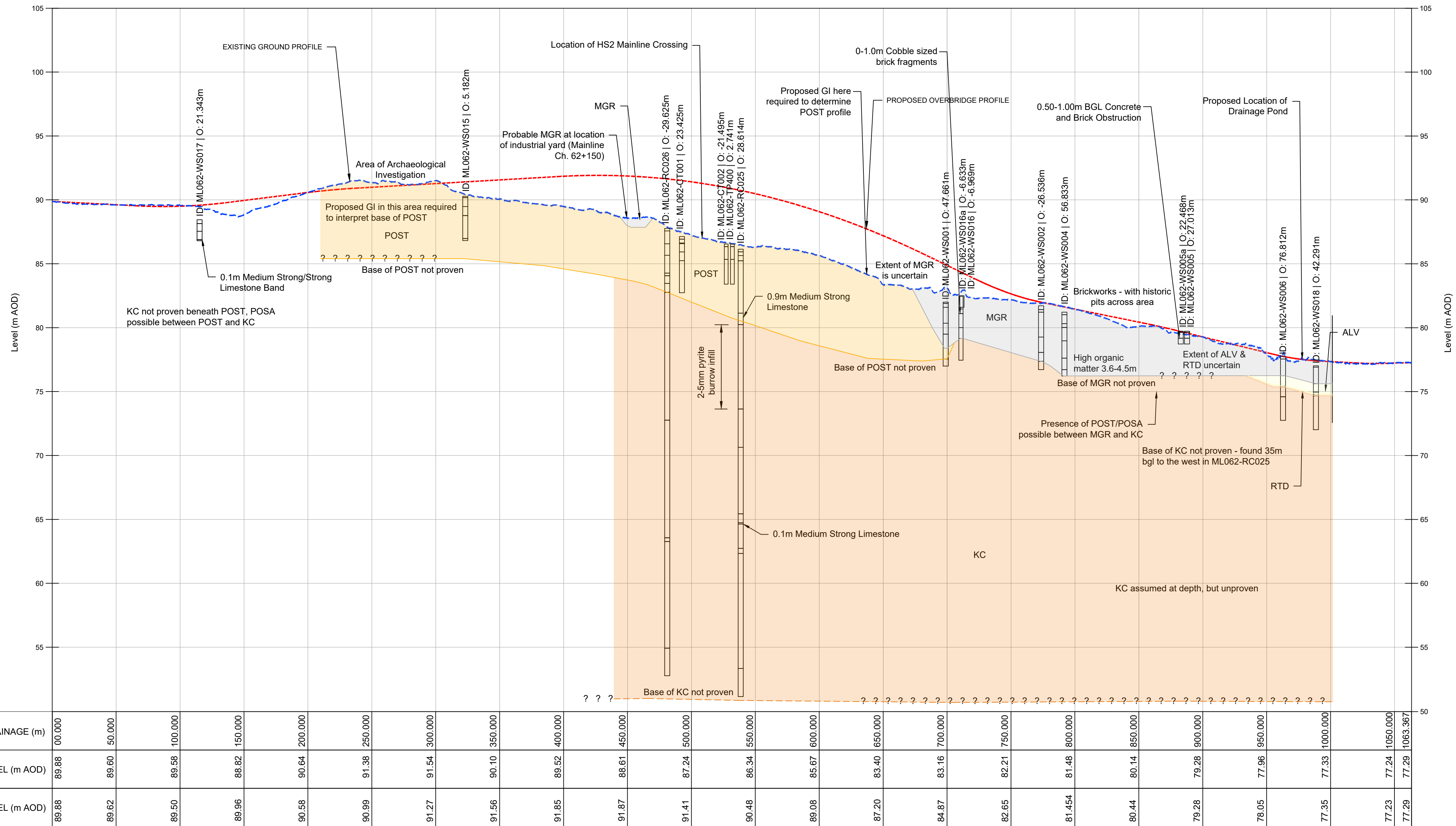
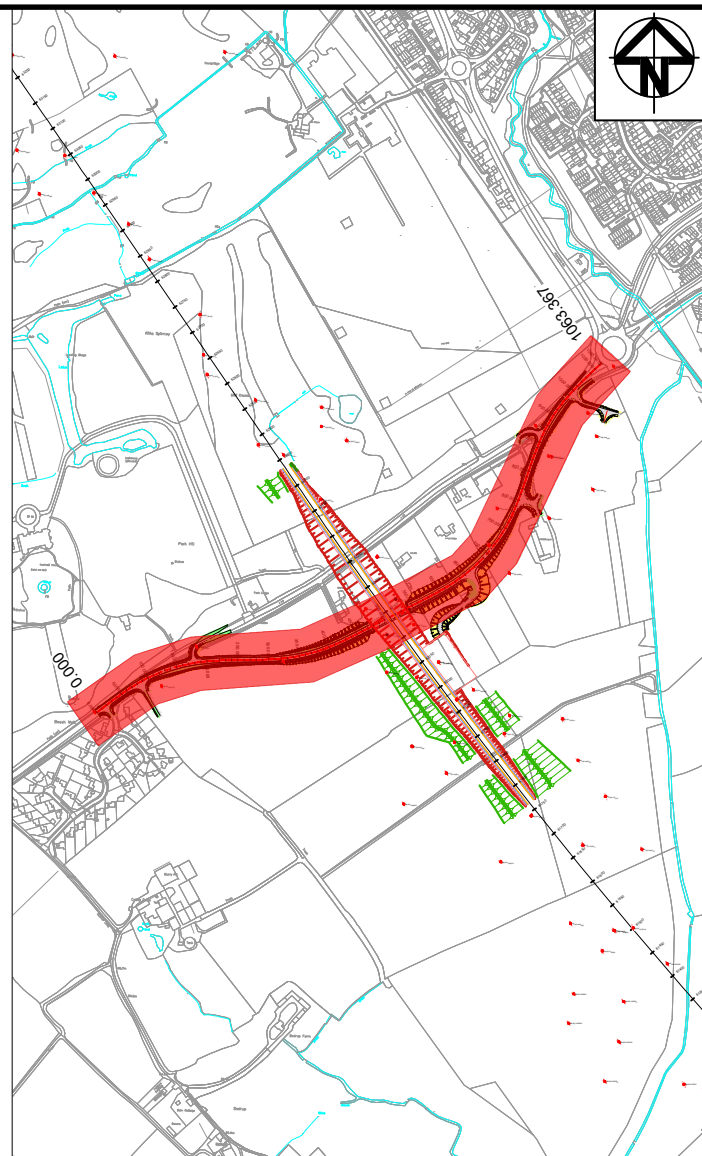
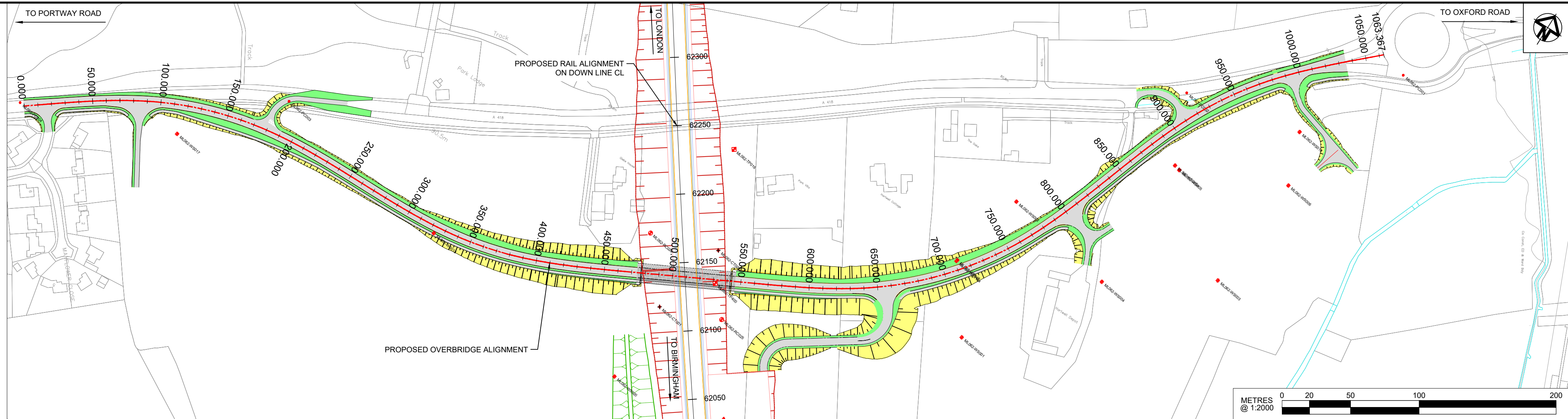


GEOLOGICAL LONG-SECTION
(50m BUFFER) | HORZ 1:2500 & VERT 1:250

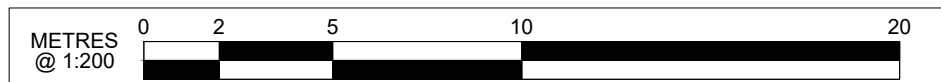
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GROUND INVESTIGATION LOCATIONS		GENERAL		DRAINAGE		GEOLOGICAL LONG SECTION							
						STRATIGRAPHY					OTHER SYMBOLS		
        	Cable Percussion Borehole		BRIDLE WAY (LWD)		Concrete Ditch CD							    	
	Rotary Cored Borehole		Limit Of Deviation(LOD)		Earth Ditch ED								
	Rotary Open Hole Borehole		Limit of Land to be Acquired or Used(LLAU)		Drainage Channel CH		ALV	Alluvium		PB	Purbeck Group		
	Trial Pit		Cutting		Cunette CUN		HEAD	Head		POSA	Portland Sand Formation		
	Observation Pit		Embankment		Filter Drain FDR						POST		Portland Stone Formation
	Cone Penetration Test		Landscape Bund		Central Drainage Channel								
	Window Sample		Chainsages on Down Line to Snake Grid		Under Track Crossing UT		AMC	Amphill Clay Formation					
	Surface Water Sample				Solid / Sealed Drain CDR		WHS	Whitchurch Sand Formation					
	Pavement Core		Noise Barrier		Drainage Pond		GLT	Gault Formation					

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Zone		
Route Wide C2		
Figure title		
Geological Long section		
Sheet 3 of 12		
CH 61000m to 62700m		
Date	Scale	Size
09/10/2019	As Shown	A1



GEOLOGICAL CROSS SECTION LEGENDS			
STRATIGRAPHY		OTHER SYMBOLS	
MGR	MADE GROUND	---	EXISTING GROUND PROFILE
POST	PORTLAND STONE	---	PROPOSED OVERBRIDGE PROFILE
ALV	ALLUVIUM	---	PROPOSED OVERBRIDGE ALIGNMENT
RTD	RIVER TERRACE DEPOSIT	---	POSSIBLE FAULT
KC	KIMMERIDGE CLAY	---	WATER STRIKE
		---	WATER LEVEL (20 MINUTE WAIT)



GEOLOGICAL CROSS SECTION
HORZ 1:500 & VERT 1:200

GROUND INVESTIGATION LOCATIONS	GENERAL	DRAINAGE
CABLE PERCUSSION BOREHOLE	BRICK WAY TYPED	FPD DESIGN
ROTARY CORED BOREHOLE	LIMIT OF DEVIATION(LOD)	CONCRETE DITCH CD
ROTARY OPEN HOLE BOREHOLE	LIMIT OF LAND TO BE ACQUIRED OR USED(LAU)	EARTH DITCH ED
TRIAL PIT	CUTTING	DRAINAGE CHANNEL CH
OBSERVATION PIT	EMBANKMENT	CUNETTE CLIN
CONE PENETRATION TEST	LANDSCAPE BUND	FILTER DRAIN FDR
WINDOW SAMPLE	RAIL ALIGNMENT ON DOWN LINE CL	CENTRAL DRAINAGE CHANNEL
PAVEMENT CORE	NOISE BARRIER	UNDER TRACK CROSSING UT
		SOLID / SEALED DRAIN CDR
		DRAINAGE POND

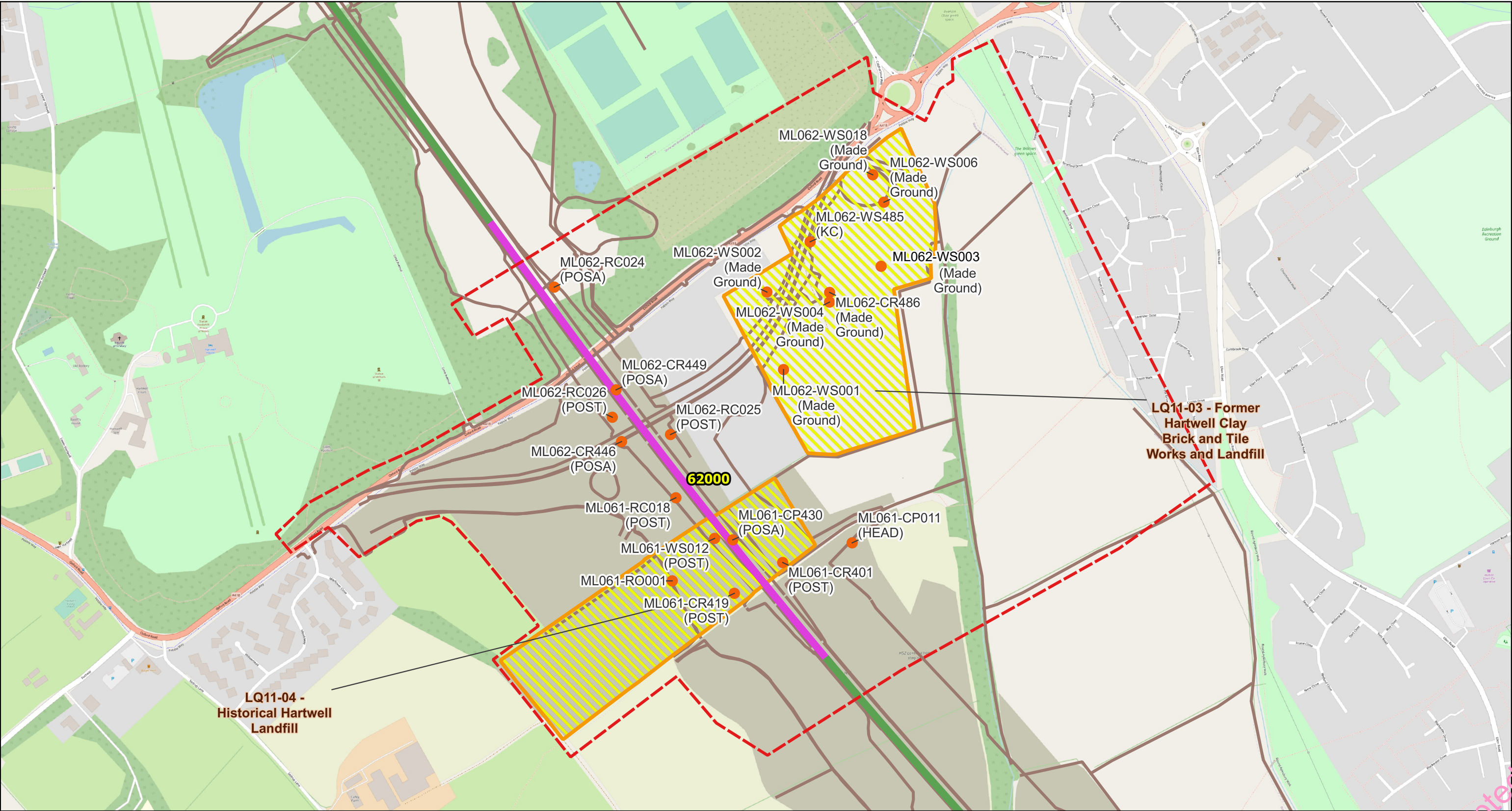
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Design Stage	DETAILED DESIGN			Discipline/Function	Geotechnical		
Drawing Title	Oxford Road Overbridge - Geological Cross Section Drawing Sheet 1			Drawn	Checked	Approved	
Design Status	S0			Date	Scale	Size	Rev.
	Initial non-contractual code			08/06/2020	AS SHOWN	A1	
				Drawing No.			

Appendix E

Groundwater Monitoring Locations

Number of Pages:01

HS2 Ltd - Code 1 - Accepted

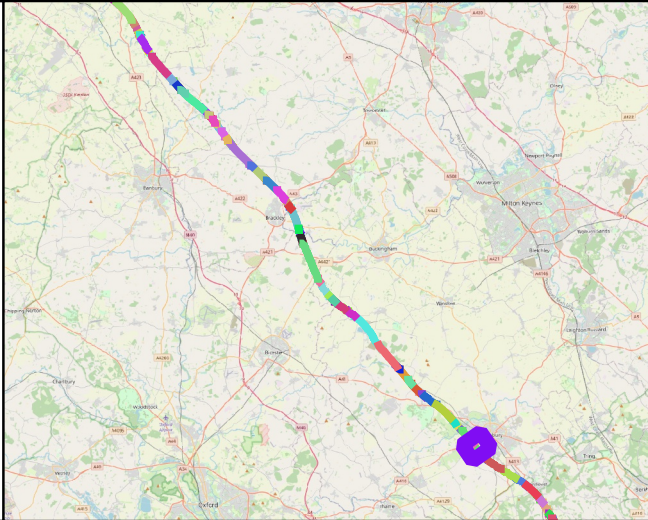


1MC06-CEK-EV-REP-CS04_CL18-000001

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**Historical Hartwell Landfill
Geo-environmental Assessment Report**

**Figure D- Groundwater Monitoring
Location Plan**



Legend

- Site Boundary
- Land Quality (LQ) Areas
- Extent of Hartwell Landfill
- HS2 Route Chainage (m)

Engineering Design :

- Cutting
- Embankment

Groundwater Monitoring Locations

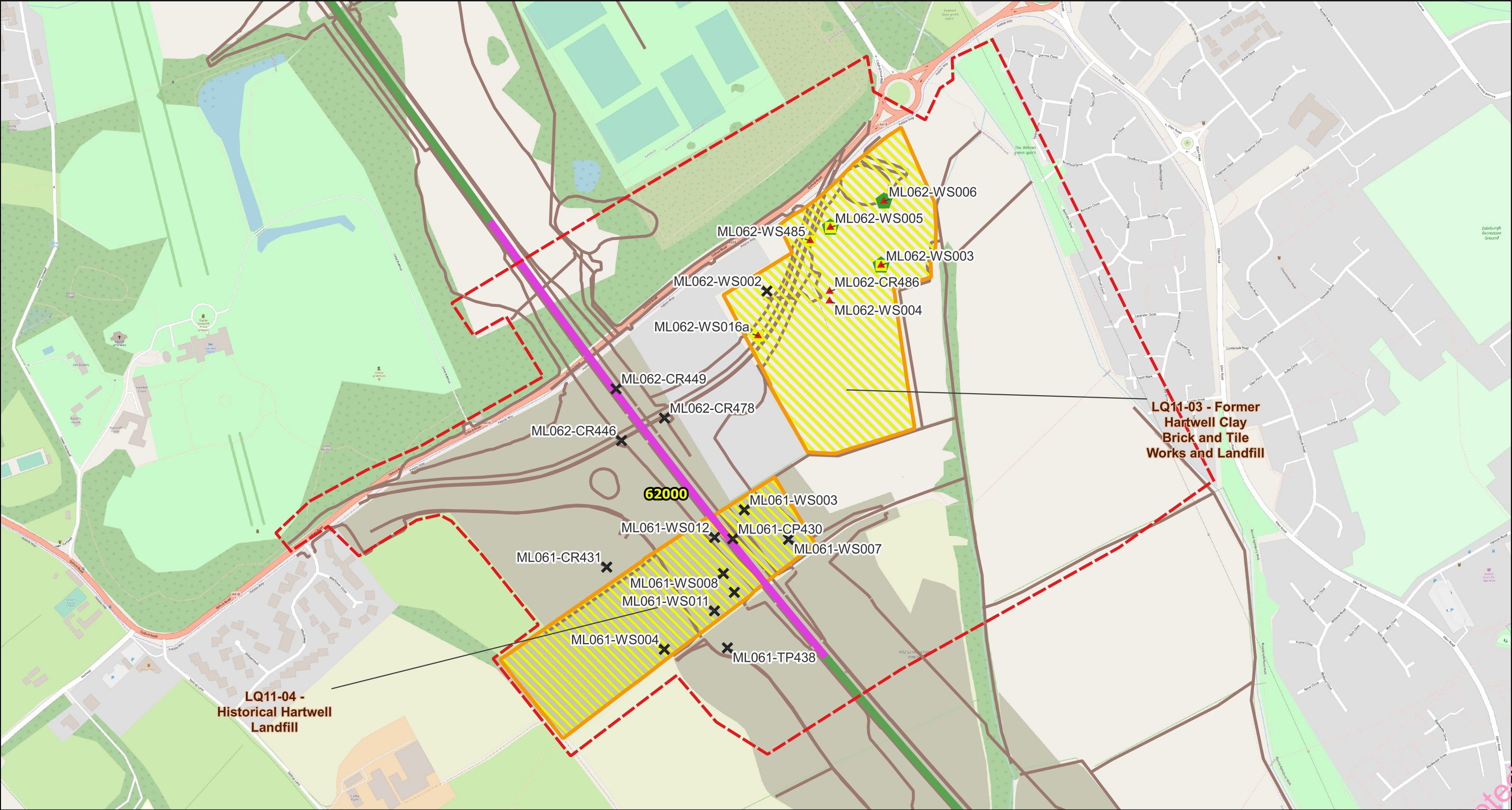
0 0.05 0.1 0.15 km

Scale at A3: 1:5,000

Appendix F

Soil Screening Results

Number of Pages:07

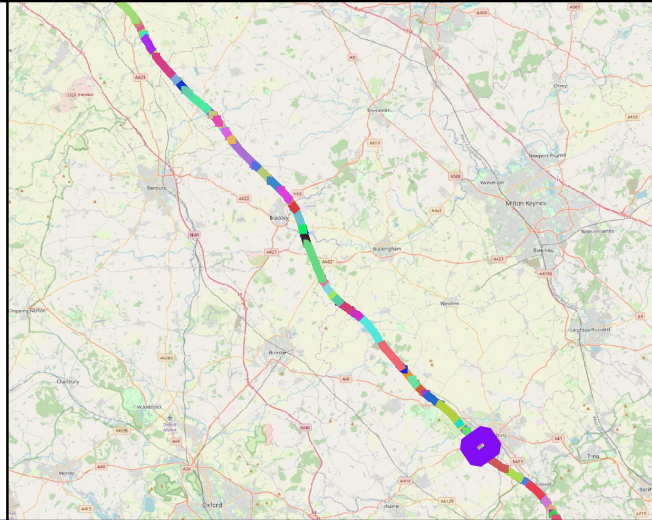


1MC06-CEK-EV-REP-CS04_CL18-000001

Revision : C04

Historical Hartwell Landfill
Geo-environmental Assessment Report

Figure F- Soil Exceedances



Legend

- Site Boundary
- Land Quality (LQ) Areas
- Extent of Hartwell Landfill
- HS2 Route Chainage (m)
- Engineering Design :
 - Cutting
 - Embankment
- Soil Exceedance
 - Metals
 - No exceedances
 - PAHs
 - TPH

Scale at A3: 1:5,000

Date: 17/10/2022

[illegible]

Historical Hartwell Landfill
 Geoenvironmental Assessment Report
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 Rev: C04

[illegible][illegible]

[illegible]

Historical Hartwell Landfill Geoenvironmental
Assessment Report
1MC06-CEK-EV-REP-CS04_CL18-000001
Rev C04

Soil Screening Assessment

				Location_Codes ML02-W0003 ML02-W0003 ML02-W0004 ML02-W0004 ML02-W0005 ML02-W0006 ML02-W010a ML02-W011a ML02-W0405 ML02-W0405 ML02-W0405 ML02-W0405 ML02-W0405 ML02-W0405 ML02-W0405 ML02-W0405																											
				Sampled_Date_Time 23/04/2018 23/04/2018 23/04/2018 23/04/2018 23/04/2018 23/04/2018 23/04/2018 23/04/2018 23/04/2018 23/04/2018 23/04/2018 23/04/2018 23/04/2018 23/04/2018 23/04/2018 23/04/2018																											
				Sample_Depth_Avg 0.3 0.5 0.2 2.25 0.2 1 2 0 1 0.2 1.2 1.7																											
				Geology MGR MGR MGR MGR MGR MGR MGR MGR ALV MGR MGR MGR MGR KC																											
				Area 11.03 11.03 11.03 11.03 11.03 11.03 11.03 11.03 11.03 11.03 11.03 11.03 11.03 11.03 11.03 11.03																											
				LQM SAIL Alerts - LQM SAIL Commercial/Industrial - 1% BOM LQM SAIL Public Open Space (POS) Park - 1%																											
				Statistical Summary																											
Chem_Group	ChemName	output unit	ESL															Number of Results	Number of Defects	Minimum Concentration	Minimum Defects	Maximum Concentration	Maximum Defects	Average Concentration	Median Concentration	Standard Deviation	Number of Guidelines Exceeded	Number of Guidelines			
Metals	Arsenic	mg/kg	0	43	640	170	27.5	93.2	11.6	34.6	34.7	93.2	15	21.8	26.3	14	5	11	49	49	3.39	3.39	93.2	93.2	15	9	18	2	2		
	Barium	mg/kg	0				1320	209	134	320	362	969	60.3	353	354	-	-	-	17	17	15.9	15.9	1320	1320	245	134	320	0	0		
	Beryllium	mg/kg	0	35	12	63	2.32	6.66	1.16	1.18	4.03	4.92	1.12	2.81	1.41	-	-	-	17	17	0.378	0.378	6.66	6.66	1.46	1.12	1.8	0	0		
	Boron	mg/kg	0.02	48	240000	46000	28.6	114	22.6	23.1	31.7	121	23.9	26.6	20.3	0.5	1	1.7	49	48	+0.2	0.2	121	121	13	1.5	24	2	2		
	Cadmium	mg/kg	0	1.9	190	532	0.483	13	0.903	0.948	1.08	3.49	0.622	16.8	4.38	0.7	+0.1	0.1	49	37	+0.0002	0.1	16.8	16.8	1.2	0.2	3.3	6	6		
	Chromium (hexavalent)	mg/kg	0.01	1.8	33	220	+0.006	+0.006	+0.006	+0.006	+0.006	+0.006	+0.006	+0.006	0.082	+1	+1	+1	49	1	+0.006	0.082	+1	0.082	0.33	0.5	0.24	0	0		
	Chromium	mg/kg	0				36.4	82.7	28.5	35	54.3	60.6	26.7	94.8	48.8	15	4.3	22	49	49	3.5	3.5	94.8	94.8	21	13.5	19	49	49		
	Chromium (Trivalent)	mg/kg	0.01	18000	8800	33000	36.4	82.7	28.5	35	54.3	60.6	26.7	94.8	48.8	-	-	-	17	17	8.03	8.03	94.8	94.8	34	28.5	26	0	0		
	Copper	mg/kg	0	520	68000	44000	70.2	512	23.4	15.5	797	539	12.7	271	80	44	7	13	49	49	2.58	2.58	797	797	86	13	153	2	2		
	Lead	mg/kg	0	80	2300	1300	228	962	89.6	41.3	313	791	18.5	465	83.3	120	4	12	49	49	2.5	2.5	962	962	83	16	188	11	11		
	Mercury	mg/kg	0				0.22	0.93	+0.00002	+0.00002	+0.00002	+0.00002	+0.00002	2.85	0.667	0.13	+0.05	+0.05	49	17	+0.00002	0.05	2.85	2.85	0.16	0.005	0.45	49	49		
	Nickel	mg/kg	0	53	980	880	37.7	235	27	44.2	44.8	211	27.7	191	77.8	18	5.4	22	49	49	5.4	5.4	235	235	32	13	50	7	7		
	Selenium	mg/kg	0	88	12000	1900	0.00398	0.00916	0.00454	0.00507	0.00502	0.00511	0.00511	0.00511	0.00511	+0.5	+0.5	+0.5	49	15	0.00286	0.00286	0.7	0.7	0.17	0.25	0.14	0	0		
	Vanadium	mg/kg	0	91	9000	3000	46.6	66.1	40.5	59	37.5	50.3	36.3	38.4	70.3	-	-	-	17	17	7.9	7.9	70.3	70.3	38	38.4	20	0	0		
	Zinc	mg/kg	0	620	730000	170000	190	2430	83.3	108	970	2200	78.7	448	165	100	13	44	49	49	13	13	2500	2500	213	47	521	4	4		
	Inorganics	Ammoniacal Nitrogen as NH4	mg/kg	0.5				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Ammoniacal Nitrogen as N	mg/kg	0.5				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloride		mg/kg	0				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Cyanide (Free)		mg/kg	1				<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	
Cyanide Total		mg/kg	0.1				<1	2.55	+0.1	+0.1	+0.1	+0.1	+0.1	+0.1	+0.1	+0.1	+0.1	+0.1	+0.1	+0.1	+0.1	+0.1	+0.1	+0.1	+0.1	+0.1	+0.1	+0.1	+0.1	+0.1	
Potassium		mg/kg	1				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Sodium		mg/kg	0.1				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
PAH	Naphthalene	mg/kg	0.009	4.1	(not)	(not)	0.122	0.129	+0.009	0.0081	112	0.234	+0.009	0.0037	+0.009	+0.03	+0.03	41	8	+0.009	0.0214	112	112	2.8	0.015	17	1	1	1	1	
	Acenaphthene	mg/kg	0.008	34	(not)	(not)	0.0597	0.0591	+0.008	0.0592	+0.04	+0.008	+0.008	0.0245	+0.008	0.09	0.15	+0.03	41	7	+0.008	0.0245	0.15	0.15	0.022	0.015	0.029	0	0	0	0
	Acenaphthylene	mg/kg	0.012	28	(not)	(not)	0.223	0.5557	+0.012	+0.012	0.134	0.0267	+0.012	0.108	+0.012	0.08	+0.03	+0.03	41	6	+0.012	0.0267	0.5557	0.5557	0.038	0.015	0.093	0	0	0	0
	Fluoranthene	mg/kg	0.017	52	23000	8300	2.76	2.03	0.131	1.17	1.5	0.426	+0.017	1.28	0.07	4.2	0.15	+0.03	41	20	+0.017	0.0278	4.2	4.2	0.38	0.015	0.88	0	0	0	0
	Anthracene	mg/kg	0.016	380	520000	190000	0.389	0.218	+0.016	0.258	0.327	0.0635	+0.016	0.195	+0.016	0.28	0.04	+0.03	41	10	+0.016	0.04	0.389	0.389	0.06	0.015	0.1	0	0	0	0
	Phenanthrene	mg/kg	0.015	15	22000	6200	1.04	0.846	0.0452	1.39	0.981	0.418	+0.015	0.526	0.0353	0.98	0.19	+0.03	41	15	+0.015	0.0282	1.39	1.39	0.18	0.015	0.35	0	0	0	0
	Fluorene	mg/kg	0.01	27	(not)	(not)	0.112	0.0545	+0.01	0.209	0.087	+0.01	+0.01	0.0554	+0.01	0.07	0.09	+0.03	41	8	+0.01	0.0218	0.209	0.209	0.036	0.015	0.039	0	0	0	0
	Chrysene	mg/kg	0.01	4.1	350	93	1.58	1.12	0.0647	0.183	0.637	0.268	+0.01	0.665	0.0362	2.1	0.14	+0.03	41	17	+0.01	0.0143	2.1	2.1	0.19	0.015	0.44	0	0	0	0
	Pyrene	mg/kg	0.015	110	54000	19000	2.55	1.65	0.112	0.855	1.23	0.314	+0.015	1.11	0.0804	4	0.11	+0.03	41	19	+0.015	0.024	4	4	0.34	0.015	0.79	0	0	0	0
	Benz[a]anthracene	mg/kg	0.014	2.9	170	49	1.71	1.23	0.0823	0.297	0.746	0.243	+0.014	0.836	0.0367	2.5	0.08	+0.03	41	17	+0.014	0.0352	2.5	2.5	0.22	0.015	0.51	0	0	0	0
	Benz[b]fluoranthene	mg/kg	0.015	0.93	44	13	2.28	1.34	0.11	0.22	0.703	0.435	+0.015	1.18	0.0711	3.9	0.11	+0.03	41	18	+0.015	0.0183	3.9	3.9	0.3	0.015	0.76	4	4	4	4
	Benz[k]fluoranthene	mg/kg	0.014	37	1200	370	0.786	0.638	0.0357	0.957	0.316	0.215	+0.014	0.394	0.029	2	+0.03	+0.03	41	12	+0.014	0.029	2	2	0.13	0.015	0.34	0	0	0	0
	Benz[a]pyrene	mg/kg	0.015	0.97	35	11	1.82	1.34	0.0735	0.181	0.608	0.257	+0.015	0.897	0.0563	4	0.08	+0.03	41	15	+0.015	0.0349	4	4	0.25	0.015	0.71	3	3	3	3
	Dibenz[a,h]anthracene	mg/kg	0.023	0.14	3.5	1.1	0.346	0.282	+0.023	0.0314	0.144	0.0676	+0.023	0.159	+0.023	0.7	+0.03	+0.03	41	8	+0.023	0.0314	0.7	0.7	0.094	0.015	0.13	5	5	5	5
	Benz[ghi]perylene	mg/kg	0.024	280	3900	1400	1.23	0.944	0.065	0.112	0.471	0.285	+0.024	0.675	0.0678	4.1	+0.03	+0.03	41	12	+0.024	0.06	4.1	4.1	0.22	0.015	0.67	0	0	0	0
	Indene[1,2,3-c,d]pyrene	mg/kg	0.018	9.5	800	180	1.12	0.826	0.0527	0.0974	0.33	0.202	+0.018	0.548	0.0465	3.8	+0.03	+0.03	41	12	+0.018	0.0465	3.8	3.8	0.19	0.015	0.62	0	0	0	0
TPH 16 Total	mg/kg	0.118				17.2	13.3	0.772	5.23	121	3.38	+0.118	8.7	0.538	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
TPH CWG	PAHs (Sum of total)	mg/kg	0.1				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	+C8-C8 Aliphatics	mg/kg	0.01	720	(not)	(not)	<0.01	0.0149	+0.01	<0.01	-	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	+C8-C8 Aliphatics	mg/kg	0.01	2200	(not)	(not)	<0.01	0.0402	+0.01	<0.01	-	0.0161	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
TPH CWG	+C8-C10 Aliphatics	mg/kg	0.01	3200	(not)	(not)	<0.01	0.0358	+0.01	0.0166	-	0.0201	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	+C10-C12 Aliphatics	mg/kg	0.01	2200	(not)	(not)	<0.01	0.0879	+0.01	0.0218	-	0.0255	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	+C12-EC18 Aliphatics	mg/kg	0.1	11000	(not)	(not)	<0.1	6.88	0.657	0.851	-	3.08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	+C16-C21 Aliphatics	mg/kg	0.1	130000	800000	225000	0.978	20.6	2.38	15.4	-	7.37	-</																		

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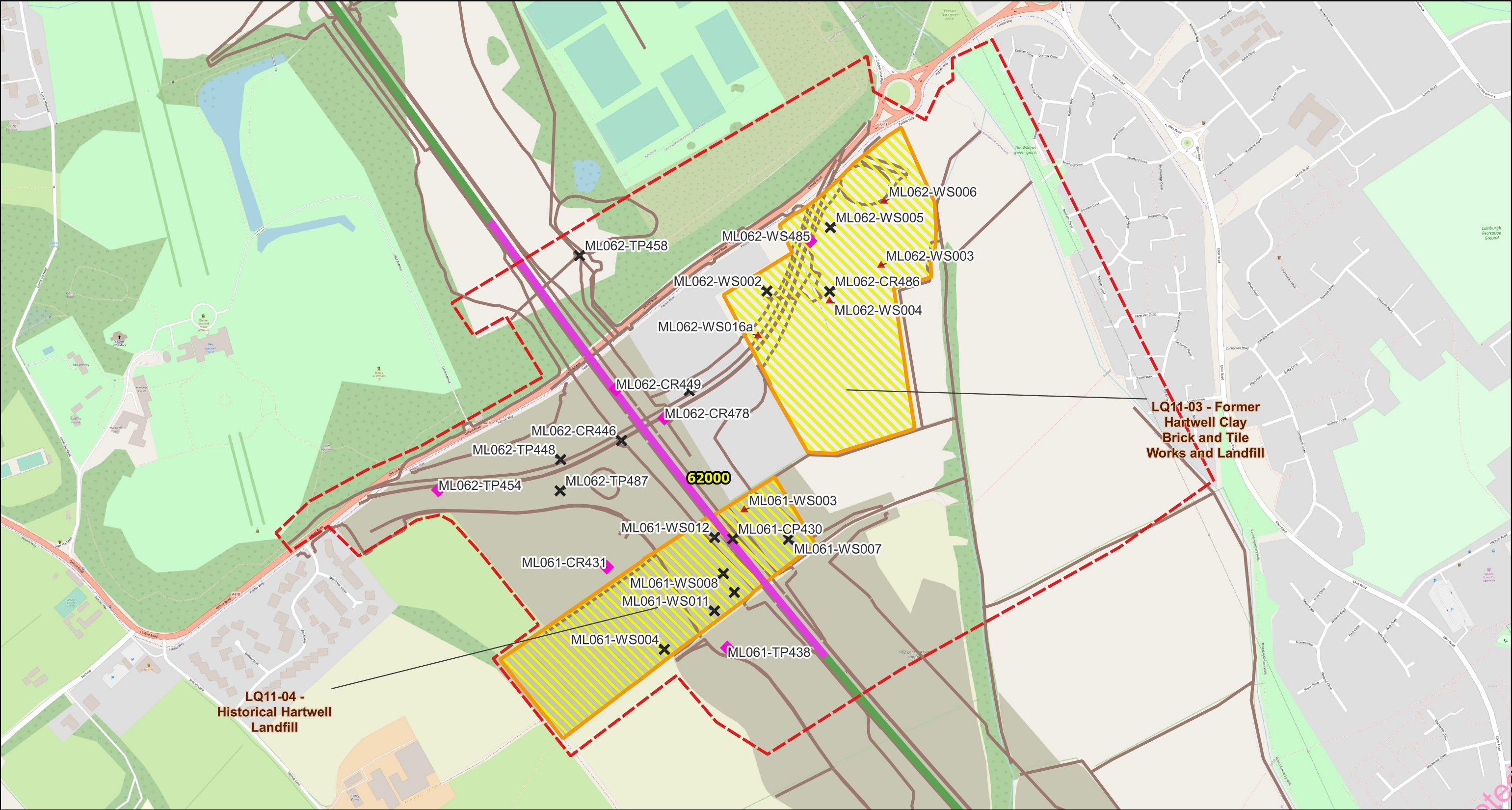
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Appendix G

Leachate Screening Results

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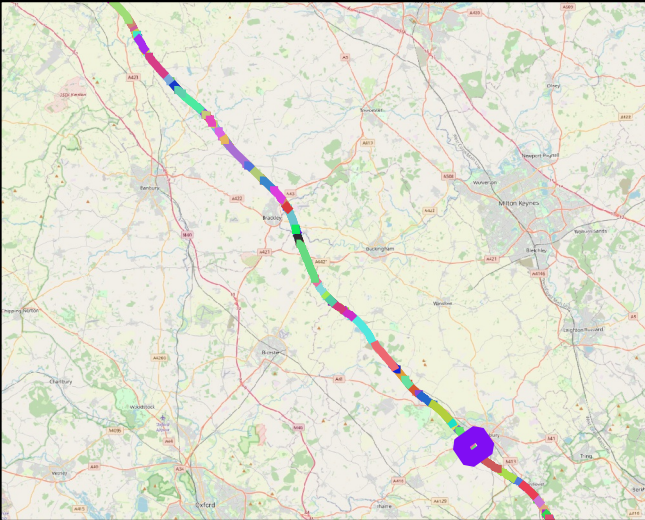


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Historical Hartwell Landfill
Geo-environmental Assessment Report

Figure G- Leachate Exceedances Plan



Legend

- Site Boundary
- Land Quality (LQ) Areas
- Extent of Hartwell Landfill
- HS2 Route Chainage (m)

Engineering Design :

- Cutting
- Embankment

Leachate Exceedences

- Metals
- No exceedances
- pH

0 0.05 0.1 0.15 km

Scale at A3: 1:5,000

Leachate Screening Assessment

				Location_Code	ML061-CP430	ML061-CP430	ML061-CR419	ML061-CR419	ML061-CR431	ML061-CR431	ML061-TP438	ML061-TP438	ML061-WS003	ML061-WS004	ML061-WS007	ML061-WS008	ML061-WS011	ML061-WS012	ML062-CR446	ML062-CR446	ML062-CR446	ML062-CR449	ML062-CR449	ML062-CR478	
				Sampled_Date_Time	01/09/2021	01/09/2021	01/09/2021	01/09/2021	01/09/2021	01/09/2021	26/01/2022	26/01/2022	23/04/2018	23/04/2018	23/04/2018	23/04/2018	23/04/2018	23/04/2018	01/09/2021	01/09/2021	01/09/2021	01/09/2021	01/09/2021	01/09/2021	
				Sample_Depth_Avg	0.5	0.95	0.1	0.4	0.1	0.4	0.05	0.45	0	0.1	3.15	0.35	1	2	0.05	1.8	10.2	0.1	0.3	0.1	
				Geology	MGR	POSA	MGR	POST	MGR	PB	MGR	HEAD	TOP	TOP	POST	POST	POST	POST	MGR	POSA	KC	MGR	POSA	MGR	
				Area	11.04	11.04	11.04	11.04	Greenfield	Greenfield	Greenfield	Greenfield	11.04	11.04	11.04	11.04	11.04	11.04	Greenfield	Greenfield	Greenfield	Greenfield	Greenfield	Greenfield	
				UK Drinking Water UK Freshwater Standards EQS																					
Chem_Group	ChemName	output unit	EQL																						
Metals	Arsenic	µg/L	0	10	50	0.26	0.52	0.97	0.59	0.78	0.93	0.78	0.3	1.71	0.236	<0.12	1.04	0.341	0.579	0.38	0.23	1.8	0.74	0.97	0.34
	Barium	µg/L	0	1300	-	-	-	-	-	-	-	-	-	12.5	14.4	6.54	15.3	5.53	3.67	-	-	-	-	-	-
	Beryllium	µg/L	0			-	-	-	-	-	-	-	-	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	-	-	-	-	-	-
	Boron	µg/L	10	1000	2000	22	24	<12	<12	<12	<12	<12	<12	27.7	30.9	25.7	23.3	28.7	18.8	<12	<12	60	<12	13	<12
	Cadmium	µg/L	0	5	0.08	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.03	<0.03	<0.03	<0.03	0.05	<0.03
	Chromium (hexavalent)	µg/L	0		3.4	<7	<7	<7	<7	<7	<7	<7	<7	<3	<3	<3	<3	<3	<3	<7	<7	<7	<7	<7	<7
	Chromium	µg/L	0	50	3.4	<0.25	0.32	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	3.54	0.971	0.483	1.32	2.13	1.35	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
	Chromium (Trivalent)	µg/L	0		4.7	-	-	-	-	-	-	-	-	3.54	<3	<3	<3	<3	<3	-	-	-	-	-	-
	Copper	µg/L	0	2000	42.23 (PNEC)	0.7	2.4	2.9	1.8	2.5	3.5	1.9	0.7	12.1	<0.85	<0.85	3.76	<0.85	0.999	0.8	1.8	0.9	1	1.8	0.6
	Lead	µg/L	0	10	10.72 (PNEC)	<0.09	0.2	<0.09	0.11	<0.09	<0.09	0.32	<0.09	3.47	0.096	0.021	0.093	<0.02	<0.02	<0.09	<0.09	<0.09	0.14	0.3	<0.09
	Mercury	µg/L	0	1	0.07(MAC)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
	Nickel	µg/L	0	20	23.12 (PNEC)	<0.5	1.9	<0.5	<0.5	<0.5	<0.5	0.7	<0.5	3.2	0.869	0.716	1.61	0.817	0.527	<0.5	<0.5	0.7	<0.5	0.7	<0.5
	Selenium	µg/L	0	10		<0.25	<0.25	0.53	0.31	<0.25	<0.25	<0.25	<0.25	1.2	0.847	<0.39	<0.39	1.05	0.82	<0.25	<0.25	7.1	<0.25	1.4	<0.25
	Vanadium	µg/L	0		20	-	-	-	-	-	-	-	-	2.67	0.882	0.383	2.15	0.68	0.512	-	-	-	-	-	-
	Zinc	µg/L	0	3000	35.65 (PNEC)	1.7	13	2.3	9.4	3.2	1.7	8.5	8.1	10.5	<0.41	<0.41	1.25	0.416	0.489	1.5	<1.3	<1.3	1.4	1.6	<1.3
Inorganics	Cyanide Total	µg/L	50	50	1	-	-	-	-	-	-	-	-	<50	<50	<50	<50	<50	<50	-	-	-	-	-	-
Other	Temperature	°C				-	-	-	-	-	-	-	-	20	18.3	18.4	20.4	20.1	19.3	-	-	-	-	-	-
	Conductivity @ 20oC	µS/cm				-	-	-	-	-	-	-	-	266	205	264	241	209	143	-	-	-	-	-	-
	pH (Lab)	pH_Units	1	6.5-9.5	6-9(MAC)	6.7	7	7.2	7.9	6.3	6.6	5.9	6	8.62	8.35	8.17	8.45	8.3	8.02	8	7.2	6.9	6.5	6.4	6.3

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Leachate Screening Assessment

				UK Drinking Water Standards																				
				UK Freshwater EQS																				
Chem_Group	ChemName	output unit	EQL	Location_Code	ML062-CR478	ML062-CR486	ML062-CR486	ML062-CR486	ML062-CR486	ML062-CR486	ML062-TP448	ML062-TP448	ML062-TP448	ML062-TP448	ML062-TP454	ML062-TP454	ML062-TP458	ML062-TP484	ML062-TP487	ML062-WS002	ML062-WS002	ML062-WS003	ML062-WS003	ML062-WS004
				Sampled_Date	01/09/2021	20/04/2022	20/04/2022	20/04/2022	20/04/2022	20/04/2022	10/06/2021	10/06/2021	01/09/2021	01/09/2021	28/07/2021	01/09/2021	01/12/2021	25/05/2022	26/01/2022	23/04/2018	23/04/2018	23/04/2018	23/04/2018	23/04/2018
				Sample_Depth_Avg	0.3	0.5	2	4	7	8	0.1	0.5	0.2	0.5	0.5	0.2	0.2	0.3	0.05	1.2	2.45	0.3	0.5	0.2
				Geology	POSA	MGR	MGR	MGR	MGR	MGR	KC	MGR	POSA	HEAD	POSA	POSA	MGR	HEAD	POSA	MGR	MGR	MGR	MGR	MGR
				Area	Greenfield	11.03	11.03	11.03	11.03	11.03		Greenfield	Greenfield	Greenfield	Greenfield	Greenfield	Greenfield	Greenfield	Greenfield	11.03	11.03	11.03	11.03	11.03
				</																				

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Leachate Screening Assessment

				Location_Code ML062-WS004 ML062-WS005 ML062-WS006 ML062-WS006 ML062-WS016a ML062-WS016a ML062-WS485 ML062-WS485 ML062-WS485 Sampled_Date_Time 23/04/2018 23/04/2018 23/04/2018 23/04/2018 23/04/2018 23/04/2018 22/12/2021 22/12/2021 22/12/2021 Sample_Depth_Avg 2.25 0.2 1 2 0 1 0.2 1.2 1.7 Geology MGR MGR MGR ALV MGR MGR MGR MGR KC Area 11.03 11.03 11.03 11.03 11.03 11.03 11.03 11.03 11.03																				
				UK Drinking Water Standards UK Freshwater EQS										Statistical Summary										
Chem_Group	ChemName	output unit	EQL											Number of Results	Number of Detects	Minimum Concentration	Minimum Detect	Maximum Concentration	Maximum Detect	Average Concentration	Median Concentration	Standard Deviation	Number of Guideline Exceedances	
Metals	Arsenic	µg/L	0	10	50	7.63	1.61	0.964	0.242	13.2	0.897	2.4	<0.16	0.68	49	46	<0.12	0.22	13.2	13.2	1.4	0.78	2.3	1
	Barium	µg/L	0	1300		415	82.9	55.1	21	77.8	40.6	-	-	-	17	17	3.67	3.67	415	415	59	35.7	96	0
	Beryllium	µg/L	0			<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	-	-	-	17	0	<0.07	ND	<0.07	ND	0.035	0.035	0	0
	Boron	µg/L	10	1000	2000	341	216	1430	748	185	312	<12	<12	15	49	28	<12	13	1590	1590	143	16	327	2
	Cadmium	µg/L	0	5	0.08	<0.1	<0.1	0.368	<0.1	1.19	0.23	<0.03	<0.03	<0.03	49	6	<0.03	0.03	2.09	2.09	0.1	0.015	0.34	17
	Chromium (hexavalent)	µg/L	0		3.4	<3	<3	<3	<3	<3	4.1	<7	<7	<7	49	1	<3	4.1	<7	4.1	2.9	3.5	0.96	33
	Chromium	µg/L	0	50	3.4	1.8	2.38	1.67	1.65	4.57	5.61	<0.25	<0.25	0.42	49	24	<0.25	0.32	5.61	5.61	0.77	0.125	1.2	3
	Chromium (Trivalent)	µg/L	0		4.7	<3	<3	<3	<3	4.57	<3	-	-	-	17	2	<3	3.54	4.57	4.57	1.8	1.5	0.87	0
	Copper	µg/L	0	2000	42.23 (PNEC)	3.13	15.2	8.14	1.84	74.4	9.24	4.6	0.5	1.4	49	43	<0.4	0.5	74.4	74.4	4.1	1.8	11	1
	Lead	µg/L	0	10	10.72 (PNEC)	0.096	0.15	0.347	0.49	1.8	0.132	0.93	0.14	0.37	49	31	<0.02	0.021	3.47	3.47	0.32	0.11	0.67	0
	Mercury	µg/L	0	1	0.07(MAC)	<0.01	<0.01	<0.01	<0.01	0.115	<0.01	<0.01	<0.01	<0.01	49	2	<0.01	0.01	0.115	0.115	0.0073	0.005	0.016	1
	Nickel	µg/L	0	20	23.12 (PNEC)	20.7	2.56	35.3	1.74	89.3	18.8	0.9	<0.5	<0.5	49	27	<0.5	0.5	278	278	10	0.527	41	4
	Selenium	µg/L	0	10		2.85	0.46	14.1	0.753	0.413	<0.39	<0.25	<0.25	0.47	49	22	<0.25	0.25	14.1	14.1	1	0.195	2.3	1
	Vanadium	µg/L	0		20	1.43	1.72	0.456	0.681	7.98	1.06	-	-	-	17	17	0.259	0.259	7.98	7.98	1.6	1.06	1.8	0
	Zinc	µg/L	0	3000	35.65 (PNEC)	1.28	40.7	634	0.806	10.3	3.17	7.1	8.1	2.9	49	33	<0.41	0.416	976	976	36	1.5	164	3
Inorganics	Cyanide Total	µg/L	50	50	1	<50	<50	<50	<50	<50	<50	-	-	-	17	0	<50	ND	<50	ND	25	25	0	17
Other	Temperature	°C				20.2	20.2	20.8	19.5	19.6	20.6	-	-	-	17	17	18.3	18.3	20.8	20.8	20	20.2	0.76	0
	Conductivity @ 20oC	µS/cm				947	407	2090	460	533	408	-	-	-	17	17	143	143	2380	2380	618	407	643	0
	pH (Lab)	pH_Units	1	6.5-9.5	6-9(MAC)	8.22	8.44	7.92	8.59	8.71	8.46	5.9	7.3	7.2	49	49	5.9	5.9	8.71	8.71	7.4	7.2	0.85	9

Leachate Screening Assessment

	Location_Code
	Sampled_Date_Time
	Sample_Depth_Avg
	Geology
	Area

UK Drinking Water Standards
UK Freshwater EQS

Chem_Group	ChemName	output unit	EQL			Number of Guideline
Metals	Arsenic	µg/L	0	10	50	1
	Barium	µg/L	0	1300		0
	Beryllium	µg/L	0			0
	Boron	µg/L	10	1000	2000	2
	Cadmium	µg/L	0	5	0.08	4
	Chromium (hexavalent)	µg/L	0		3.4	1
	Chromium	µg/L	0	50	3.4	3
	Chromium (Trivalent)	µg/L	0		4.7	0
	Copper	µg/L	0	2000	42.23 (PNEC)	1
	Lead	µg/L	0	10	10.72 (PNEC)	0
	Mercury	µg/L	0	1	0.07(MAC)	1
	Nickel	µg/L	0	20	23.12 (PNEC)	4
	Selenium	µg/L	0	10		1
	Vanadium	µg/L	0		20	0
	Zinc	µg/L	0	3000	35.65 (PNEC)	3
Inorganics	Cyanide Total	µg/L	50	50	1	0
Other	Temperature	°C				0
	Conductivity @ 20oC	µS/cm				0
	pH (Lab)	pH_Units	1	6.5-9.5	6-9(MAC)	9

Appendix H

Groundwater Screening Results

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	0.42	0.42	150	0	53	58	3	3	
2	<=0.0152	0.0362	0.133	0.133	0.03	0.0076	0.047	0	0
5	<1000	5500	14400	14400	7686	9100	5640	0	0
7	1300	1300	40100	40100	12624	7160	14273	5	5
18	1.42	1.42	32	32	8	5.84	7.6	3	3
18	9	9	90	90	30	16.15	28	0	0
7	32.2	32.2	229	229	102	91.8	67	0	0
7	13	13	390	390	97	32	138	0	0
5	<10	10	140	140	33	11	49	0	0
0	<20	ND	<20	ND	10	10	0	0	0
3	<=0.01	0.08	<1	0.18	0.11	0.03	0.17	0	0
1	<=0.01	0.01	<4	0.01	0.38	0.01	0.59	21	21
0	<=0.01	ND	<4	ND	0.38	0.005	0.59	21	21
2	<=0.01	1.31	4.5	4.5	0.54	0.005	1	21	2
1	<=0.01	0.02	<4	0.02	0.38	0.02	0.59	10	0
2	<=0.01	0.01	<4	0.02	0.38	0.02	0.59	21	1
1	<=0.01	0.01	<4	0.01	0.38	0.01	0.59	21	21
0	<=0.01	ND	<4	ND	0.38	0.005	0.59	21	0
0	<=0.01	1.25	<4	1.25	0.42	0.005	0.62	1	21
0	<=0.01	ND	<4	ND	0.38	0.005	0.65	21	21
1	<=0.01	1.1	<4	1.1	0.41	0.005	0.61	10	1
0	<=0.01	ND	<4	ND	0.38	0.005	0.61	10	0
0	<=0.01	ND	<4	ND	0.38	0.005	0.59	21	0
0	<=0.01	ND	<4	ND	0.38	0.005	0.59	21	21

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[illegible]

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 rev:004

<1	ND	<4	ND	0.71	0.5	0.54	0	0
<1	ND	<4	ND	0.71	0.5	0.54	0	0
<1	ND	<4	ND	0.89	0.5	0.51	0	0
<1	ND	<1	ND	0.5	0.5	0	0	0
<1	ND	<1	ND	0.5	0.5	0	0	0
<1	ND	<1	ND	0.5	0.5	0	0	0
<1	ND	<1	ND	0.5	0.5	0	0	0
<0.5	ND	<4	ND	0.66	0.5	0.53	0	0
<0.1	ND	<4	ND	0.44	0.25	0.62	0	0
<0.1	ND	<4	ND	0.44	0.25	0.62	0	0
<0.5	ND	<4	ND	0.66	0.5	0.53	0	0
<1	ND	<1	ND		0.5	0	0	0
<1	ND	<4	ND	0.71	0.5	0.54	0	0
<0.1	ND	<0.1	ND	0.05	0.05	0	0	0
<1	ND	<4	ND	0.71	0.5	0.54	0	0
<1	ND	<4	ND	0.71	0.5	0.54	0	0
<0.5	ND	<4	ND	0.66	0.5	0.53	0	0
<1	ND	<4	ND	0.71	0.5	0.54	0	0
<0.5	ND	<4	ND	0.66	0.5	0.53	0	0
<1	ND	<4	ND	0.71	0.5	0.54	0	0
<0.5	ND	<4	ND	0.78	0.5	0.7	0	0
<1	ND	<4	ND	0.71	0.5	0.54	0	0
<0.1	ND	<4	ND	0.46	0.1	0.66	0	0
<1	ND	<4	ND	0.93	0.5	0.73	0	0

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7	72	72	92	92	81	79	7.2	0		0
0	<1	ND	<1	ND	0.5	0.5	0	0		0
12	765	765	1710	1710	1030	956	315	0		0
7	584	584	1290	1290	801	650	300	0		0
4	<1	3.6	7.1	7.1	4.2	3.9	2.5	0		0
4	<10	17	39	39	21	18	12	0		0
13	3000	3000	68000	68000	10154	4600	17562	0		0
24	6.9	6.9	8	8	7.4	7.4	0.29	0		0
7	1650	1650	9090	9090	9606	5480	2991	0		0
7	465	465	44300	44300	12325	6550	15876	0		0

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Appendix I

Mass Haul Extract

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