LITHOS

Geoenvironmental Appraisal

Land at Long Lane, Earlsheaton

For Britology Ltd

Report no: 2986/1B

Date: June 2020

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SUMMARY OF GEOENVIRONMENTAL ISSUES

Job No.	2986	**Site area/ha**	0.6ha
Client:	Britology Ltd	**NGR:**	SE 257 204
Site:	Long Lane, Earlsheaton	**Nearest postcode:**	WF12 8LJ

The site is located off Long Lane, approximately 1.6km south of Dewsbury town centre, and currently comprises a single parcel of farmland which is understood to have previously been used for crop production; but at the time of writing was overgrown.

It is apparent that the centre and east of the site have historically been used as a tip (c. early 1900s) although this is not recorded on historical mapping or BGS/EA records etc.

Lithos were commissioned by Britology to provide a geoenvironmental appraisal of the site, which it is understood is to be redeveloped with 16 no. residential dwellings. Lithos' investigation included a review of the site's history and environmental setting, and a ground investigation comprising 9 trial pits.

A summary of salient geoenvironmental issues is provided in the table below.

Issue	Remarks
Made ground	Ash & Clinker in Area A (former Tip) to maximum depth of 1.6m.
Natural ground	Granular Residual Soil over Thornhill Rock Sandstone & Coal Measures bedrock at 1.5m to 2.9m depth.
Contamination	Existing Topsoil is not considered suitable for re-use due to elevated concentrations of arsenic, lead and zinc. Elevated concentrations of inorganic & organic contaminants have been identified in the Ash & Clinker which is also considered potentially combustible.
Mining & quarrying	Site lies within a CA Development Low Risk Area. The shallowest coal seam lies at c. 30m depth. An intrusive mining risk assessment is not considered necessary. No known quarries on or within 50m of the site's boundary.
Hazardous gas	Whilst the risk of gas migrating on to this site is considered low it cannot be entirely discounted. Basic radon protection measures are required anyway and will afford protection against any low levels of hazardous gas which may migrate to the site. However, it would be prudent to increase protection measures to comply with Amber 1 requirements **or** install 5 monitoring wells and undertake gas monitoring (9 visits over 6 months).
Preparatory & Remediation works	Where Ash and Clinker remains beneath gardens or landscaped areas it should be isolated beneath a minimum 1,000mm inert soil cover. There will be a need for import of suitable topsoil for use as clean cover.
Foundations	Strip/trenchfill footings are considered the most suitable means of foundations for all buildings at this site. Foundations will require deepening where deep made ground is encountered to found in natural residual soils of adequate bearing capacity.
Groundwater & excavations	Excavations should remain dry. Excavations into natural soils should remain stable in the short term, but excavations into made ground will likely require shoring.
Flooding & drainage	The east of the site is considered at risk of flooding from rivers (the adjacent Chickenley Beck). Soakaways are likely to provide a suitable means of surface water disposal, but it is recommended these are not constructed in, or allowed to drain to, made ground.
Highways	Re-engineered made ground should provide a CBR of at least 3%. Natural soils should provide a CBR of at least 4%.

Significant developer abnormals relating to geoenvironmental issues at the site are:

- Development on an old tip (albeit fill is predominantly Ash & Clinker)
- Amber 1 gas measures
- Import of Topsoil for use as clean cover
- Placement of 1,000mm of clean cover in garden and POS areas

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FOREWORD (geoenvironmental appraisal report)

This report has been prepared for the sole internal use and reliance of the Client named on page 1. This report shall not be relied upon or transferred to any other parties without the express written authorisation of Lithos Consulting Limited (Lithos); such authorisation not to be unreasonably withheld. If any unauthorised third party comes into possession of this report, they rely on it at their peril and the authors owe them no duty of care and skill.

The report presents observations and factual data obtained during our site investigation and provides an assessment of geoenvironmental issues with respect to information provided by the Client regarding the proposed development. Further advice should be sought from Lithos prior to significant revision of the development proposals.

The report should be read in its entirety, including all associated drawings and appendices. Lithos cannot be held responsible for any misinterpretations arising from the use of extracts that are taken out of context. However, it should be noted that in order to keep the number of sheets of paper in the hard copy to a minimum, some information (e.g. full copy of the Landmark/Groundsure Report) is not included in the pdf, by request, it can be provided on a CD.

The findings and opinions conveyed in this report (including review of any third-party reports) are based on information obtained from a variety of sources as detailed within this report, and which Lithos believes are reliable. All reasonable care and skill has been applied in examining the information obtained. Nevertheless, Lithos cannot and does not guarantee the authenticity or reliability of the information it has relied upon.

The report represents the findings and opinions of experienced geoenvironmental consultants. Lithos does not provide legal advice and the advice of lawyers may also be required.

Intrusive investigation can only investigate shallow ground beneath a small proportion of the total site area. It is possible therefore that the intrusive investigation undertaken by Lithos, whilst fully appropriate, may not have encountered all significant subsurface conditions. Consequently, no liability can be accepted for conditions not revealed by the exploratory holes. Any opinion expressed as to the possible configuration of strata between or below exploratory holes is for guidance only and no responsibility is accepted as to its accuracy

It should be borne in mind that the timescale over which the investigation was undertaken may not allow the establishment of equilibrium groundwater levels. Particularly relevant in this context is that groundwater levels are susceptible to seasonal and other variations and may be higher during wetter periods than those encountered during this commission.

Where the report refers to the potential presence of invasive weeds such as Japanese Knotweed, or the presence of asbestos containing materials, it should be noted that the observations are for information only and should be verified by a suitably qualified expert.

This report assumes that ground levels will not change significantly from those existing at present and that houses will be of two storey construction. If this is not to be the case, then some modification to this report may be required.

Lithos cannot be responsible for the consequences of changing practices, revisions to waste management legislation etc that may affect the viability of proposed remediation options.

Lithos reserve the right to amend their conclusions and recommendations in the light of further information that may become available.

GEOENVIRONMENTAL APPRAISAL
of land at
LONG LANE, EARLSHEATON

1 INTRODUCTION

1.1 The commission and brief

1.1.1 Lithos Consulting Limited were commissioned by Britology Ltd to carry out a geoenvironmental appraisal of land at Long Lane, Earlsheaton.

1.1.2 This document is a revision of the Geoenvironmental Appraisal (Report 2986/1A) issued by Lithos in May 2020; Report 2986/1A is now superseded. This document has been updated with a revised development layout with the only significant revisions being made to Drawings 2986/2 and 2986/10 and Sections 1.2 and 15.4.

1.1.3 Correspondence regarding Lithos' appointment, including the brief for this investigation, is included in Appendix C. The agreed scope of works included:

- Review of a third party report.
- A site walkover and inspection.
- An assessment of the land use history.
- Determination of the site's environmental setting.
- A mining risk assessment in accordance with Coal Authority guidance.
- An intrusive ground investigation comprising 9 trial pits, with soakaway testing in 4 pits.
- Assessment of the geotechnical properties of the near surface deposits to enable provision of foundation and highway recommendations.
- A qualitative assessment of contamination risks.
- Recommendations for the necessary site preparatory works.

1.1.4 Primary aims of this investigation were to identify salient geoenvironmental issues affecting the site to support the submission of a planning application, and also to enable Britology to obtain budget costs for: foundations; gas protection measures; and site preparatory works.

1.2 The proposed development

1.2.1 It is understood that consideration is being given to development of the site with 16 'traditional' two storey residential dwellings, associated gardens, an area of POS and adoptable roads and sewers. A site layout has been provided (Drawing reference 0067_LON_SK103, dated 28th May 2020) which is reproduced in Drawing 2986/2 in Appendix B to this report.

1.3 Report format and limitations

1.3.1 All standard definitions, procedures and guidance are contained within Appendix A, which includes background, generic information on:

- Assessment of the site's environmental setting
- Ground investigation fieldwork
- Geotechnical testing
- Contamination testing
- Soakaways

1.3.2 General notes and limitations relevant to all Lithos geoenvironmental investigations are described in the Foreword and should be read in conjunction with this report. The text of the report draws specific attention to any modification to these procedures and to any other special techniques employed.

2 SITE DESCRIPTION

2.1 General

2.1.1 The site's location is shown on Drawing 2986/1 presented in Appendix B to this report. Site details are summarised in the table below.

Detail	Remarks
Location	1.6km south east of Dewsbury town centre
NGR	SE 257 204
Approximate area	0.6 hectares
Known services	Underground & overhead electric

2.2 Site features

2.2.1 Lithos completed a walkover survey of the site on the 30th August 2018.

2.2.2 Existing salient features, at the time of the walkover are presented on Drawing 2986/3 in Appendix B to this report and summarised in the table below.

Feature	Remarks
Current Access	Gated; off Long Lane
Topography	Slopes, moderately steeply, down to the east.
Approximate areas	6,400m^2 rough grass and weeds
Nature of boundaries	North – garden fences and hedgerows South – mature conifer trees & hedgerow West – dry stone wall with access gate East – no physical boundary; Chickenley beck flows immediately beyond site's boundary.
Surrounding land uses	North – residential dwellings accessed off Woodburn Avenue. South – Residential dwelling & agricultural building with arable farmland beyond East – Chickenley Beck with disused hospital buildings & arable farmland beyond. West – Long Lane with arable farmland beyond.

2.2.3 A selection of site photographs is included on Drawing 2986/4.

2.2.4 Long Lane runs roughly north to south immediately beyond the western boundary. Access to the site is via a metal gate which opens out onto Long Lane in the north western corner of the site.

2.2.5 At the time of walkover, the entire site was overgrown with long grasses, immature shrubs, weeds and brambles.

2.2.6 Chickenley Beck flows south immediately beyond the eastern boundary.

2.2.7 The site falls down to the east with a typical gradient of 1v:9h and a maximum gradient of 1v:9h (in the centre-west). A steep bank (1v:1h to 1v:3h) about 2m high runs along the site's eastern boundary, adjacent to Chickenley Beck.

2.2.8 Land east of the site rises up from Chickenley Beck, whilst land to the west (beyond Long Lane) falls down moderately steeply to the River Calder, which flows south about 200m beyond the site's western boundary.

2.2.9 The southern and eastern boundaries of the site are heavily wooded with mature trees, shrubs and hedgerows. The western boundary is made up of a dry stone wall.

2.2.10 Two overhead electrical utilities cross the site; one runs roughly north – south across the centre-east; the second runs roughly east to west across the south west. Both utilities are suspended atop wooden poles.

3 SITE HISTORY

3.1 Site centred extracts from Ordnance Survey (OS) plans dating back to 1855 have been examined. Some of these plans are presented in Appendix D to this report.

3.2 The table below provides a summary of the salient points relating to the history of the site. It is not the intention of this report to describe in detail all the changes that have occurred on or adjacent to the site. Significant former uses/operations are highlighted in **bold** text for ease of reference.

Date	Site	Surrounding land
1855	Site comprises a single green field.	**Chickenley Beck** flows south immediately beyond eastern boundary. River Calder flows south 200m to the west. Long lane runs north to south immediately beyond western boundary. Surrounding land predominantly comprises arable farmland & woodland. Earls Heaton Colliery 250m north.
1894	Site divided into two fields.	Buildings (presumed agricultural) immediately beyond north western corner with further (presumed residential) buildings beyond. Chickenley Wood **Colliery** 100m to 300m north with associated earthworks and at least 2 old **shafts**. Scar End Wool Mill 150m south west with an associated **old quarry**. **Sewage farm** with reservoir and earthworks from 200m to the south.
1907	Site no longer divided into two fields.	Infectious diseases hospital developed 40m east. Hospital building built 25m north east atop **earthworks** (likely a raised level). Closest building to site eastern boundary includes a chimney and may have been the hospital incinerator.
1922	No significant changes.	Sands Mill with associated Mill race cut from River Calder 270m west.
1931	Site named Clough Farm	No significant changes.
1938	No significant changes.	Development of Earlsheaton to the north.
1956		Land 200m to west shown to slope steeply down; possible cutting or earthworks. Further earthworks (raising of levels) immediately east.
1974		Development of housing (Woodburn Ave.) Immediately to the north. **Sewage ventilation shaft** shown 130m west.
1984		Mill race 270m east no longer shown.
1992		Hospital, building & earthworks to the east no longer shown. Disused Chickenley Colliery no longer shown.
1999 (Aerial)		Residential dwelling & farm buildings with associated farmyard developed immediately south.
2003		Sewage farm now labelled Dewsbury Waste Water Treatment Works & comprises 13 open bodies of water.
2018		Sewage Ventilation shaft now labelled as a disused shaft.

3.3 The locations of the historical quarry, earthworks associated with the former hospital and Chickenley Colliery, including the old shafts, are shown on Drawing 2986/8.

3.4 The Colliery at Chickenley Wood to the north east was established in 1876 by the Chickenley Wood Coal Co. Shafts were sunk from 1867 to 1878 with coal being extracted from 1876 to 1882.

3.5 At the time of Lithos' investigation the site's current owner suggested that the east of the site had formerly been used as a Victorian tip. In addition, it was anecdotally suggested that in relatively recent history (c. the last 30 years) the tip had been excavated to retrieve antique bottles etc. The landowner suggested that as part of the excavation at least 1.0m of tipped material had been removed from the far-east of the site.

3.6 Given the sloping nature of the site and surrounding land, including the steeply sloping bank adjacent to Chickenley Beck it is considered likely that the tip material was placed over existing ground in order to raise levels and reduce the slope of the site. It is considered unlikely that the tipped material has been used to backfill an excavation/quarry.

3.7 It is understood, from discussions with local residents, that in recent years the site has been used for the production of arable crops.

4 ENVIRONMENTAL SETTING

4.1 General

4.1.1 Notes describing how the site's environmental setting has been assessed are included in Appendix A to this report. Extracts from the response received from Landmark, and responses from the Coal Authority and the BGS are presented in Appendix E. These responses are summarised below, together with the findings of our own "desk study" investigation.

Issue	Data reviewed	Summary
Geology	1:50,000 BGS map (Sheet SE22SE) BGS Technical Report ref. WA/96/17 & BGS BH ref. SE22SE.16	Drift – none mapped (likely veneer of residual soils). Solid – Thornhill Rock Sandstone (west) & Middle Coal Measures (centre & east). Shallowest coal seam – Joan Coal at around 30m depth Fault runs north east to south west just beyond the site's southern boundary.
Mining	Coal Authority	This site is located within a Coal Mining Development Low Risk Area (within the defined coalfield, but no known defined risks have been recorded by the Coal Authority; there may still be unrecorded issues). A Development High Risk Area is located immediately to the south & is defined by the geological fault. See further details in Section 5.
Quarrying	Historical OS plans	Small scale quarrying 150m south.
Radon	Public Health England Environment Agency Envirocheck Report	The site lies in an area where between 3% and 5% of homes are estimated to be above the action level. Therefore, basic radon measures are required. See further details in Section 13.
Hydrogeology		Groundwater Source Protection Zone? None beneath the site. Aquifer – Secondary A Aquifer (Solid). Groundwater abstractions? None within 1km of sites boundary. Soil leaching potential – High (Cat. U). Pollution incidents? None of significance to the site (see comments in Section 4.1.2 below)
Hydrology		Nearest watercourse(s) – Chickenley Beck; flows south immediately beyond the eastern boundary. Within Catchment of River Calder. Water Quality is moderate (ecology) & failing (chemical) as of 2016. Chickenley Beck has a water Quality GQA grade of D. Pollution incidents? None of significance to the site (see comments in Section 4.1.2 below). Abstractions? None within 1km of site's boundary. Discharge consents? None of significance to the site.
Flood risk		The east of the site lies within an area which is considered to be at risk from flooding from rivers or sea. The site does not lie in an area considered at risk of surface water flooding; although Chickenley Beck immediately to the east is. The far-east of the site has a limited susceptibility to groundwater flooding. In accordance with Chapter 10 of the National Planning Policy Framework, a site-specific flood risk assessment is required for in an area within Flood Zone 1 which has critical drainage problems (as notified to the local planning authority by the Environment Agency) and new developments within Flood Zones 2 & 3.

4.1.2 Whilst there are no recorded pollution incidents which adversely affect this site (no incidents within or close to the site's boundary; no significant incidents to groundwater; and, no incidents to Chickenley Beck up stream of the site) the surrounding area has a legacy of relatively small scale pollution incidents to waters, with incidents affecting the River Calder, Chickenley Beck other local watercourses.

4.1.3 Information from the Environment Agency shows that the water quality in the surrounding catchment area is failing in terms of chemical quality and is only moderate in terms of ecological quality. Examination of the EA water quality reports generally suggests that there are no clear causes of the poor water quality in the area, and frequently no technical solutions are offered. Therefore, whilst there are no significant pollution incidents relating to this site; it should be ensured that the proposed development does not have an adverse effect on the surrounding water quality during the design, construction and completion stages; this aligns to the requirements of the Water Framework Directive.

4.1.4 The extents of the underlying geology of the site (Thornhill Rock, Coal Measures and the line of the geological fault as shown on BGS mapping) are reproduced on Drawing 2986/8 in Appendix B.

4.2 Landfills

4.2.1 Known or suspected areas of landfill in the vicinity of the proposed development site are summarised below:

Location	NGR (proximity to site)	Remarks	Source of data
Bretton Street	SE 253 202 (230m west)	Also named 'Tipping Site'. First input May 1970. Last input unknown. Provider ref. EAHLD31820. c. 10 hectares.	EA

4.2.2 The footprint of the landfill is shown on Drawing 2986/8 in Appendix B.

4.2.3 Considering this landfill the following points are raised:

- The landfill is recorded as being commenced in 1970 and is not shown on historical OS mapping despite being a relatively large feature (OS mapping in the area of the landfill at this time period has a relatively poor coverage). Therefore, it is tentatively suggested that landfill operations were not 'long lived' and the fill material is unlikely to be especially deep or extensive.
- Tipped materials in the 1970s were generally of a less degradable nature that modern day landfill materials; therefore the potential to generate hazardous gasses is somewhat reduced.
- The River Calder lies between the recorded landfill and this site. The river; and resultant saturated ground; is likely to act as a good barrier to hazardous ground gas.
- The landfill is located on Alluvium (drift deposits) which do not extend into the site. It is highly unlikely that ground gas would migrate down through relatively impermeable drift deposits into bedrock and then across to this site.
- The landfill is located almost 230m from the site's boundary therefore the risk of gas migration is not considered significant.

4.2.4 It is considered unlikely that the recorded landfill poses a significant hazard to this site.

4.2.5 See further comments in Section 13 regarding gas protective measures.

4.3 Other issues

4.3.1 A site with a planning hazardous substances consent (PHSC) is located 550m to the west. The site is operated by British Gas and is located at North Eastern, Bretton Street. The PHSC was issued by Kirklees MBC Planning Services in 1992 ref. 92/50/04971/AO and covers handling of liquified flammable gas, including LPG.

4.3.2 A site with a notification of installations handling hazardous substances (NIHHS) is located 600m to the west. The NIHHS notification is held by Transco and is located at Dewsbury Gas Works, Mill Street East although it is understood to no longer be active.

4.3.3 Areas around such sites (chemical plants etc) are zoned with respect to the implementation of emergency plans. The HSE are a statutory consultee to the local planning authority for all COMAH sites. The COMAH site may have to revise its emergency action plan if development occurs. This might be quite straightforward or could entail significant expenditure. Consequently, the COMAH site may object to proposed development (although it is the LPA who have final say, and they are likely to place more weight on advice from the HSE).

5 COAL & MINING

5.1 General

5.1.1 In July 2011 the Coal Authority (CA) formalised their requirements in relation to planning applications and introduced some new terminology relating to coal mining development areas. This Section provides the necessary mining risk assessment required by the proposed planning application.

5.1.2 This site is located within a Coal Mining Development Low Risk Area - within the defined coalfield, but no known defined risks have been recorded by the Coal Authority; there may still be unrecorded issues.

5.2 This site

5.2.1 Geological mapping and the BGS borehole suggest that the shallowest coal beneath the site is the Joan Coal Seam.

5.2.2 BGS mapping shows the Joan Coal outcropping 270m to the west (at c.35mAOD), whilst a BGS log (reproduced in Appendix E) located 150m east records the Joan Coal at 0.6m thick at 50m depth (-3mAOD). Given these levels and the site's level of c. 50 to 55m AOD the Joan Coal would be expected to underlie the site at a depth of about 30m.

5.2.3 The BGS generalised stratigraphic column and technical report suggest that the Joan Coal lies 10m below the base of the Thornhill Rock Sandstone which outcrops about 150m to the east. This 'ties in' to the depths and assumptions made above.

5.2.4 The BGS Technical Report notes that the Joan Coal only occasionally reaches a reachable thickness in the local area (up to 1.8m thick). A marker horizon (the Vanderbeckei Marine Band) makes up the roof of the Joan Coal and in the Earlsheaton Area this is located about 10m below the lowest unit of the Thornhill Rock Sandstone.

5.2.5 The BGS technical report also notes that there is some doubt over the validity of recorded depths to the Joan Coal.

5.2.6 The next shallowest coal is the Cannal Coal which is anticipated at 65m depth (c.15m below the Joan Coal).

5.2.7 Geological mapping and information from the Coal Authority show a geological fault which runs north east to south west immediately beyond the site's southern boundary. To the south of the fault an un-named coal seam is conjectured to outcrop. Land above the outcrop lies within a Development High Risk Area; the line of the geological fault defines the extent of the High Risk Area.

5.2.8 It should be noted that seam outcrops and geological faults plotted on geological maps have been known to be inaccurate by distances in excess of 100m.

5.2.9 Approximate coal outcrops, the underlying geology of the site and the geological fault, are shown on Drawing 2986/8.

5.2.10 A CA consultants coal mining report states that:

- *Known past underground mining has occurred within the Black Bed Coal Seam at about 300m depth beneath the site. The worked seam has a thickness of 0.66m.*
- *The coal Authority does not consider the site to be underlain by probable unrecorded shallow workings. In addition there are no spine roadways recorded at shallow depth.*
- *There are no known mine entries located within, or within 100m of, the sites boundary*
- *There are no opencast mines located within 500m of the site's boundary*
- *There are no Coal Authority managed tips within 500m of the site's boundary.*
- *The Coal Authority is not aware of any damage due to geological faults or other lines of weakness that have been affected by coal mining.*
- *The Coal Authority has no record of a mine gas emission requiring action.*
- *The property is in an area where notices to withdraw support were given in 1950 and 1951.*
- *The property is not in an area where a notice has been given under Section 41 of the Coal Industry Act 1994, cancelling the entitlement to withdraw support.* This means that coal could be extracted from depth beneath the site in the future. However, given the decline of coal mining in the UK this is highly unlikely to occur.

5.2.11 The CA mining report states that there are no probable shallow unrecorded mineworkings. Lithos has contacted the CA and confirmed that essentially this means the CA do not know of any coal at shallow depth (i.e. <30m) beneath this site.

5.2.12 The Coal Authority has given notice of entitlement to withdraw support; this means that the CA have the right to remove coal from beneath this site using underground methods.

5.2.13 The Leeds, Bradford & Wakefield coalfield contained large areas of Coal, Ironstone, Fireclay and Gannister; all of which were extracted from the area using underground methods.

5.2.14 The switch from coal to natural gas, the replacement of steam engines with diesel and electricity, new environmental legislation and the general change in generating electricity from coal to oil and nuclear power in the late 1960's placed stresses upon the Coal industry and forced the Coal Authority (then the National Coal Board) to streamline and rationalise coal production. As a result, the majority of mines in West Yorkshire were phased out and mining was focused on land to the east of the M1 motorway (the Selby coalfield).

5.2.15 UK Coal generally work on a five-year rolling plan updated annually in March/April. However, following closure of the last deep underground coal mines in the UK (Kellingley Pit in 2015) there is no current 5 year plan with respect to coal beneath the proposed development, and it considered extremely unlikely that coal will be extracted from beneath the site in the foreseeable future.

5.2.16 It is our understanding that if a new colliery were ever opened, and mining were to proceed in the future, then UK Coal/The Coal Authority would be liable for damage claims arising from future mining beneath the site.

5.2.17 Immediately prior to development it would be prudent to check the above with UK Coal, but risks appear negligible.

5.3 Discussion

5.3.1 The shallowest coal to underlie this site is the Joan Coal which is anticipated at about 30m depth. Several sources have been referenced to support the estimation of this coal seams depth. In addition, the Coal Authority do not consider the site to be underlain by shallow coal (i.e. less than 30m depth).

5.3.2 The Joan Coal is recorded as being 0.6m thick. Therefore at least 6m of competent (i.e. solid rock) cover is required above the coal in order to mitigate the risk to the surface from unrecorded shallow mineworkings.

5.3.3 Greater than 6m of competent cover is anticipated; therefore, the site is not considered to be at risk from shallow mineworkings and an intrusive mining investigation is not considered necessary.

6 PREVIOUS INVESTIGATION FINDINGS

6.1 General

6.1.1 Britology have provided Lithos with a copy of the following letter report: Coal Mining Risk Assessment – Long Lane, Earlsheaton (Ref. BRL/01/JRjc) issued by ARP Geotechnical Ltd in March 2017

6.1.2 The letter includes a review of BGS mapping and a Coal Authority mining report.

6.2 Summary of ARPs' findings

6.2.1 The findings of ARPS' letter report are broadly in line with the findings of Sections 1 to 5 of this report; however with less detail or interpretation of the geology beneath this site.

6.2.2 ARP conjecture that the Joan Coal underlies the site at a depth of between 5m and 10m and suggest that an intrusive mining investigation is required.

6.3 Lithos comments

6.3.1 ARP state that an intrusive mining risk assessment is required for the site as the Joan Coal is present between 5m and 10m depth. However as discussed in Section 5 of this report it is considered that the coal in fact lies at about 30m depth; sufficient competent cover is present above the seam; and, an intrusive mining risk assessment is not considered necessary.

7 GROUND INVESTIGATION DESIGN

7.1 Anticipated ground conditions & potential issues

7.1.1 Based on the data reviewed in Section 4 (Environmental Setting) and 6 (Previous Investigation Findings), anticipated ground conditions are expected to comprise:

Anticipated condition	Remarks
Made ground	No significant made ground anticipated
Natural soils	Topsoil over a veneer of residual soils (likely gravelly clay).
Bedrock	Thornhill Rock Sandstone & Middle Coal Measures bedrock anticipated at relatively shallow depth.
Mineworkings	None at shallow depth.
Groundwater	Anticipated at depth within bedrock.

7.1.2 Based on the data above and that in Sections 2 (Site Description) and 3 (History), potential ground-related issues associated with this site are likely to include:

Type of issue	Specific issue	Remarks
Potential on-site contamination sources	1. farming related activities	1. metals, spillage/leakage of fuels
Potential off-site contamination sources	1. none identified	
Potential geotechnical hazards	1. sloping ground	1. site slopes moderately steeply down to the east
Other potential constraints	1. overhead utilities	1. electrical utilities cross the centre & south of the site

7.2 Preliminary conceptual site model

7.2.1 A preliminary conceptual site model, presented as Drawing 2986/5 in Appendix B, has been prepared after consideration of all the data presented in Sections 2 to 7.1 inclusive of this report.

7.2.2 Historical plans show that the site has been occupied by arable farmland which is not considered likely to have caused significant ground contamination. Nonetheless, activities such as slurry spreading, the discharge of chemicals to ground, and unregulated burial have all occurred on farmland. Potential pollutants associated with farming activity might include any of the following:

Agricultural activity	Potential contaminant
Sewage farming, slurry spreading	Methane, metals, nitrates, oxygen depletion
Plant & animal protection	Pesticides & herbicides
Soil conditioners	Metals, sulphates, PAH
Naturally occurring contaminants	Arsenic, metals

7.2.3 Whilst it is likely that pesticides have been applied during arable use of the land, these are not likely to include the persistent organochloride pesticides such as Dieldrin, Aldrin, DDT etc. Pesticides routinely used on arable crops the UK (Phenoxy Acetic acid herbicide or PAAH) rapidly degrade in soils or leach via rainwater infiltration to groundwater. It is highly unlikely these would be detected by soil sampling and therefore these have not been included within the proposed sampling suite.

7.2.4 Potential pollutant linkages are shown on the preliminary conceptual site model.

7.3 Ground investigation design & strategy

7.3.1 The preliminary conceptual site model was used as a basis for design of an appropriate ground investigation, the scope of which is summarised below.

Exploratory holes	Purpose
About 9 trial pits	To determine the general nature of soils underlying the site, including the: • Nature, distribution and thickness of shallow soils, including any made ground • Suitability of the ground for founding structures and highways
Including at least 4 pits	To determine whether soakaways could be utilised for storm water drainage

7.3.2 Proposed exploratory hole locations were selected to provide a representative view of the strata beneath the site. Additional exploratory hole locations might be scheduled by the site engineer in light of the ground conditions actually encountered.

7.3.3 The number of representative samples taken will be reflective of the geological complexity actually encountered. However, in general about 3 samples will be taken from most trial pits.

8 FIELDWORK

8.1 Objectives

8.1.1 The original investigation strategy is outlined in Section 7.3 above.

8.2 Exploratory hole location constraints

8.2.1 No access was available beneath the line of overhead electrical utilities which cross the site.

8.3 Scope of works

8.3.1 Fieldwork was supervised by Lithos on the 31st August 2018 and comprised the exploratory holes listed below.

Technique	Exploratory holes	Final depth(s)	Remarks
Trial pitting (machine dug)	TPs 01 to 09	2.0m to 3.2m	Trial pits remained dry & stable during excavation.
Soakaway tests	Within TPs 01 to 04	2.6m to 3.2m	

8.3.2 Notes describing ground investigation techniques, in-situ testing and sampling are included in Appendix A to this report.

8.3.3 Exploratory hole logs are presented in Appendix F to this Report. These logs include details of the:

- Samples taken
- Descriptions of the solid strata, and any groundwater encountered.
- Results of the in-situ testing

8.3.4 Exploratory hole locations are shown on Drawing 2986/6 presented in Appendix B.

9 GROUND CONDITIONS

9.1 General

9.1.1 A complete record of strata encountered beneath the site is given on the various exploratory hole records, presented in Appendix F.

9.1.2 The site can be divided into two areas based on ground conditions. These areas are shown on Drawing 2986/9 and are summarised in the table below:

Site area	General location	Area (m^2)
A	Centre & east of the site (former Tip)	4,800m^2
B	West of the site (greenfield area)	1,600m^2

9.1.3 Typical ground conditions encountered at the site are described below in Sections 9.2 (made ground) and 0 (natural ground), with a summary provided in the table on page 14.

9.2 Made ground

9.2.1 Made Ground was only encountered within Area A up to 1.6m depth and typically comprised the following strata:

- **Made Ground Topsoil:** Encountered within TPs 2, 3, 6 & 9 to a typical depth of 0.25m (max 0.3m in TP09) comprising sandy clay/silt with occasional gravel of pottery, glass, siltstone, sandstone and coal; over,
- **Ash & Clinker**: Encountered within TPs 2 to 6 & 9 to between 0.5m (TP06) and 1.6m (TPs 4 & 5) comprising ash sand and gravel of clinker, pottery, glass and occasional coal, brick, sandstone, mudstone, brick and bone. Occasionally with fragments of wood and leather.

9.2.2 Review of the trial pit logs suggests that the made ground typically deepens to the east and thins out to the west of the site. Given the steep bank about 2m high runs along the site's eastern boundary, adjacent to Chickenley Beck, and surrounding topography, it is considered most likely that material was placed above original ground (rather than as backfill to a former pit/quarry) to reduce the slope down to Chickenley Beck.

9.2.3 Given the nature of the made ground encountered it is considered likely that it was tipped during the late Victorian/early Edwardian periods (i.e. the late 1800s to early 1900s).

9.2.4 The approximate footprint of the former Tip is shown on Drawing 2986/9.

9.3 Obstructions

9.3.1 Examination of historical mapping does not show any historical buildings at this site. In addition, no obstructions were encountered during Lithos' investigation.

9.3.2 However, it cannot be guaranteed that some isolated oversized materials are not present within the Ash & Clinker. Any oversized objects would likely result in some overbreak of excavation walls if/where encountered.

9.4 Natural ground

9.4.1 Natural ground was encountered from surface in exploratory holes in Area B, and beneath the Ash & Clinker in Area A.

9.4.2 Natural ground typically comprised the following succession:

- **Topsoil:** typically <0.3m thick, comprising sandy silt/clay.
- **Cohesive Residual Soil**: firm very sandy silty clay encountered in TP03 with firm to stiff sandy clay in TPs 04, 05 & 09
- **Granular Residual Soil:** Sandy gravel of sandstone with a low to medium sandstone cobble content.
- **Bedrock:** Encountered from 1.5m (TP07) to 2.8m (TP05); average 2.3m). Penetration into bedrock was typically about 0.5m.

9.4.3 Bedrock predominantly comprised medium strong fine-grained Sandstone (likely the Thornhill Rock Sandstone Unit). However, TPs 04 & 09 (in the east of the site) encountered thinly interbedded Siltstones and Sandstones (likely Middle Coal Measures strata).

9.4.4 Cohesive Residual Soil was encountered in the east over/close to interbedded Siltstone / Sandstone bedrock, whilst Granular Residual Soil was typically encountered in the centre and west overlying the Thornhill Rock Sandstone.

9.4.5 The above is based on field description, not subsequent geotechnical analysis (see Section 14) has found that material logged in the field as Cohesive Residual Soil is actually clayey Granular Residual Soil and not shrinkable.

9.5 Visual & olfactory evidence of organic contamination

9.5.1 No visual or olfactory evidence of gross contamination was noted during Lithos' investigation. However, the made ground included Ash & Clinker which can be potentially combustible and is frequently associated with a number of potential contaminants; most notably:

- Inorganics (metals)
- Organics (PAHs)

9.6 Groundwater

9.6.1 No significant inflows of groundwater were encountered during the investigation.

9.7 Stability

9.7.1 Stability of excavations within both made and natural ground was generally good.

Summary of Ground Conditions

Site Area	Hole ID	Final Depth (mbgl)	Total Made Ground (mbgl)	Depth to base (mbgl)					Depth to Rockhead (mbgl)	Penetration into rock (m)	Remarks
				Made Ground Topsoil	Tipped Ash	Topsoil	Cohesive Residual Soil	Granular Residual Soil			
A	TP01	2.8	-	-	-	0.3	-	2.0	2.0	0.8	Soakaway test Undertaken. Bedrock is Thornhill Rock Sandstone.
A	TP07	2.0	-	-	-	0.3	-	1.5	1.5	0.5	Bedrock is Thornhill Rock Sandstone.
A	TP08	2.1	-	-	-	0.3	-	1.8	1.8	0.3	Bedrock is Thornhill Rock Sandstone.
B	TP02	2.6	1.0	0.25	1.0	-	-	2.0	2.0	0.6	Soakaway test Undertaken. Bedrock is Thornhill Rock Sandstone.
B	TP03	3.0	1.1	0.25	1.1	-	1.5*	2.8	2.8	0.3	Soakaway test Undertaken. Bedrock is Thornhill Rock Sandstone.
B	TP04	3.2	1.6	-	1.6	-	2.7*	-	2.7	0.5	Soakaway test Undertaken. Bedrock is Coal Measures.
B	TP05	3.2	1.6	-	1.6	-	2.8*	-	2.8	0.4	Bedrock is Thornhill Rock Sandstone.
B	TP06	2.4	0.5	0.25	0.5	-	-	1.8	1.8	0.6	Bedrock is Thornhill Rock Sandstone.
B	TP09	3.1	1.3	0.30	1.3	-	2.9*	-	2.9	0.2	Bedrock is Coal Measures.

* Note: see results of geotechnical testing; Section 14.2.

9.8 Revised conceptual ground model (ground conditions)

9.8.1 The Preliminary Conceptual Site Model has been revised in light of data obtained during the ground investigation, most notably with respect to:

- The presence, nature and distribution of made ground (Ash & Clinker)
- The strength, nature and depth of underlying natural strata
- The nature and distribution of contamination (based on visual/olfactory evidence only)

9.8.2 The revised Conceptual Site Model is presented in Appendix B, as Drawing 2986/7.

9.8.3 Further refinement of the Conceptual Site Model is presented in Section 12.3, where the results of laboratory testing for contaminants have been considered.

10 SOAKAWAY TEST RESULTS

10.1 UK Guidance

10.1.1 General notes about soakaways, including their location, design, and Lithos' test methodology are presented in Appendix A.

10.1.2 UK guidance does not explicitly state that soakaways cannot be constructed in made ground, but such construction is not generally considered good practice. There may be a risk of settlement caused by wash out of fine soil particles if soakaway waters are allowed to infiltrate into made ground. Furthermore, UK guidance does state that the soakaways should not be built where the presence of contamination could result in pollution of groundwater.

10.1.3 CIRIA C753:2015[1] recommends that soakaways should not be constructed 'in ground where the water table reaches a level within 1m below the base of the soakaway at any time of the year'.

10.1.4 BRE Digest 365 "Soakaway Design" advises that each soakaway pit should be filled and allowed to drain three times to near empty on the same or consecutive days.

10.2 Field tests

10.2.1 A total of 10 soakaway tests were carried out in 4 trial pits in general accordance with BRE Digest 365[2] "Soakaway Design". The locations of the soakaways are shown on Drawing 2986/6 presented in Appendix B to this report.

10.2.2 The tests in TPs 3 & 4 were undertaken at depth in natural strata below overlying made ground.

10.2.3 Infiltration rates for each soakaway test have been calculated (where possible) in accordance with BRE Digest 365. This design takes into account time for the water level to fall from 75% to 25% of its effective depth. The effective depth is the difference between the starting water level and the soakaway pit base depth.

10.2.4 Where the water level did not fall to 50% effective depth within 3 hours, the test was not considered suitable for calculation of an infiltration rate; this was the case for the unsuccessful test in TP04.

[1] CIRIA C753. The SUDS Manual (2015).
[2] BRE Digest 365. Soakaway Design (1991).

10.2.5 Calculated infiltration rates for each successful test are summarised in the table below, and copies of the associated calculations are presented in Appendix I to this report.

Site Area	Hole ID	Test No	Stratum	Infiltration rate (m/s)	Remarks
B	TP01	1	Thornhill Rock Sandstone & Granular Residual Soil	1.83 E-03	Soakaway dry after 4 minutes.
		2		1.98 E-03	Soakaway dry after 3 minutes.
		3		1.56 E-03	Soakaway dry after 4 minutes.
A	TP02	1	Thornhill Rock Sandstone & Granular Residual Soil	2.24 E-03	Soakaway dry after 1 minute.
		2		5.15 E-03	Soakaway dry after 1 minute.
		3		3.04 E-03	Soakaway dry after 1 minute.
A	TP03	1	Thornhill Rock Sandstone & Granular Residual Soil	1.06 E-03	Soakaway dry after 6 minutes.
		2		5.68 E-04	Soakaway dry after 8 minutes.
		3		3.78 E-04	Soakaway dry after 16 minutes.
A	TP04	1	Middle Coal Measures Bedrock & Cohesive Residual Soil	N/A	Test did not reach 50% full after 3 hours.

10.3 Discussion & conclusions

10.3.1 Drainage Engineers could use the infiltration rates reported above to determine the feasibility of soakaways as a solution for the discharge of surface water run-off. However, regard must be made to seasonal groundwater levels; UK guidance indicates that the seasonally high groundwater table must be at least 1m below the base the soakaway.

10.3.2 Given the topography of the site, and the location of Chickenley Beck immediately beyond the site's eastern boundary it is considered likely that groundwater levels will lie at moderately shallow depth in the east but at greater depths across the centre and west of the site.

10.3.3 It should be noted that soakaway percolation in bedrock is predominately via joints within the rock mass. It is possible that a soakaway might be constructed which does not intercept joints and therefore does not give a sufficient infiltration rate to work effectively. However given the relatively consistent results within TPs 01 to 03 and the relatively small size of a trial pit excavation this is considered unlikely subject to the comments below.

10.3.4 Tests in TPs 01 to 03 excavated through Granular Residual Soils into Thornhill Rock Sandstone gave consistently good infiltration rates of at least 10^{-4} m/s.

10.3.5 However, the test in TP04 excavated through Cohesive Residual Soils into Middle Coal Measures strata was unsuccessful.

10.3.6 In addition, TP04 was excavated close to Chickenley Beck, in an area which was topographically lower than TPs 01 to 03.

10.3.7 Consequently, soakaways are likely to provide a suitable drainage solution for the discharge of surface water run-off in the centre and west of the site; however, soakaways constructed in the low-lying east of the site might not prove effective.

10.3.8 Leaching of mobile contaminants must be considered during design of the drainage solution; further detail is provided in Section 15.8.

11 CONTAMINATION (ANALYSIS)

11.1 General

11.1.1 The site has been formerly used as farmland with made ground (Ash & Clinker) deposited in the east (c. early 1900s).

11.1.2 The west of the site is not considered likely to be significantly contaminated (historical use as farmland is not considered a 'high risk' activity). However, the centre and east of the site has been used as a historical tip and may contain a number of inorganic and organic contaminants.

11.1.3 In the context of risks to human health associated with residential redevelopment, the Tier 1 Soil Screening Values referenced in this report have been derived via the CLEA default conceptual site model (CSM) used for generating SGVs, but amended, where appropriate, to be more specific to redevelopment within the planning process.

11.1.4 Where available, Category 4 Screening Levels (C4SL) have also been referenced.

11.1.5 Generic Note 04 in Appendix A provides further details with respect to current guidance and the interpretation of analytical data.

11.2 Testing scheduled

11.2.1 Based on the above assessment, Lithos submitted a test schedule (summarised in the table below) to a UKAS accredited laboratory.

Type of sample	No. of samples	Determinands
Ash & Clinker **(Area A)**	5	pH, water soluble boron, and total metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc) & Asbestos ID. Total Organic Carbon (TOC). Speciated Polycyclic Aromatic Hydrocarbons (PAH).
	3	Leachable metals: arsenic, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc. Calorific Value (CV). Water soluble sulphate, chloride, nitrate and magnesium. Banded Total Petroleum Hydrocarbons (TPH).
Made Ground Topsoil **(Area A)**	3	pH, water soluble boron, and total metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc) & Asbestos ID. Total Organic Carbon (TOC). Speciated Polycyclic Aromatic Hydrocarbons (PAH).
Topsoil **(Area B)**	3	

11.2.2 In addition to the above, consideration was given to testing for Dioxins & Furans and pathogens.

11.2.3 **Dioxins & Furans** are both groups of chlorinated tricyclic aromatics and are generally considered together as they are structurally related and share similar chemical properties. Dioxins and furans are always found in mixtures (similar to PAH compounds). All are produced by similar processes which may be natural or anthropogenic. Those that could be associated with this site include:

- Incomplete combustion of organic matter i.e. domestic burning of coal, wood, gas and oil.
- Combustion of chemical, clinical and household waste in incinerators (areal emissions)
- Ash produced by the incinerators

11.2.4 Dioxins & furans have a low volatility and as such are unlikely to pose an inhalation risk if encountered at depth. No analysis for Dioxins & Furans in the Ash & Clinker was scheduled as this material was not anticipated (and the test is very expensive so would not be undertaken as a matter of course). However, the high CV, inorganic and localised organic concentrations require remediation to suitably break direct contact pathways; see Section 12.6. Such remedial action will also address potential exposure from this group of contaminants.

11.2.5 The hospital to the east was originally established to deal with infectious disease. Although it cannot be completely guaranteed, it is considered quite likely that the Ash & Clinker found on site originated from the hospital incinerator.

11.2.6 The purpose of incineration used at such hospitals, whilst used extensively to manage waste, was also a recognised method of destroying disease-contaminated material; indeed this is still a recognised way of managing clinical wastes. **Pathogens** are therefore not considered to present a viable concern at the site.

11.3 Soil contamination results

11.3.1 The soil contamination test results are summarised in the tables on pages 19 to 21.

11.3.2 Laboratory test certificates as received from the laboratory are presented in Appendix G to this report.

Inorganic determinands

11.3.3 Of the 8 samples of made ground analysed for inorganic parameters, all 8 can be classified as contaminated. In addition of the three samples of Topsoil tested, two samples could be classified as contaminated and one sample could be considered uncontaminated.

11.3.4 These samples have been classified by comparison with Tier 1 Soil Screening Values for an end use including domestic gardens and any area where plants are to be grown (the most sensitive of the proposed end-uses).

11.3.5 The most common contaminants are arsenic, lead and zinc, with occasional exceedances of copper.

Calorific value

11.3.6 The Calorific Value (CV) of three samples of Ash & Clinker from within the former Tip, have yielded an average CV of 30 MJ/kg (maximum 33 MJ/kg). Materials whose CVs exceed 10MJ/kg are almost certainly combustible.

Asbestos

11.3.7 No asbestos fibres were identified in any of the Ash and Clinker or Topsoil samples screened.

Summary of degree of soils contamination (inorganics)

Site Area	Expl Hole	Depth (m)	Material	Concentrations in mg/kg unless otherwise stated. Results are quoted to 1 decimal place if <10, and whole numbers if >10. Trigger Level Concentrations are shown in BLUE and assume a **residential with gardens** end-use.												
				pH	As ∞	B~	Cd ∞	Cr x	Cu♣$	Pb ∞	Hg*	Ni	Se	Zn$	CV	Asbestos
					37	5	26	3000	200	200	169	127	350	200	2	
A	TP02	0.50	Ash & Clinker	7.6	**140**	0.6	0.2	23	120	**210**	0.6	43	0.9	110	**29**	N.D.
	TP03	0.40	Ash & Clinker	7.6	**350**	0.8	1.4	47	**310**	**1,100**	4.8	81	2.1	**610**	-	N.D.
	TP04	0.50	Ash & Clinker	7.6	**200**	0.8	0.5	47	**230**	**500**	1.4	54	1.3	**330**	**33**	N.D.
	TP05	0.30	Ash & Clinker	7.7	**230**	0.7	0.5	45	**530**	**510**	1.7	60	1.3	**330**	-	N.D.
	TP09	0.50	Ash & Clinker	7.5	**590**	0.6	0.4	33	**470**	**570**	0.9	42	2.1	190	**29**	N.D.
	TP02	0.10	Made Ground Topsoil	7.4	**160**	0.5	0.4	52	140	**260**	0.9	45	1.3	180	-	N.D.
	TP03	0.10	Made Ground Topsoil	7.4	**170**	0.7	0.6	34	180	**750**	1.5	47	1.2	**320**	-	N.D.
	TP06	0.10	Made Ground Topsoil	7.5	**150**	0.6	0.5	45	180	**500**	1.8	52	1.3	**260**	-	N.D.
B	TP01	0.10	Topsoil	7.8	31	0.4	0.5	33	65	190	0.6	28	0.7	160	-	N.D.
	TP07	0.10	Topsoil	7.9	**46**	0.4	0.5	38	78	**350**	0.7	30	1	170	-	N.D.
	TP08	0.10	Topsoil	7.9	**40**	0.5	0.3	42	72	170	0.6	26	0.9	140	-	N.D.

Key		Source of guidance trigger level	
36	Parameter tested for and found to be in excess of Tier 1 value.	With the exception of those annotated with one of the symbols below (∞, $, ~), all Soil Screening Values in brackets above have been derived using CLEA v1.06.	
179	Parameter tested for and found to be > 5 x Tier 1 value.		
12	Parameter tested for but not found to be in excess of Tier 1 value.	∞	Category 4 Screening Level – SP1010, December 2013 (CL:AIRE/Defra).
-	Parameter not tested for.	$	MAFF. Code of Practice for Agricultural Practice for the Protection of Soil, 1998.
♣	Tier 1 Value is pH dependent.	*	Assumes mercury present as an inorganic compound (cf elemental metal or within organic compound). See Science Report SC050021/Mercury SGV.
x	Assumes Cr is CrIII. If demonstrated Cr is CrVI Tier 1 would be 21mg/kg.		
ND	No fibres detected (asbestos screen)		
~	Engineering judgement (Lithos). Boron is a phytotoxic, although most phytotoxic compounds can pose a risk to human health if sufficient concentrations are present. However, plants represent the most sensitive receptor, and a Tier 1 value which is protective of flora is therefore also protective of human health.		

Summary of the leachability testing

Site Area	Depth (m)	Material	Concentration in µg/litre unless otherwise Shown. Results are quoted to 1 decimal place if <10, and whole numbers if >10. Tier 1 Screening Concentrations are shown in **BLUE**.									
			pH	As ~	B *	Cd ~	Cr ~	Cu ~	Pb ~	Hg ~	Ni ~	Se *	Zn ~
				50	1	5	5	5	50	1	50	10	30
A	0.5	Ash & Clinker	9.1	**84**	< 20	< 0.08	**9.3**	3	< 1.0	< 0.5	< 1.0	< 1.0	< 1.0
	0.5	Ash & Clinker	8.0	33	**31**	< 0.08	2.6	3.8	< 1.0	< 0.5	< 1.0	< 1.0	< 1.0
	0.5	Ash & Clinker	7.4	10	< 20	< 0.08	< 1.0	2.9	2.2	< 0.5	< 1.0	< 1.0	3.6

Key		Source of guidance trigger level	
36	Parameter tested for and found to be in excess of Tier 1 concentration	~	Directive (2000/60/EC) establishing a framework for Community action in the field of water policy (Water Framework Directive)
0.3	Parameter tested for but not found to be in excess of Tier 1 concentration	*	Water Supply (Water Quality) Regulations 1989, as amended in 2000

Summary of degree of soils contamination (organics)

Site Area	Expl Hole	Depth (m)	Material	Concentrations in mg/kg. Results are quoted to 1 decimal place if <10, and whole numbers if >10. Trigger Level Concentrations are shown in BLUE and assume a **residential with gardens and 600mm** cover end use					
				% TOC	PAH		TPH - C6 to C40		
					B(a)P ∞	Naphthalene	GRO~ C_6 to C_{10}	DRO◊ C_{10} to C_{21}	LRO C_{21} to C_{40}
					25	9	34	156	5000
A	TP02	0.50	Ash & Clinker	8.6	< 0.1	< 0.1	< 1.0	< 1.0	< 1.0
	TP03	0.40	Ash & Clinker	27.0	0.7	4.3	-	-	-
	TP04	0.50	Ash & Clinker	17.0	**37**	**130**	< 1.0	36	50
	TP05	0.30	Ash & Clinker	19.0	1.8	6.3	-	-	-
	TP09	0.50	Ash & Clinker	9.6	0.2	3.3	< 1.0	5.7	20
	TP02	0.10	Made Ground Topsoil	11.0	0.9	3.4	-	-	-
	TP03	0.10	Made Ground Topsoil	18.0	5.8	**12**	-	-	-
	TP06	0.10	Made Ground Topsoil	8.9	3.6	2.7	-	-	-
B	TP01	0.10	Topsoil	5.3	10	8.4	-	-	-
	TP07	0.10	Topsoil	5.2	8.7	1.9	-	-	-
	TP08	0.10	Topsoil	4.6	1.3	0.8	-	-	-

Key		Source of guidance trigger level	
60	Parameter tested for and in excess of Tier 1 concentration.	All Soil Screening Values in brackets above have been derived using CLEA v1.06. Values assume contaminants located in a sandy loam, with 6% soil organic matter (SOM).	
0.3	Parameter tested for but not in excess of Tier 1 concentration.		
-	Contaminant not tested for.	◊	Assumes all DRO is aliphatic fraction C10 to C12.
~	Assumes all GRO is aromatic fraction C7 to C8.	∞	Category 4 Screening Level – SP1010, December 2013 (CL:AIRE/Defra).

Leachables

11.3.8 Of the leachability tests conducted on three samples of Ash and Clinker two samples had concentrations of leachable contaminants above the maximum permissible concentrations as defined in the Water Supply (Water Quality) Regulations 1989, as amended in 2000.

11.3.9 Given 2 of the 3 samples analysed for leachability reported elevated concentrations the Ash and Clinker cannot be considered completely inert. Leachability is not considered overly significant due to the following factors:

- Groundwater which would drive the leaching of contaminants was not encountered in the Ash & Clinker in any of the exploratory holes.
- The leachability testing process is much more aggressive and direct than the 'real world' scenario which comprises more steady and gentle infiltration of rainwaters.
- Turnover of made ground is anticipated. Turnover and subsequent compaction during placement is expected to reduce the permeability of the made ground reducing the volume of surface water which might infiltrate through it.
- Gardens and green spaces will include a 1,000mm clean capping layer (see Section 12.6) which will reduce the infiltration of surface water.
- Construction of highways, roofs, hardstanding etc during development will result in a reduction in the volume of surface waters infiltrating into the ground.
- Soakaways are envisaged to be the chosen drainage solution (see below) which are likely to direct groundwater into natural strata below the made ground, essentially bypassing the leachable contaminants.

11.3.10 However, whilst there are a number of possible sources that could influence surface water quality in the surrounding area, it would be prudent to obtain up and down gradient surface water samples to provide a further line of evidence that this site is not contributing to any deterioration of surface water quality.

11.3.11 Whilst not readily soluble in water, dioxins & furans will attach to small particles of organic matter, plants and plankton. Organic matter, washed into surface waters, typically settles out into sediment and any sampling of the surface water should include up and down gradient kick samples to collect sediment.

11.3.12 Leachability should be considered during design of the development's drainage strategy; see comments in Section 15.8.

Organic determinands

11.3.13 The centre and west of this site is underlain by Ash & Clinker (a former Tip) which has yielded significantly elevated concentrations of a number of inorganic contaminants and is also considered to be combustible. Therefore, for organic compounds, the Tier 1 Values used in this report have been derived with reference to a CSM that assumes a minimum 600mm of clean soil cover will be placed in gardens/landscaped areas (Lithos Scenario B).

11.3.14 Lithos have used the CLEA model to derive risk-based screening values for hydrocarbons, in accordance with the methodology detailed by the TPHCWG, and reviewed by a UK workshop of experts with respect to UK adoption of the method.

11.3.15 However, these screening values assume a Soil Organic Matter (SOM) of 6% (equivalent to a TOC of 3.5%). Many organic contaminants are more mobile when the SOM is lower, and consequently comparison of soil results with lower screening values may be required.

11.3.16 In order to check the validity of Lithos' Tier 1 Soil Screening Values, the average TOC for each common fill type (beyond any areas of obvious hydrocarbon impact) have been determined.

Fill type	Typical TOC (%)	Comparison of soil results with revised screening value necessary?
Ash & Clinker	14%	No.
Topsoil & Made Ground Topsoil	8%	

Hydrocarbons (TPH)

11.3.17 Given the previous uses of the site and the absence of visual/olfactory evidence of any hydrocarbon contamination, only a simple banded TPH (cf full speciation) was initially scheduled on three samples of Ash & Clinker.

11.3.18 Assessment of TPH would normally be undertaken in accordance with a 3-step approach, (outlined in Generic Note 04 in Appendix A) on fully speciated TPH results. However, although only banded TPH analysis has been scheduled here, none of the fractions exceed their respective Tier 1 criteria, even if it is conservatively assumed all of each fraction is either aliphatic or aromatic.

11.3.19 Consequently, no significant petroleum hydrocarbon concentrations have been identified.

Hydrocarbons (PAH)

11.3.20 There are numerous PAH compounds. The USEPA identified 16 PAHs that are considered to represent the most problematic in terms of toxicology, fate and behaviour. The UK have also focused on these 16 and these are included in the laboratory report where speciated PAH analysis has been scheduled.

11.3.21 Speciated PAH analysis has been undertaken in order to determine concentrations of the key "marker" compounds: benzo(a)pyrene (considered the most toxic of the PAHs); and naphthalene (the most mobile and volatile of the PAHs).

11.3.22 Speciated analysis has confirmed the presence of benzo(a)pyrene in a single sample of Ash & Clinker (TP04 at 0.5m); and, naphthalene in one sample of Ash & Clinker and one sample of Made Ground Topsoil.

12 CONTAMINATION (QUALITATIVE RISK ASSESSMENT & REMEDIATION)

12.1 Topsoil

12.1.1 Topsoil, including made ground Topsoil, typically 0.25m thick is present across the site. Testing suggests this material is not suitable for re-use.

12.2 Summary of significant contamination

12.2.1 A former Tip is located in Area A in the centre and east of the site which comprises Ash & Clinker (maximum depth of 1.6m). The Ash & Clinker is contaminated with inorganic and organic contaminants and is also potentially combustible. In addition, the Ash & Clinker contains a number of materials (glass, metal etc) which are considered undesirable as near surface materials in garden and landscaped areas.

12.2.2 The approximate footprint of the former tip is shown on Drawing 2986/9 in Appendix B.

12.3 Revised conceptual ground model (contamination)

12.3.1 The conceptual site model has been revised with regards to:

- The nature and distribution of contamination beneath this site.

12.3.2 A revised Conceptual Site Model is presented as Drawing 2986/7 in Appendix B. The Model includes the contaminants described in Section 12.2 above, and potential pollutant linkages (summarised below in Section 12.5) to receptors.

12.4 Environmental setting & end use

12.4.1 As discussed in Section 12.2 above, contamination exists in the soils beneath this site. In order to assess the significance of this contamination, consideration must be given to the site's environmental setting and the proposed end use.

12.4.2 The underlying Thornhill Rock sandstone and Coal Measures bedrock are classified as a Secondary A aquifer. The nearest surface watercourse is Chickenley Beck which flows to the south immediately beyond the site's eastern boundary. Therefore, the site's environmental setting is considered to be of moderate sensitivity.

12.4.3 With respect to human health, the proposed end use (residential) is considered sensitive.

12.4.4 Transient risks to construction workers can be addressed by the adoption of appropriate health and safety measures, see Section 16.6.

12.5 Pollutant linkages

12.5.1 In terms of a proposed redevelopment of this site, plausible pollutant linkages can be summarised as follows.

Contaminants

12.5.2 Contaminants have been summarised in Section 12.2 above.

Pathways

12.5.3 Potential contaminant pathways include:

- Ingestion
- Dermal contact
- Inhalation of contaminated particulates
- Surface water run-off, including existing drainage infrastructure
- Downward infiltration of leachable/mobile contaminants to groundwater and Chickenley Beck

Receptors

12.5.4 Potential contaminant receptors include:

- The environment – Secondary A aquifer and Chickenley Beck
- End users of the site (residents)

12.5.5 It can be concluded that there are plausible pathways between the soil contaminants summarised in Section 12.2 above and potential receptors i.e. end users and the environment. Consequently, some remediation will be required; either treatment/removal of the contaminant, or "breakage" of the pathway.

12.6 Potential remediation options

12.6.1 Approval of the recommendations given below should be sought from the appropriate regulatory authorities prior to commencement of site redevelopment.

Combustibility

12.6.2 The Ash and Clinker at this site yielded an average CV of 30 MJ/kg and is considered combustible and, in accordance with current guidance, the following remediation measures should be adopted if it is left on site:

- Garden areas: isolate beneath a minimum 1,000mm thickness of inert soil, comprising 850mm of "clean" subsoil plus 150mm topsoil.
- Services: utility trenches (especially those carrying potential heat sources e.g. electric cables) should be cut oversize and backfilled with clean, inert material. This applies to any utility trenches that run beneath estate roads or extend under houses. It is strongly recommended that further advice be sought from all statutory service bodies with respect to the ground conditions within which they will lay services.
- Estate roads: no action required (although generally less than 1,000mm thick, the road construction is considered to provide adequate isolation as there will be no heat source). Local Authority Highways approval should be sought.
- Houses: no action required (the floor slab will include insulation and therefore heat transfer into the ground will be negligible). Local Authority Building Control and Warranty Provider approval should be sought.

12.6.3 As further mitigation against the risk of spontaneous combustion, the ash could be excavated, replaced in approximate 300mm thick layers, wetted and subjected to nominal compaction, comprising at least 2 passes with a towed vibratory roller of at least 2,900 kg per metre width. Compaction will help to prevent the material drying out and reduce the ingress of oxygen.

Inorganic contamination

12.6.4 Elevated concentrations of inorganic contaminants have been identified in the Topsoil, Made Ground Topsoil and the Ash and Clinker with significantly elevated concentrations (i.e. > 5 times Tier 1 values) recorded in the Made Ground Topsoil and the Ash & Clinker.

12.6.5 The proposed 1,000mm cover over the Ash & Clinker is considered sufficient to break potential pollutant linkages between the contaminated made ground and future end-users.

12.6.6 The uppermost 600mm of cover should comprise 'clean' soils, however, the lowermost 400mm could comprise inert materials such as natural foundation arisings, granular sub-base or imported screened crushed demolition materials etc.

12.6.7 Existing Topsoil and Made Ground Topsoil should be excavated and removed from site or isolated beneath a minimum 600mm clean cover. Given the compressible nature and gas-generating potential of this material if buried at depth, it is recommended that it is placed in garden or landscaped areas, immediately beneath the proposed 600mm cover, and that it is overlain by no more than 1m of soil.

12.6.8 Topsoil at this site is not considered suitable for placement beneath hardstand, roads etc.

12.6.9 Garden and landscaped areas underlain by natural Residual Soils (Area B) simply require provision for placement of 300mm of Topsoil in order to provide a suitable growing medium for plants etc.

Organic contamination

12.6.10 The Ash & Clinker does contain a significant proportion of clinker and coal which are commonly associated with high concentrations of PAHs. Organic compounds bound within coal and clinker are significantly less mobile than those within fuel/oil spills. Consequently, it is considered that the naphthalene found here is significantly less volatile / mobile than would be expected if it were associated with a hydrocarbon spill/leak.

12.6.11 The recommended 1,000mm of clean cover should act as a suitable barrier to isolate end users from organic contaminants within the Ash & Clinker.

12.6.12 Dioxins & furans have a low volatility and as such are unlikely to pose an inhalation risk if encountered at depth. Dioxins & furans bind very strongly to organic matter within soil; as such they are not likely to contaminate groundwaters through vertical migration but may persist in soils for many years due to their chemical stability and resistance to biodegradation and photodegradation.

12.6.13 The proposed 1.0m cover will break direct contact pathways and thereby address potential exposure from this group of contaminants.

12.7 Summary of potential pollutant linkages & mitigation

12.7.1 In terms of the proposed redevelopment plausible pollutant linkages, and feasible remediation options, can be summarised as follows:

Receptors	Pathways	Contaminants	Plausible pollutant linkage? (and remediation options where required)
Human health (Future residents) ◊	Consumption of contaminated vegetables	Inorganics (metals)	Isolation beneath at least 1,000mm clean soil cover in garden and landscaped areas
	Ingestion	Inorganics (metals) & organics (PAHs)	
	Dermal contact		
	Inhalation (dust and/or vapours)		
Groundwater & Chickenley Beck	Surface water run-off	Metals, hydrocarbons in the made ground	Careful consideration during design of drainage solution

◊ transient risks to construction workers will be addressed by the adoption of appropriate health and safety measures in accordance with the Health and Safety at Work Act 1974 and regulations made under the Act including for example the COSHH Regulations.

12.8 Waste classification

12.8.1 Disposal of the made ground off site is generally not considered appropriate, economically viable, nor in line with current Government philosophy regarding sustainable development. However, some excess arisings may be generated by excavations for foundations, sewers etc. Disposal to landfill (or an appropriate soil / aggregate transfer station) may be the most practical solution, if redistribution and retention on site is not feasible.

12.8.2 Following excavation and stockpiling, sampling will be required prior to disposal.

12.8.3 As there is no WRAP protocol for soils, the characterisation, sampling and classification of soils arising from brownfield sites has been incorporated within the Environment Agency's Technical Guidance WM3[3]. Classification of soils as inert, non-hazardous or hazardous in accordance with WM3 is quite a complex process.

12.8.4 If waste soil is classed as hazardous following classification under WM3, and destined for landfill, waste acceptance criteria (WAC) leachate testing will need to be undertaken. However, non-hazardous soil waste can go to a non-hazardous landfill facility; no further testing (e.g. WAC) is required.

12.8.5 WAC analysis is different to the 'routine' laboratory testing (such as that included earlier in this Section) undertaken in order to determine hazardous properties. Lithos typically only include WAC analysis if significant off-site disposal (of soil classified as hazardous waste) is anticipated.

12.8.6 It is critical if material is to be exported from site that this is allocated an appropriate waste code, following the steps within WM3. Waste carriers transporting, and sites accepting, this material should have a corresponding code within their permits. It is the responsibility of those generating the waste (i.e. the site), to ensure that the waste is handled and disposed of appropriately.

[3] Technical Guidance WM3 – Guidance on the classification and assessment of waste. Environment Agency 2015

12.8.7 Soil treatment facilities (STFs) provide an alternative to landfill. STFs are regulated by the Environment Agency and allow soils to be treated and screened (effectively recycled to be used at other sites). Export to an STF does not require WAC testing and suitability of various soil types will be dependent on material waste codes, which may be allocated after consideration of the data in Section 11 but will often need supplementing with further testing after soils have been stockpiled (see also advice in Section 16.3).

12.8.8 Most STFs are permitted to accept soils with waste code 17 05 04 (i.e. soils which do not exhibit hazardous properties). Lithos has a list of permitted STFs and can help identify one local to this development site.

12.8.9 With respect to asbestos, waste soils will be classed hazardous if the soil mass contains more than 0.1% asbestos fibres that are free and dispersed. However, WM3 states that where the waste contains identifiable pieces of asbestos (i.e. any particle of a size that can be identified as potentially being asbestos by a competent person if examined by the naked eye), then the waste is hazardous if the concentration of asbestos in the pieces alone is 0.1%. If a stockpile of soil contained rare fragments of broken asbestos-cement sheeting, the whole stockpile would be classed as hazardous unless all the fragments could be picked-out (even though the concentration of asbestos in the soil mass might be orders of magnitude less than 0.1%).

13 HAZARDOUS GAS

13.1 Radon

13.1.1 The Public Health England UK radon map and the Landmark report indicate that the site is in an area where between 3% and 5% of homes are estimated to be above the action level, and basic radon protection measures are required in new dwellings.

13.1.2 In accordance with BR211:2015, basic radon measures simply comprise a barrier (membrane) laid within the floor construction, which is linked to a damp-proof course (DPC) within the walls of the building. The DPC to cavity walls should be in the form of a cavity tray to prevent radon entering the building through the cavity. Sealing of joints in the barrier and sealing around service penetrations are also required. A 1200-gauge polythene membrane should suffice, and sub-floor ventilation is not essential.

13.1.3 BRE211:2015 highlights the importance of good practice and workmanship to ensure radon membranes are installed to a high standard and suggests regular supervision and inspection. Whilst there are no specific statutory requirements to inspect radon barriers, BRE and Lithos strongly recommend a programme of inspections.

13.1.4 It is not deemed necessary to inspect each barrier before it is covered but Lithos would suggest the first plot is inspected and 1 in 20 plots thereafter.

13.2 Methane & carbon dioxide

13.2.1 There are 3 potential sources of hazardous gas:

- Made ground (predominantly Ash & Clinker), up to 1.6m thick, has been tipped in the east of the site (Area A), most likely above original ground (rather than as backfill to a former pit/quarry) to reduce the slope down to Chickenley Beck.
- Earthworks about 20m beyond the site's eastern boundary, beyond Chickenley Beck, associated with the former hospital; see Section 3 & Drawing 2986/8.
- An off-site landfill (1970s), located about 230m to the west; see Section 4.2 & Drawing 2986/8.

13.2.2 Risks posed by the made ground in Area A ('old tip') and the off-site earthworks east of Chickenley Beck are considered low as:

- The made ground (Ash & Clinker) has been found to contain very little degradable material and is not of an overly significant thickness (only 1.6m);
- The earthworks are also likely to comprise essentially inert soil with minimal degradable content and a low likelihood of giving off hazardous gas.

13.2.3 Risks posed by the off-site landfill are considered very low as:

- The landfill is located 230m away;
- Waste was deposited in the 1970s and is likely to have included a significant proportion of inert waste;
- The River Calder lies between the landfill and this site. The river and significant associated flowing groundwater beneath/around the river is likely to act as a barrier to hazardous gasses; and,
- The landfill is placed within Alluvial deposits. The site is sat on Coal Measures bedrock. It is considered unlikely that ground gasses would migrate from alluvium into relatively impermeable Coal Measures Bedrock rather than simply venting into the atmosphere.

13.2.4 Whilst the risk of hazardous ground gas migrating on to this site is considered low but cannot be entirely discounted. Basic radon protection measures are required anyway and will afford protection against any low levels of hazardous gas which may migrate to the site.

13.2.5 However, it would be prudent to increase protection measures to comply with Amber 1 requirements **or** install 5 monitoring wells and undertake gas monitoring (9 visits over 6 months). Assuming the latter allowed a less onerous classification of Green/CS2 (equivalent to basic radon measures), gas monitoring would likely be less costly than installation of Amber 1 measures in 16 new dwellings. However, whilst it is considered reasonably likely that monitoring would allow a less onerous classification of Green/CS2, this cannot be guaranteed, and therefore it might be that the developer incurs costs with both monitoring and Amber 1 measures.

13.2.6 Assuming Amber 1 measures are adopted, and subject to agreement of NHBC and Wakefield City Metropolitan District Council, they would comprise (for information only at this stage, the table overleaf also outlines requirements for Green/CS2 (basic radon) measures:

Traffic light classificn and "score" req'd by BS8485#	Floor slab (BS8485 "score")	Protective measures	
		Sub-floor ventilation (BS8485 "score")	Membrane
			Type (BS8485 "score")
Green & **CS2** (Wilson & Card) **2.5***	*Select one from:* i. Block & Beam – **(0)**. ii. Reinforced ground bearing slab – **(0.5)**. iii. Reinforced, cast in-situ suspended slab (with minimal and suitably sealed service penetrations & joints) – **(1.5)**. iv. Reinforced ground bearing raft (with limited service penetrations cast into slab). Note: the venting area through any downstand beam should be 3 times greater than that provided by the side ventilation (air bricks) – (1.5).	*Select one from:* Passive sub-floor ventilation; venting layer could be: i. A min. 150mm clear void (2.5), or ii. A proprietary void former providing an equivalent clear void depth of 60mm; see Section B7 in BS8485:2015 (2.5), or iii. Min. 300mm thick blanket of min. 20mm single size gravel (1.0). Min. ventilation = 1,500 mm^2/m run of external wall (via air bricks on each of 2 opposite sides), with 100mm pipes at 1.75m centres or honeycombing of any sub-floor sleeper walls.	Waterproof DPM (2000 gauge polyethylene). Lapped & sealed in accordance with BR 414. **(0)**
Amber 1 **3.5**	*Select one from:* i. Block & Beam – **(0)**. ii. Reinforced ground bearing slab – **(0.5)**. iii. Reinforced, cast in-situ suspended slab (with minimal and suitably sealed service penetrations & joints) – **(1.5)**.	*Select one from:* Passive sub-floor ventilation; venting layer could be: i. A min. 150mm clear void (2.5), or ii. A proprietary void former providing an equivalent clear void depth of 60mm; see Section B7 in BS8485:2015 (2.5), or iii. Min. 300mm thick blanket of min. 20mm single size gravel (1.0). Min. ventilation = 1,500 mm^2/m run of external wall (via air bricks on each of 2 opposite sides), with 100mm pipes at 1.75m centres or honeycombing of any sub-floor sleeper walls.	Gas resistant membrane meeting all of the following criteria: • sufficiently impervious to gases with a methane gas transmission rate <40.0 ml/day/m^2/atm (average) for sheet and joints (tested in accordance with BS ISO 15105-1 manometric method); • sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions; • sufficiently strong to withstand in-service stresses (e.g. settlement if placed below a floor slab); • sufficiently strong to withstand the installation process and following trades until covered (e.g. penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, tearing due to working above it, dropping tools, etc); • capable, after installation, of providing a complete barrier to the entry of the relevant gas; and • a minimum 0.4 mm thickness (1600g polyethylene) reinforced membrane (virgin polymer) • verified in accordance with CIRIA C735∞ **(2.0)**

Footnotes:

\# Scores are broadly based on those outlined in BS8485:2015 (for Characteristic Situations 2 & 3, and Building Type A).

* Modified from BS8485:2015 by Lithos. Monitoring data has also been reviewed using Wilson & Card methodology and found to be Characteristic Situation 2.

∞ In accordance with CIRIA C735, a Verification Plan should be prepared which outlines the activities (inspection and testing), the relevant personnel, and the type of records to be collected. Gas membranes need to be visually inspected to establish possible damage. For Amber 2 sites inspection & verification should be carried out by an independent third party. However, whilst conflicts of interest in verification should be avoided, the Developer's staff on site could undertake inspection & verification on Amber 1 sites. In all circumstances, the verifier should be competent, experienced and suitably trained.

Note NHBC guidance only requires membranes to be certified on Amber 2 sites. However, BS8485 is considered to 'outrank' NHBC guidance, and it would be prudent to comply with this Standard and CIRIA C735. Furthermore, (YALPAG) local authorities have issued guidance requiring a detailed verification method statement in advance of the construction phase. This should address how gas measures will be installed and what verification information will be provided to demonstrate that installation has been carried out in accordance with the appropriate guidance.

1. A combination of 2 or more of the 3 types of protection (slab, ventilation & membrane) should be used to achieve the BS8485 score.
2. The membrane should always be lapped and sealed in accordance with BRE\Environment Agency Report BR 414 (2001) – "*Protective Measures for housing on gas-contaminated land*". The membrane should be **continuous** across internal walls & the cavity, and there should be a **cavity tray** in external walls.
3. In all cases there should be minimum penetration of floor slab by **services**; any penetrations should be suitably sealed.
4. Integral **garages** with occupied rooms above, or direct access through a doorway from the garage to the house, should be provided with the same protective measures as the rest of the dwelling. Buildings with basement car parks (with ventilation in accordance with Building Regulations) may not require gas resistant membranes.

13.2.7 In accordance with recent YALPAG guidance[4], a detailed verification method statement should be issued to Wakefield City MDC in advance of the construction phase. This should address how the gas protection measures will be installed and what verification information will be provided to demonstrate the installation has been carried out in accordance with the appropriate guidance. As a minimum the report should include (but not be limited to):

- A summary of the gas risk assessment.
- The gas protection measures proposed and confirmation they will meet the gas protection requirements for the lifetime of the development.
- Technical drawings showing how the gas protection measures will be incorporated.
- Formal qualifications/experience/training of the person carrying out the installation.
- Formal qualifications/experience/training of the person carrying out the verification.
- Clear demonstration of the independence of the person carrying out the verification.
- The manufacturer's specification of the gas protection membrane to be used.
- Full details of what the verification process will comprise and at what stage verification will be carried out.
- Details of how any non-conformance will be dealt with.
- Details of the number of plots to be validated.
- Timeline of when during the build, each of the gas protection measures will be installed.
- Details of management measures proposed to ensure how damage to the membrane will be prevented prior to the floor being installed, post installation.
- Details of how all site personnel (including follow-on trades) will be made aware of the presence of the membrane and that damage to the membrane must be prevented.
- Details of the extent of overlap and method of sealing.

13.2.8 BRE\Environment Agency Report BR 414 (2001) – "*Protective Measures for housing on gas-contaminated land*" provides a practical guide to good practice for the detailing and construction of passive soil gas protection measures for new residential development. Of particular relevance are a list of 'Watchpoints', which offer practical information for installation and buildability.

[4] *Verification Requirements for Gas Protection Systems - Technical Guidance for Developers, Landowners and Consultants. Yorkshire and Lincolnshire Pollution Advisory Group, December 2016.*

14 GEOTECHNICAL TESTING

14.1 General

14.1.1 A total of 7 samples of natural soil were delivered to a suitably accredited laboratory with a schedule of geotechnical testing drawn up by Lithos.

14.1.2 The geotechnical laboratory test results are presented in Appendix H to this report.

14.2 Atterberg limits

14.2.1 The plasticity indices of 4 samples of cohesive soil have been determined; results are summarised below.

Soil type	No. samples tested	Moisture content range (average)	Range of Plasticity Indices* (average)	Shrinkability
Cohesive Residual Soil	4	9 – 14 (12)	2 – 12 (7)	Not shrinkable

* Modified where appropriate in accordance with Chapter 4.2 of the NHBC Standards.

Note. The term Shrinkability is equivalent to the term Volume Change Potential used in Chapter 4.2.

14.2.2 Laboratory testing suggests that samples of material logged in the field as Cohesive Residual Soil are actually clayey Granular Residual Soil and are not shrinkable.

14.3 Particle size distribution

14.3.1 The grading of 4 samples of material logged in the field as Cohesive Residual Soil has been determined by wet sieving and the results are summarised in the table below:

Sample & depth	Field description	% passing 37.5mm sieve	% passing 20mm sieve	% passing 2mm sieve	% fines	Material description (based on grading & plasticity)
TP03 – 1.3m	Very sandy clayey SILT.	100	84	67	20	Very gravelly silty/clayey SAND.
TP04 – 1.9m	Slightly sandy silty CLAY.	100	52	46	9	Sandy clayey slightly silty SAND.
TP05 – 2.3m	Very sandy slightly gravelly SILT.	100	89	81	18	Slightly gravelly slightly silty slightly clayey SAND.
TP09 – 2.0m	Very sandy CLAY.	100	82	27	7	Slightly silty slightly clayey SAND.

14.3.2 Fines (silt and clay) were found to comprise between 7% and 20% (average 14%) of the material sampled. NHBC Chapter 4.2 considers shrinkable soils to be those containing more than 35% fines and having a Modified Plasticity Index greater than 10%.

14.3.3 All residual soils encountered on this site can therefore be regarded as non-shrinkable.

14.3.4 The exploratory hole logs have been amended and all Residual Soils at this site can now be considered to be essentially granular.

14.4 Soluble sulphate and pH

14.4.1 In accordance with BRE Special Digest 1:2005, this site has been classified as brownfield with a mobile groundwater regime.

14.4.2 It is envisaged foundations will extend to depths of up to about 2.5m through made ground and natural strata and samples taken from this depth range have been submitted for pH and water-soluble sulphate (2:1 soil/water extract).

14.4.3 The concentrations of sulphate in the aqueous natural soil extracts of 7 samples were determined. In addition, three samples of made ground were tested as part of the contamination suite. The pH value of each sample has also been determined.

14.4.4 The highest water-soluble sulphate concentration and the lowest pH value for each soil type analysed are shown in the table below.

Soil type	No. samples tested	Lowest pH values	Highest soluble sulphate concentration (mg/l)
Ash & Clinker	3	7.5	16
Residual Soil	5	6.8	30
Thornhill Rock/Coal Measures (bedrock)	2	6.9	50

14.4.5 pH values were all above 5.5, therefore concentrations of chloride and nitrate are considered insignificant.

14.4.6 In accordance with Tables C1 and C2 of SD1, sub-surface concrete should be Design Sulphate Class DS-1, with the site allocated an ACEC Classification of AC-1.

14.5 Undrained shear strength testing

Hand shear vane testing

14.5.1 Hand shear vane testing was undertaken within trial pits where suitable cohesive soils (i.e. clays which were not too sandy/gravelly) were encountered.

14.5.2 The results of hand vane tests are presented on the exploratory hole logs.

14.5.3 Hand vane test results generally suggest that the Cohesive Residual Soils are of medium strength.

15 GEOTECHNICAL ISSUES

15.1 Conceptual site model

15.1.1 The conceptual site model has been amended - material initially logged in the field as Cohesive Residual Soil is actually clayey Granular Residual Soil.

15.1.2 Made Ground (Ash & Clinker) underlies Area A to a maximum depth of 1.6m.

15.1.3 Natural soils comprise Granular Residual Soils, with sandstone bedrock encountered from 1.5m to 2.8m depth.

15.2 Mining & quarrying

15.2.1 This site is located within a Coal Mining Development Low Risk Area. The shallowest coal is the Joan Coal which is anticipated at greater than 30m depth beneath the site. No coal mining surface instability issues are anticipated, and an intrusive mining risk assessment is not considered necessary.

15.2.2 There are no known quarries on, or within 50m of the site.

15.3 Site regrade and/or ground improvement

15.3.1 Ash & Clinker (a former Tip) currently underlies Area A deepening from west to east up to a maximum 1.6m depth. This made ground is of variable and poor strength and is therefore not considered a suitable foundation material. It has also yielded elevated concentrations of a number of inorganic and organic determinands and contains materials (e.g. glass, metal, clinker etc), which would generally be considered undesirable as a near-surface material in garden areas.

15.3.2 Given the substantial volume of made ground present, export to landfill is unlikely to be economically viable.

15.3.3 Consideration could be given to turnover (excavation, screening and replacement in engineered layers) of the full thickness of made ground beneath the site, although given the absence of obstructions and mobile contaminants such earthworks should probably be restricted to ground beneath proposed highways which should yield CBR values in excess of 3%, thereby reducing abnormals associated with the construction of estate roads and car parking areas. Excavations through the engineered fill, for drainage etc and foundations should be stable with little overbreak.

15.3.4 Given existing topography (much of the site is sloping, with gradients of up to 1v:7h in the centre-east), some site regrade is anticipated, with the need for underbuild and retaining walls.

15.3.5 Careful consideration will need to be given to earthworks design, and implications for slope stability, retaining walls, foundations, highway gradients and drainage

15.3.6 Any digital terrain modelling undertaken or commissioned by the developer should consider implications for the foundation recommendations outlined below.

15.3.7 Natural ground underlying this site is often clayey, therefore consideration should be given to the implication of undertaking earthworks in poor/wet weather when the ground surface is likely to become difficult to cross with heavy machinery.

15.3.8 Wherever possible, Lithos recommend that excavated soils are retained on site. However, if this is not possible the comments in Section 12.8 should apply.

15.4 Foundation recommendations

General

15.4.1 Foundation recommendations assume that development will be two or three storey construction and that line loads will not exceed 90kN/m run. If this is not the case significant alteration to these recommendations will be required.

15.4.2 We have assumed that final development levels will not differ significantly from ground levels existing at the time of investigation. Any digital terrain modelling undertaken or commissioned by the developer should consider implications for the foundation recommendations outlined below.

15.4.3 Made ground is not considered a suitable foundation material and foundations should therefore be taken through these materials into underlying natural strata of adequate bearing capacity.

15.4.4 Sub-surface concrete in contact with the made and natural ground should be Design Sulphate Class DS-1, with the site allocated an ACEC Classification of AC-1.

15.4.5 Strip/trenchfill footings are considered the most suitable foundation solution option for two or three storey residential properties constructed on this site and these are discussed below.

Strip/trench fill footings

15.4.6 It is considered that shallow strip or deepened trench fill footings will be the most suitable foundation solution for two or three storey houses constructed at the site. Footings will be founded in residual soils or competent rock.

15.4.7 Reinforcement, as a precaution against differential settlement, is recommended only where foundation excavations encounter significant lateral and vertical variations in strata. One layer of B385 mesh placed 75mm above the base of the footing is likely to provide suitable reinforcement, but further advice should be sought from the Structural Engineer.

15.4.8 Foundations will be required to be placed below a line drawn up at 45° from the base of any service or similar excavation.

15.4.9 Overdeepened foundations should be stepped in accordance with NHBC Standards, Chapter 4.4.

15.4.10 In order to minimise loosening of granular soils, it is recommended that footings are cast as soon as formation level is reached (or alternatively the formation could be blinded using concrete with as low a water:cement ratio as possible).

15.4.11 Whilst strip or trench fill footings generally represent a simple and inexpensive foundation solution, there are a number of potential disadvantages associated with their use on this site:

- The made ground contains elevated concentrations of some inorganic contaminants and a 1,000mm thick cover of clean subsoil (see Section 12.6) has been recommended. Subject to final remediated development levels, this cover is likely to increase footing depth/underbuild.
- Disposal of arisings will be required.
- Foundation and drainage excavations will almost certainly require shoring in made ground.

15.4.12 In addition to the above, the developer should review proposed plot designs and layouts since deeper excavations for trench fill are likely to be unstable where the centre-lines of parallel trenches are closer than about 2m (assuming 600mm widths). The developer should supervise their groundworker to ensure footings are excavated in a controlled and safe manner.

15.4.13 The developer or their groundworker should seek further advice from Lithos if unexpected ground conditions are encountered in foundation or sewer excavations, including any conflict between soft ground associated with a backfilled trial pit excavation and the line of a proposed footing.

Granular Residual Soil

15.4.14 The weathered in-situ sandstone (sand, gravel and cobbles) is assumed to have a relative density of at least medium dense (in accordance with BS5930:2015). Groundwater is assumed to lie at greater than 1.0m depth (based on the findings of Lithos' investigation).

15.4.15 A safe bearing capacity of around 150kPa, allowing a maximum foundation line load of 90KN/m run, can be assumed if the following are true:

- A foundation length of 10m
- A foundation breadth of 0.6m
- A foundation thickness of 225mm
- A foundation depth of 0.6m depth
- An angle of shearing resistance of ϕ=32° for the granular deposits

15.4.16 Assuming the foundation geometry detailed above, minimal settlements would be anticipated. This is considered likely to be acceptable, however, further advice should be sought from the Structural Engineer responsible for foundation design.

15.4.17 In accordance with NHBC Standards, a minimum founding depth of 450mm (due to potential frost susceptibility) is required in granular soils. This depth should be taken from finished ground level to the underside of the footing. If finished ground level is to be above existing ground level, then the foundation excavation simply needs to ensure that there is sufficient depth of excavation to allow casting of the footing entirely within natural ground (not made ground or topsoil).

15.4.18 However, if the excavation is dug from original ground level in cold conditions when freezing is expected, then foundation depth should be taken from the existing, not finished, ground level.

15.4.19 It should be noted that founding at shallow depth (450mm), whilst desirable from an excavation stability viewpoint, may not provide sufficient bearing capacity due to the lesser depth of (resisting) overburden. Consequently, a minimum founding depth of 750mm is recommended.

15.4.20 It should also be noted that the footing may require deepening or stepping in order to allow plot drainage to exit the plot footprint (either over or under the footing).

15.4.21 A 'simple' foundation zoning plan is presented as Drawing 2986/10 in Appendix B.

15.4.22 Lithos could prepare a detailed Foundation Schedule if provided with an External Works Drawing (with proposed FFLs & infrastructure details) and a topographic survey.

15.5 Floor slabs

15.5.1 Suspended floor slabs should be utilised where the depth of made ground or engineered stone exceeds 600mm in accordance with NHBC Standards Chapter 5.1 (to negate potential settlement problems). The made ground on this site is non-shrinkable, therefore the slabs could be cast in-situ.

15.5.2 It is estimated that the thickness of made ground is likely to exceed 600mm beneath at least 60% of the plots.

15.5.3 It is considered that the natural ground is generally suitable for the use of ground bearing floors. However, ground bearing slabs should not be cast on topsoil or made ground. Where plots are elevated for design reasons, the depth of engineered stone below a ground bearing slab should not exceed 600mm, in accordance with NHBC guidance.

15.5.4 It should be noted that NHBC have suffered a significant number of claims resulting from the use of ground bearing floor slabs. Consequently, if ground bearing slabs are proposed, care should be taken to ensure correct and careful construction. For example, if fill to the internal face of the foundation excavation is not properly compacted, subsequent settlement can result in cracking of the slab.

15.6 Designated concrete mixes

15.6.1 Designated mixes are considered in BRE Special Digest SD1 and BS 8500 -1:2015+A1:2016. However, in addition to soil chemistry (sulphate class), there are a number of other considerations relating to structural design that need to be considered when determining an appropriate concrete mix.

15.6.2 Consequently, Britology should seek advice from their appointed Structural Engineer.

15.7 Excavations

15.7.1 Groundwater should be controlled in accordance with CIRIA report 113 "Control of Groundwater for Temporary Works".

15.7.2 Based on the results of the investigation it is considered unlikely that major groundwater flows will be encountered in shallow excavations.

15.7.3 Excavations into natural ground should remain stable in the short term, however excavations into made ground are likely to be unstable and may require shoring if left open for any significant period of time.

15.7.4 Bedrock has been encountered across the site from 1.5m and 2.8m depth. Based on the exploratory hole logs excavation to greater than 0.5m to 1.0m into underlying bedrock is likely to prove difficult. Therefore, it would be prudent to allow for 'hard rock' excavations where deep drainage etc is proposed.

15.8 Drainage

15.8.1 Based on observations made during the investigation, soakaways placed into bedrock or Granular Residual Soil in the centre and east of the site beyond the made ground should provide a suitable drainage solution for surface water run-off at the site.

15.8.2 Made Ground (a former Tip, backfilled with Ash & Clinker) underlies Area A which might make soakaway construction problematic. It should be noted that soakaways should not be allowed to infiltrate into made ground due to the risk of settlement caused by wash out of fine soil particles and the risk of leaching of mobile contaminants.

15.8.3 If soakaways are adopted as the drainage solution at this site, the drainage designer should ensure that groundwaters infiltrate downward into natural soil/bedrock and not laterally into the made ground.

15.9 Highways

15.9.1 This site is underlain by made ground which is likely to be subject to re-engineering prior to the construction of new estate roads. Consequently, there was no merit in obtaining CBR values at this stage.

15.9.2 Made ground is present across the centre and east of the site and consultation with the adopting authority, regarding the specification of the highways, is strongly recommended.

15.9.3 The made ground present beneath this site is highly variable in terms of both composition, and strength/density.

15.9.4 Consequently, where made ground is present its full thickness (up to a maximum of 2m - from existing ground level or proposed highway formation, whichever is the lower) should be excavated and either:

- replaced with suitable aggregate in accordance with Series 600 (Earthworks) of The Highways Agency (HA) "Specification for Highway Works" 1998; or
- screened, to allow selection of suitable material, before being replaced in engineered layers (in accordance with Series 600). Unsuitable materials include any soft or wet materials, biodegradables including topsoil, wood, scrap metal, frozen material and oversize.

15.9.5 Some refinement of the above advice might be possible after highways design (with consideration of the proposed formation level cf existing ground level), and via inspection (and usually CBR testing) of the proposed formation during site preparatory groundworks.

15.9.6 Any residual made ground materials in the base of the excavation should be inspected and (where necessary) any soft spots removed and replaced with suitable engineered fill.

15.9.7 Where the made ground is re-engineered it is considered that a CBR value of at least 3% should be achievable. However, this should be verified by field trials.

15.9.8 The natural soils present at shallow depth (in the east of the site) are granular. Based on visual inspection of the natural materials published tables[5] indicate that the Granular Residual Soils would be expected to provide a CBR value of at least 4%. This value should be verified prior to or during construction.

[5] *Interim Advice Note 73/06 Revision 1 (2009), Chapter 5. Characterisation of Materials Design Guidance for Road Pavement Foundations - Draft HD25*

15.9.9 Whilst the CBRs estimated above should be achievable, significant deterioration during/after periods of significant rainfall and/or site trafficking is likely. Consequently, it would be prudent to consider flexibility in the groundworks programme to enable highway construction during prolonged dry/warm weather (typically between May and September) when formation will be least vulnerable to deterioration. Alternatively, a minimum 200mm thickness of suitable granular fill (i.e. a "blanket" of 6F2) could be placed along the line of proposed highways to protect formation during the construction phase.

15.10 External works

15.10.1 Any digital terrain modelling undertaken or commissioned by the developer should be made available to their Engineering Designer prior to issue of an External Works Drawing.

16 REDEVELOPMENT ISSUES

16.1 General

16.1.1 This report has presented options with respect to foundation solutions, treatment of contamination etc that are considered technically feasible and in line with current good practice. Consequently, we would expect to obtain regulatory approval for whichever option is adopted, although this cannot be guaranteed. Copies of this report should be forwarded to the relevant regulatory authorities (Warranty Provider & Local Authority) for their comment/approval.

16.1.2 Even after an appropriate preliminary investigation and ground investigation, with exploratory holes on a closely spaced grid (say trial pits at 30m centres), a geoenvironmental appraisal is typically based on inspection of the ground underlying less than 0.5% of the total site area (and much less at depths in excess of about 3.5m). Consequently, there is always a possibility that unanticipated ground conditions will be encountered during the site preparatory works.

16.1.3 If unanticipated ground is encountered during the site preparatory works, the Contractor should immediately seek further advice from the Engineer.

16.2 Remediation strategy

16.2.1 Redevelopment of this site will almost certainly be subject to planning conditions relating to remediation and validation. Once a specific, preferred development strategy has been decided, Lithos could liaise with local Planning Authority and Warranty Provider and prepare a detailed Remediation Strategy document for approval.

16.2.2 The Remediation Strategy document would include:

- General background information, including site location, site description and a summary of ground investigation data
- An overview of existing constraints on development and the aims of the proposed remediation works
- Specific details of the anticipated site remediation/preparatory works
- Details of site supervision and verification
- A summary of implications for redevelopment

16.2.3 The Remediation Strategy will describe what is required, but not how it is achieved; the appointed Contractor would normally be expected to undertake an Options Appraisal, and then prepare a Method Statement.

16.2.4 The anticipated remediation works are summarised below:

- General site clearance of surface materials and vegetation
- Turnover (excavation, screening and replacement in engineered layers, with nominal compaction) of the full thickness of made ground to enable:
  - Preparation of the ground for highway construction
- Excavation of natural soils from beneath made ground to source 'clean' subsoil for use in gardens and landscaped areas
- Backfill of all resultant excavations, with appropriate compaction
- Re-grade of site to levels specified by (approximately 1,000mm below final "soft" end use areas and 600mm below proposed slab levels)
- Excavation of up to a maximum depth of 2m beneath proposed adoptable road footprints and controlled re-engineering of selected materials in layers to approximately 650mm below final road levels
- Provision of a minimum 1,000mm thick cover layer of 'clean' soils in all garden and landscaped areas

16.2.5 The remediation contractor should survey reduced levels during the proposed turnover, prior to the placement of any fill.

16.2.6 Subsoil excavated during the site preparatory works for subsequent use as cover in gardens and landscaped areas, would be best placed during the construction phase; i.e. it should be left in stockpile(s) on completion of the site preparatory works.

16.2.7 A minimum 200mm thickness of suitable granular fill (i.e. a "blanket" of 6F2) could be placed along the line of proposed haul roads to provide a firm and stable running layer for the subsequent construction works.

16.3 Control of excavation arisings

16.3.1 Excavations into made ground are likely to yield contaminated arisings. The groundworker should carefully segregate (and stockpile separately) made ground arisings from arisings of "clean" natural soils, in order that an excessive volume of unsuitable material is not generated.

16.3.2 It should be ensured that the groundworker understands the need for good materials management. Most notably the importance of not mixing different materials within a given stockpile; i.e. there should be separate stockpiles of topsoil; Ash & Clinker; excess clean, natural soil arisings; general construction waste etc.

16.3.3 Further characterisation of stockpiled materials is likely to be required if off-site disposal is proposed. See also comments in Section 12.8 regarding asbestos.

16.3.4 Natural ground arisings should be suitable for use as subsoil in the proposed soil cover.

16.4 Good practice guidance

16.4.1 The construction phase groundworker should follow good environmental practice to minimise the risks of spillage, leakage etc with reference, but not limited, to the following documents:

- CIRIA C502 'Environmental Good Practice on Site'
- EA Pollution Prevention Guidelines[6]:
  - PPG6 - Working at construction and demolition sites
  - PPG2 - Above ground oil storage tank
  - PPG7 – The safe operation of refuelling facilities.
  - PPG21 – Incident Response Planning

16.4.2 Site preparatory works associated with this project are likely to involve the re-use of both natural and made ground soils on site and the import of natural soils from another development site/the use in of material that has been excavated from another site, following treatment at an authorised Hub site. Therefore, the Contractor should prepare a Materials Management Plan (MMP) in accordance with the CL:AIRE Code of Practice (v2, March 2011).

16.4.3 The MMP will document how all of the materials to be excavated during the proposed site preparatory and remediation earthworks are to be dealt with.

16.5 New utilities

16.5.1 It is strongly recommended that all statutory service bodies are consulted at an early stage with respect to the ground conditions within which they will lay services in order to enable them to assess at an early stage any potential abnormal costs.

16.5.2 It is recommended that trenches for services including site drainage and water supply are cut over size in order to isolate pipe materials from potential contaminants and to enable maintenance to be conducted in "clean" material.

16.5.3 Water Companies have a statutory duty to supply wholesome water, which could be compromised by the selection of an inappropriate pipe material. For example, compounds such as petroleum hydrocarbons and solvents can permeate commonly used plastics pipes, and/or corrosive chemicals can reduce the service life of metallic pipes. Guidance has been developed for the selection of pipes in brownfield sites and is contained in a UKWIR Report[7].

16.5.4 This site is brownfield, and therefore consideration of soil contaminant concentrations is required. Samples taken must be representative of the soil conditions in which the water pipes are proposed to be laid; normally water pipes are laid 0.7m to 1.3m below finished ground level.

16.5.5 At the time of writing, the proposed route(s), and total length, of pipeline were unknown. Consequently, to date laboratory testing of soil samples in line with UKWIR guidance has not been undertaken.

[6] *Whilst this has formally been withdrawn it can still be accessed via the EA archives and provides useful information on managing risks.*
[7] *UKWIR Report 10/WM/03/21 – 'Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites'.*

16.5.6 However, given the ground conditions encountered, Yorkshire Water may require sampling within 15m of proposed water supply pipes, once infrastructure design has been completed. In the meantime, it is considered likely that Yorkshire Water will request the use of Protectaline mains, with plastic coated copper house connections, given that residual organic contaminants will still be present post-remediation, albeit at acceptable concentrations.

16.6 Health & safety issues - construction workers

16.6.1 Access into excavations etc. must be controlled and undertaken in accordance with the CDM Regulations 2015, most notably Regulation 22, to mitigate risk of collapse or asphyxiation.

16.6.2 Before site operations are started, the necessary COSHH statements and Health & Safety Plan should be drafted in accordance with the CDM regulations.

16.6.3 The bulk of the made ground will be retained on site. This made ground contains contaminants at concentrations above the guidance threshold values for an end use that includes domestic gardens. Workers involved in excavations for foundations, drainage, utilities etc are likely to come into direct contact with the made ground.

16.6.4 Although workers will only be exposed to the contaminated soil for a relatively short time, the contaminants represent a risk, and simple precautionary measures are required, i.e. good personal hygiene and basic personnel protective equipment.

16.6.5 Consequently, during the remediation and construction phases of the site development it will be necessary to protect the health and safety of site personnel. General guidance on these matters is given in the Health and Safety Executive (HSE) document "Protection of Workers and the General Public during the Redevelopment of Contaminated Land". In summary, the following measures are suggested to provide a minimum level of protection:

- All ground workers should be issued with protective clothing, footwear and gloves. Personnel should be instructed in why and how they are to be used.
- Hand-washing and boot-washing facilities.
- Care should be taken to minimise the potential for off-site migration of contamination by the provision of dust suppression control and wheel cleaning equipment during the construction works.
- Good practices relating to personal hygiene should be adopted on the site.
- The contractor should satisfy the Health & Safety Executive with regard to any other matters concerning the health, safety and welfare of persons on the site.

16.7 Potential development constraints

16.7.1 Area A is a former tip (see Section 9.2), probably associated with placement of material, in late 1800s to early 1900s, above original ground (rather than as backfill to a former pit/quarry) to reduce the slope down to Chickenley Beck. Consequently, difficulties unrelated to ground should be anticipated if development is proposed in Area A.

16.7.2 As the tip does not have an active waste disposal permit, excavation and replacement of material is likely to be considered as remediation activity and covered by the deployment of a mobile treatment permit, regulated by the Environment Agency.

16.7.3 A robust materials management plan and strategy to mitigate nuisance to surrounding land users would be required to support the necessary permit required to undertake any remediation works.

16.7.4 Britology will be purchasing this site with knowledge of the former old tip. It is Lithos' understanding that Britology could be liable, under Part IIA of the Environmental Protection Act 1990, for any pollution associated with the migration of contaminants from this old tip. Therefore, specialist legal advice should be sought prior to making an unconditional offer for the site.

16.7.5 However, Part IIA is a 'last resort' where significant risk exists and is considered unlikely here. If a leachate release to waters were to occur, it would be considered an offence under Environmental Permitting Regulations 2010, and likely result in enforcement or even a works notice, with onus on landowner to investigate and mitigate. Consequently, whilst the old tip is considered unlikely to pose a risk to the proposed residential development, careful consideration should be given at the earliest opportunity to restoration, ongoing maintenance, and appropriate uses of this area.

16.7.6 Furthermore, development in Area A has implications for drainage design and will require:

- Overdeepening of foundations
- Placement of 1,000mm clean cover in garden and landscaped areas underlain by Ash & Clinker;
- Placement of utilities in 'oversized' utility trenches in order to protect future utility workers; and,
- Excavation/turnover & re-engineering with nominal compaction.

16.7.7 The overhead electrical utilities present a potential development constraint. It is understood that for this reason the utilities are to be diverted. Additional enquiries are required to ascertain the feasibility of such diversionary works and the particular easement required by each service undertaker if they remain in-situ.

17 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

17.1 General

17.1.1 The site is located off Long Lane, in Earlsheaton, and occupies an area of approximately 0.6 hectares. It is understood that consideration is being given to development of the site with 16 no. 'traditional' two storey residential dwellings. A proposed layout has been provided.

17.1.2 The centre and east of the site (Area A) is underlain by Ash & Clinker deepening, to a maximum recorded depth of 1.6m, towards Chickenley Beck in the east. Granular Residual Soils underlie the Ash & Clinker in Area A and directly underlie topsoil in the west (Area B).

17.1.3 Bedrock has been encountered beneath the whole site from 1.5m to 2.8m depth.

17.2 Mining

17.2.1 This site is located within a Coal Mining Development Low Risk Area.

17.2.2 The shallowest coal seam (Joan Coal, 0.6m thick) is anticipated at about 30m depth.

17.2.3 Whilst the site lies within a Coal Authority Low Risk area, no significant risks have been identified, and an intrusive mining investigation will not be required.

17.3 Hazardous gas

17.3.1 The site is in an area where between 3% and 5% of homes are estimated to be above the radon action level therefore basic radon protective gas measures will be required.

17.3.2 Whilst the risk of hazardous ground gas migrating on to this site is considered low it cannot be entirely discounted. Basic radon protection measures are required anyway and will afford protection against any low levels of hazardous gas which may migrate to the site.

17.3.3 However, it would be prudent to increase protection measures to comply with Amber 1 requirements **or** install 5 monitoring wells and undertake gas monitoring (9 visits over 6 months).

17.4 Contamination & remediation

17.4.1 Area A is a former tip, probably associated with placement of material, in late 1800s to early 1900s, above original ground (rather than as backfill to a former pit/quarry) to reduce the slope down to Chickenley Beck. Britology will be purchasing this site with knowledge of the former old tip and would therefore be advised to seek specialist legal advice should be sought prior to making an unconditional offer for the site.

17.4.2 The Ash & Clinker has been found to contain elevated concentrations of organic and inorganic contaminants and is also potentially combustible.

17.4.3 Where Ash & Clinker remains beneath gardens or landscaped areas it should be isolated beneath a minimum 1,000mm inert soil cover.

17.4.4 Existing Topsoil is not considered suitable for re-use due to elevated concentrations of arsenic, lead and zinc.

17.4.5 Existing Topsoil and Made Ground Topsoil should be excavated and removed from site or isolated beneath a minimum 600mm clean cover. Given the compressible nature and gas-generating potential of this material if buried at depth, it is recommended that it is placed in garden or landscaped areas, immediately beneath the proposed 600mm cover, and that it is overlain by no more than 1m of soil.

17.5 Foundations

17.5.1 Strip/trenchfill footings are considered the most suitable means of foundations for the two storey residential dwellings at this site.

17.5.2 Foundations will require deepening where deep made ground is encountered to found in natural residual soils of adequate bearing capacity.

17.6 Flooding

17.6.1 The far west of the site (beyond the proposed developments footprint) is considered to be at risk from flooding from Rivers (the Adjacent Chickenley Beck).

17.7 Drainage

17.7.1 Based on Lithos' test results soakaways may be a suitable means of surface water disposal if constructed in natural soils/bedrock in the centre or west of the site.

17.7.2 If soakaways are adopted as the drainage solution at this site, the drainage designer should ensure that groundwaters infiltrate downward into natural soil/bedrock and not laterally into the made ground.

17.7.3 In addition, CIRIA C753:2015 states that: "*A minimum distance of 1m between the base of the infiltration system and the maximum likely groundwater level should always be adopted.*

17.7.4 Therefore it would be prudent to allow for the installation of monitoring wells with a period of groundwater monitoring if soakaways are to be adopted at this site.

17.8 Highways

17.8.1 Based on visual inspection of the shallow natural materials and published guidance, the Granular Residual Soils should provide a CBR value of at least 4%. This value should be verified prior to or during construction.

17.8.2 However, made ground is present across Area A, to depths of up to 1.6m, and consultation with the adopting authority, regarding the specification of the highways, is strongly recommended.

17.8.3 Where made ground is present it should be excavated and either replaced with suitable aggregate, or screened, to allow selection of suitable material, before being replaced in engineered layers. Where the made ground is re-engineered it is considered that a CBR value of at least 3% should be achievable. However, this should be verified by field trials.

17.9 Further work

17.9.1 Whilst there are a number of possible sources that could influence surface water quality in the surrounding area, it would be prudent to obtain up and down gradient surface water samples to provide a further line of evidence that this site is not contributing to any deterioration of surface water quality.

17.9.2 Whilst not readily soluble in water, dioxins & furans will attach to small particles of organic matter, plants and plankton. Organic matter, washed into surface waters, typically settles out into sediment and any sampling of the surface water should include up and down gradient kick samples to collect sediment.

17.9.3 Preparation of a Remediation Strategy.

17.9.4 If Amber 1 protection measures are not preferred, wells should be installed in 5 boreholes and monitored for gas (9 visits over 6 months).

Appendix A

General Notes

General

Third party information obtained from the British Geological Survey (BGS), the Coal Authority, the Local Authority etc is presented in the "Search Responses" Appendix of this Geoenvironmental Report.

Geology, mining & quarrying

In order to establish the geological setting of a site, Lithos refer to BGS maps for the area, and the relevant geological memoir. Further information is sourced by reference to current and historical OS plans.

In July 2011, the Coal Authority (CA) formalised their requirements in relation to planning applications and introduced some new terminology. The CA, using its extensive records has prepared plans for all coalfield Local Planning Authorities, which effectively refines the defined coalfield areas into High Risk and Low Risk areas. High Risk areas are likely to be affected by a range of legacy issues that pose a risk to surface stability, including: mine entries; shallow coal workings; workable coal seam outcrops; mines gas; and previous surface mining sites. Low Risk areas comprise the remainder of the defined coalfield, and are areas where no known defined risks have been recorded; although there may still be unrecorded issues. Where a site lies within either a High or Low Risk area, a mining report is obtained from the CA.

Landfills

Lithos obtain data from Landmark or Groundsure, the Environment Agency and the Local Authority with respect to known areas of landfilling within 250m of the proposed development site. Historical OS plans are also inspected for evidence of backfilled quarries, railway cuttings, colliery spoil tips etc.

Radon

Radon is a colourless, odourless gas, which is radioactive. It is formed in strata that contain uranium and radium (most notably granite), and can move though fissures eventually discharging to atmosphere, or the spaces under and within buildings. Where radon occurs in high concentrations, it can pose a risk to health.

In order to assess potential risks associated with radon gas, Lithos refer to BRE Report BR211[1], and the Public Health England website. Advice on the limitation of exposure of the population to radon in buildings was originally published in 1990 by the National Radiological Protection Board (NRPB), which joined the Health Protection Agency (HPA) in 2005; the HPA updated NRPB advice in July 2010[2]. The HPA became part of Public Health England in 2013.

The HPA recommended that the NRPB radon Action Level for homes be retained, and a new Target Level for radon in homes be introduced. The values of the Action Level and Target Level, expressed as the annual average radon concentration in the home, are 200 Bqm^{-3} and 100 Bqm^{-3} respectively. The Target Level was to provide an objective for remedial action in existing homes and preventive action in new homes.

The term 'radon Affected Area' is defined as those parts of the country with >1% of homes estimated to be above the Action Levels. The NRPB first indicated which parts of the country should be regarded as radon Affected Areas in 1990. A more detailed mapping method was developed by the HPA in conjunction with the British Geological Survey in 2007[3]. The level of protection needed is site-specific and can be determined by reference to this mapping on the Public Health England website, which indicates the highest radon potential within each 1km grid square. Each 1km grid square is classified on the basis of the percentage of existing homes within that grid square estimated to have radon concentrations above the Action Level. There are 6 'bands': <1%; 1 to 3%; 3 to 5%; 5 to 10%; 10 to 30%; and >30%.

The NRPB advised that action should be taken to reduce radon concentrations in existing homes if the radon concentration exceeded the Action Level of 200 Bqm^{-3} in room air averaged over a year; ten times the average UK domestic radon concentration. NRPB advice informed changes in the requirements for radon protection in new buildings.

- Basic preventive measures are required in new buildings, extensions, conversions and refurbishments if the probability of exceeding the Action Level is >3% in England and Wales, and >1% in Scotland and Northern Ireland.
- Provision for further preventive (Full) measures is required in new buildings if the probability of exceeding the Action Level is >10%.

At present Building Regulations Approved Document C advocates basic measures for the probability banding 3% to 10%, and full measures if >10%. However, Public Health England would like to see all new build include basic measures.

Action and Target Levels should also be applied to non-domestic buildings with public occupancy exceeding 2,000 hours per year and to all schools.

Hydrogeology

Lithos obtain information from the Environment Agency (EA), and Landmark or Groundsure with respect to:

- Groundwater quality
- Recorded pollution incidents
- Licensed groundwater abstractions

From April 2010 the EA's Groundwater Protection Policy uses aquifer designations that are consistent with the Water Framework Directive. These designations reflect the importance of aquifers in terms of groundwater as a resource (drinking water supply), but also their role in supporting surface water flows and wetland ecosystems. The aquifer designation data is based on geological mapping provided by the British Geological Survey. The maps are split into two different types of aquifer designation:

- Superficial (Drift) - permeable unconsolidated (loose) deposits. For example, sands and gravels
- Bedrock - solid permeable formations e.g. sandstone, chalk and limestone

The maps display the following aquifer designations:

Principal aquifers: These are layers of rock or superficial 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.

Secondary aquifers: These include a wide range of rock layers or superficial deposits with an equally wide range of water permeability and storage. Secondary aquifers are subdivided into three types:

- Secondary A - permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers
- Secondary B - predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers
- Secondary undifferentiated - In most cases, this is because the rock type in question has previously been designated as both a minor and non-aquifer in different locations due to the variable characteristics.

[1] BRE Report BR211, 2015: "Radon: guidance on protective measures for new buildings.

[2] Limitation of Human Exposure to Radon, Documents of the Health Protection Agency - Radiation, Chemical and Environmental Hazards, RCE-15. July 2010.

[3] Miles JCH, Appleton JD, Rees DM, Green BMR, Adlam KAM and Myers AH (2007). Indicative Atlas of Radon in England and Wales. Chilton, HPA-RPD-033.

Unproductive strata: These are rock layers or superficial deposits with low permeability that have negligible significance for water supply or river base flow.

The EA maps only display the principal and secondary aquifers as coloured areas. All uncoloured areas on the map will be unproductive strata. However, for uncoloured areas on the superficial (drift) designation map it is not possible to distinguish between areas of unproductive strata and areas where no superficial deposits are present; to do this, it is necessary to consult the published geological survey maps.

For the purposes of the EA's Groundwater Protection Policy the following default position applies, unless there is site specific information to the contrary:

- If no superficial (drift) aquifers are shown, the bedrock designation is adopted
- In areas where the bedrock designation shows unproductive strata (the uncoloured areas) the superficial designation is adopted
- In all other areas, the more sensitive of the two designations is used (e.g. If secondary superficial overlies principal bedrock, an overall designation of principal is assumed)

The EA have also designated groundwater Source Protection Zones, which are based on proximity to a groundwater source (springs, wells and abstraction boreholes). The size of a Source Protection Zone is a function of the aquifer, volume of groundwater abstracted and the effective rainfall, and may vary from tens to several thousand hectares.

Hydrology

Lithos obtain information from the Environment Agency and Landmark or Groundsure with respect to:

- Surface water quality
- Recorded pollution incidents
- Licensed abstractions (groundwater & surface waters)
- Licensed discharge consents
- Site susceptibility to flooding

The EA have set water quality targets for all rivers. These targets are known as River Quality Objectives (RQOs). The water quality classification scheme used to set RQO planning targets is known as the River Ecosystem scheme. The scheme comprises five classes (RE1 to RE5) which reflect the chemical quality requirements of communities of plants and animals occurring in our rivers.

General Quality Assessment (GQA) grades reflect actual water quality. They are based on the most recent analytical testing undertaken by the EA. There are 6 GQA grades (denoted A to F) defined by the concentrations of biochemical oxygen demand, total ammonia and dissolved oxygen.

The susceptibility of a site to flooding is assessed by reference to a Flood Map on the Environment Agency's website. These maps show natural floodplains - areas potentially at risk of flooding if a river rises above its banks, or high tides and stormy seas cause flooding in coastal areas. There are two different kinds of area shown on the Flood Map:

1. Dark blue areas (Flood Zone 3) could be flooded by the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening each year, or by a river by a flood that has a 1% (1 in 100) or greater chance of happening each year
2. Light blue areas (Flood Zone 2) show the additional extent of an extreme flood from rivers or the sea. These outlying areas are likely to be affected by a major flood, with up to a 0.1% (1 in 1000) chance of occurring each year

These two colours show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements. Where there is no blue shading (Flood Zone 1), there is less than a 0.1% (1 in 1000) chance of flooding occurring each year.

The maps also show all flood defences built in the last five years to protect against river floods with a 1% (1 in 100) chance of happening each year, or floods from the sea with a 0.5% (1 in 200) chance of happening each year, together with some, but not all, older defences and defences which protect against smaller floods.

The Agency's assessment of the likelihood of flooding from rivers and the sea at any location is based on the presence and effect of all flood defences, predicted flood levels, and ground levels.

It should also be noted that as the floodplain shown is the 1 in 100 year, areas outside this may be flooded by more extreme floods (e.g. the 1 in 1000 year flood). Also, parts of the areas shown at risk of flooding will be flooded by lesser floods (e.g. the 1 in 5 year flood). In some places due to the shape of the river valley, the smaller floods will flood a very similar extent to larger floods but to a lesser depth.

If a site falls within a floodplain, it is recommended that a flood survey be undertaken by a specialist who can advise on appropriate mitigating measures; i.e. raising slab levels, provision of storage etc. In accordance with Chapter 10 of the National Planning Policy Framework, a site-specific flood risk assessment is required for: proposals of 1 hectare or greater in Flood Zone 1, or in an area within Flood Zone 1 which has critical drainage problems (as notified to the local planning authority by the Environment Agency); and any new development in Flood Zones 2 and 3.

COMAH & explosive sites

Lithos obtain information from Landmark or Groundsure with respect to Control of Major Accident Hazards (COMAH) or explosive sites within 1km of the proposed development site. Lithos' report refers to any that are present, and recommends that the Client seeks further advice from the HSE.

Areas around COMAH sites (chemical plants etc) are zoned with respect to the implementation of emergency plans. The HSE are a statutory consultee to the local planning authority for all COMAH sites. The COMAH site may have to revise its emergency action plan if development occurs. This might be quite straightforward or could entail significant expenditure. Consequently, the COMAH site may object to a proposed development (although it is the Local Authority who have final say, and they are likely to place more weight on advice from the HSE).

Preliminary conceptual site model

The site's environmental setting (and proposed end use) is used by Lithos to assess the significance of any contamination encountered during the subsequent ground investigation.

Assessment of contaminated land is based on an evaluation of pollutant linkages (source-pathway-receptor). Contaminants within the near surface strata represent a potential source of pollution. The environment (most notably groundwater), site workers and end users are potential receptors.

Potential pollutant linkages are shown on a preliminary conceptual site model (pCSM). A CSM is essentially a cross-section through a site that reflects both the surface topography and underlying geology, and shows surface features of interest. The most significant sources of contamination are then superimposed onto this cross-section together with potential receptors (human health & controlled waters), and plausible pathways between the two. In addition to environmental issues, the CSM should also highlight geotechnical issues.

A pCSM is prepared after consideration of all available "desk study" data, and before design of the ground investigation. Data reviewed should include historical plans (with superimposition on a current-day plan), previous SI reports, geological maps etc. The pCSM, in conjunction with knowledge of site constraints (buildings, services, slopes etc) is used to design the ground investigation.

The revised CSM takes account of data obtained during the ground investigation, including the distribution of made ground, the nature and distribution of contamination etc.

02 - Ground investigation fieldwork
Generic notes – geoenvironmental investigations

General

Lithos Ground Investigations are undertaken in accordance with current UK guidance including:

- BS5930:2015 "Code of practice for site investigation"
- Eurocode 7: BS EN 1997-1:2004. Geotechnical design - Part 1: General rules
- Eurocode 7: BS EN 1997-2:2007. Geotechnical design - Part 2: Ground investigation and testing
- BS10175:2013 "Code of practice for the identification of potentially contaminated sites"
- "Technical Aspects of Site Investigation" – EA R&D Technical Report P5-065/TR (2000)
- "Development of appropriate soil sampling strategies for land contamination" – EA R&D Technical Report P5-066/TR (2001)
- Contaminated Land Reports 1 to 6, most notably CLR Report No. 4 "Sampling strategies for contaminated land"
- "Guidance on the protection of housing on contaminated land" – NHBC & EA R&D Publication 66 (2000)
- AGS: 1996 "Guide to the selection of Geotechnical Soil Laboratory Testing"

Exploratory hole locations

Exploratory hole locations are selected by Lithos, prior to commencement of fieldwork, to provide a representative view of the strata beneath the site and to target potential contaminant sources identified during the preliminary investigation (desk study). Additional exploratory locations are often determined by the site engineer in light of the ground conditions actually encountered; this enables better delineation of the depth and lateral extent of organic contamination, poor ground, relict structures etc.

Investigation techniques

Ground conditions can be investigated by a number of techniques; the procedures used are in general accordance with BS5930: 2015 and BS1377: 1990. Techniques most commonly used by Lithos include:

- Machine excavated trial pits, usually equipped with a backactor and a 0.6m wide bucket.
- Cable percussive (Shell & Auger) boreholes, typically using 150mm diameter tools and casing.
- Window or windowless sampling boreholes (dynamic sampling). Constraints associated with existing buildings, operations and underground service runs can render some sites partly or wholly inaccessible to a mechanical excavator. In such circumstances, window sampling is often the most appropriate technique. A window sampling drilling rig can be manoeuvred in areas of restricted access and results in minimal disturbance of the ground (a 150mm diameter tarmac/concrete core can be lifted and put to one side). However, it should be noted that window sampling allows only a limited inspection of the ground (especially made ground with a significant proportion of coarse material).
- Rotary percussive open-hole probeholes are typically drilled using a tri-cone rock roller or polycrystalline diamond compact (PDC) bit with air as the flushing medium. Probeholes are generally lined through made ground with temporary steel casing to prevent hole collapse.

Where installed, gas\groundwater monitoring wells typically comprise a lower slotted section, surrounded by a filter pack of 10 mm non-calcareous gravel and an upper plain section surrounded in part by a bentonite seal and in part by gravel or arisings. The top of the plain pipe is cut off below ground level and the monitoring well protected by a square, stopcock type manhole cover set in concrete, or the plain pipe is cut off just above ground level and the well protected by 100mm diameter steel borehole helmet set in concrete. Monitoring well details, including the location of the response zone and bentonite seal are presented on the relevant exploratory hole logs.

In-situ testing

Relative densities of granular materials given on the trial pit logs are based on visual inspection only, they do not relate to any specific bearing capacities.

The relative densities of granular materials encountered in cable percussive boreholes are based on Standard Penetration Test (SPT) results. SPTs are carried out boreholes, in accordance with BS 1377 1990, Part 9 Section 3.3. Where full penetration (600mm) is not possible, N values are calculated by linear extrapolation and are shown on the logs as N* = x. The strength of cohesive deposits is determined using a hand shear vane.

Shear strength test results (hand vane readings) reported on trial pit logs are considered to be more reliable than those reported on window sample logs. Significant sample disturbance occurs during window sampling and consequently shear strength results on disturbed window samples are generally lower than results obtained during trial pitting, in-situ or in large excavated blocks.

Sampling

Typically Lithos collect at least three soil samples from each exploratory hole, although in practice a greater number are often taken. The collection of a sufficient number of samples provides a sound basis upon which to schedule laboratory analysis, ensuring:

- A sufficient number of samples from each (common) site material are tested
- Horizontal and vertical coverage of the site is adequate, thereby providing a robust data set for use in the conceptual ground model
- Any localised, significant, but non-pervasive conditions are considered

Made ground and natural soils encountered in the field during a ground investigation often contain a significant proportion of coarse grained material (e.g. brick etc). Soil samples obtained during most investigations are often only truly representative of the in-situ soil mass where there is an absence of particles coarser than medium gravel; i.e the entire soil mass would pass a 20mm sieve.

Representative bulk samples of the soil mass are retrieved from coarse soils for specific geotechnical tests (most notably grading and compaction); this typically requires the collection of at least 10kg of soil, and occasionally >50kg. However, in the context of assessing land contamination, it is generally accepted that samples should be representative of the soil matrix of the stratum from which they are taken. Consequently, truly representative samples of coarse soils for subsequent contaminant analysis are not obtained - only the finer fraction is placed in sample containers. Coarse constituents not sampled would typically comprise any 'particles' with an average diameter greater than about 20mm (i.e. coarse gravel, cobble and boulder).

At present, neither ISO/IEC 17025 nor MCERTS specify sample pre-treatment with respect to stone removal. Unsurprisingly therefore UKAS accredited testing laboratories do not adopt the same approach to stones[1] – some crush and test the "as received" soil, whilst others sieve out stones and analyse only the residual soil (the sieve size used varies depending on the laboratory).

[1] *Mark Perrin. Stoned – Sample Preparation for Soils Analysis. Ground Engineering, April 2007.*

In essence, samples taken from coarser soils for contaminant analysis are "screened" by the geoenvironmental engineer in the field, and often sieved again by the laboratory during sample preparation. Geoenvironmental engineers do not typically re-calculate soil mass contaminant concentrations by taking account of the unsampled coarse fraction. Likewise, laboratories that remove stones typically report contaminant concentrations based on the dry weight of soil passing the sieve. In the context of land contamination and human health risk assessment, this is considered reasonable, because it is the soil matrix which is of greatest concern. Stones are unlikely to:

- Provide a significant source for plant uptake (consumption of vegetables)
- Remain on vegetables after washing (consumption of vegetables)
- Be eaten (accidentally by an adult, or deliberately by a child)
- Be whipped-up by the wind for dust generation (inhalation)
- Stick to the skin for any length of time (dermal contact)
- Yield toxic vapour (inhalation)

Consequently, Lithos instruct labs to remove all stones >10mm, and to report the results as dry-weight based on the mass of matrix tested. However, the laboratory are given site-specific instruction where coarse stones are coated in say oil, or impregnated with mobile contaminants such as diesel. Where the stones are predominantly natural, or inert (e.g. brick, concrete etc), removal will clearly result in higher reported concentrations, than if the stones were crushed and added to the matrix.

Where the stones include a significant proportion of contaminant-rich material (e.g. slag, fragments of galvanised metal etc) an argument could be made for crushing and analysing. However, provided the stones are stable (i.e. unlikely to disintegrate or degrade) they should not pose a significant risk to human health for the reasons stated above.

Sometimes it is necessary to obtain samples that are not representative of the wider soil matrix, for example when investigating localised, significant, but non-pervasive conditions. Any such unrepresentative samples are annotated with the suffix '*' (eg 2D*, or 4G*). Lithos' site engineer describes both the unrepresentative sample, and the soil mass from which it was been taken.

Sample Containers (for contaminant analysis). Samples of soil for contaminant testing are placed into appropriate containers (see below). Soil samples for organic analysis are stored in cool boxes, at a temperature of approximately 4ºC, until delivery to the selected laboratory.

Anticipated testing	Container(s)
Asbestos identification	500ml plastic tub
pH & metals, and non-volatile organics	500ml glass jar
Speciated TPH	500ml & 50ml glass jars
VOCs (incl. naphthalene and \or GRO)	50ml glass jar

Sample Containers (for geotechnical analysis). The majority of samples are only scheduled for PI and sulphate testing, for which 500g of sample is required (a full 0.5-litre plastic tub). However, bulk bags are taken where scheduling of compaction or grading tests is proposed.

Groundwater

Where encountered during fieldwork, groundwater is recorded on exploratory hole logs. If monitoring wells are installed, groundwater levels are also recorded on one or more occasions after completion of the fieldwork. Long-term monitoring of standpipes or piezometers is always recommended if water levels are likely to have a significant effect on earthworks or foundation design.

It should be borne in mind that the rapid excavation rates used during a ground investigation may not allow the establishment of equilibrium water levels. Water levels are likely to fluctuate with season/rainfall and could be substantially higher at wetter times of the year than those found during this investigation.

Description of strata

Soils encountered during a Lithos investigation are described (logged) in general accordance with BS 5930:2015. The descriptions and depth of strata encountered are presented on the exploratory hole logs and summarised in the Ground Conditions section within the main body of text. The materials encountered in the trial pits are logged, samples taken, and tests performed on the in-situ materials in the excavation faces, to depths of up to 1.2m; below this depth these operations are conducted at the surface on disturbed samples recovered from the excavation.

Key to exploratory hole logs

Keys to logs are presented in the Appendix containing the logs. There are two Keys – Symbols & Legends and Terms & Definitions.

General

Soil samples are delivered to the laboratory for testing along with a schedule of testing drawn up by Lithos. All tests are carried out in accordance with BS 1377:1990. The following laboratory testing is routinely carried out on a selection of samples:

- Atterberg limits & moisture contents
- Soluble sulphate & pH

Where soft, cohesive soils are encountered, one-dimensional consolidation tests are scheduled in order to assess settlement characteristics, and unconsolidated undrained triaxial compression tests to assess shear strength.

The additional tests are typically only scheduled where significant earthworks regrade is anticipated:

- Grading
- Compaction tests
- Particle density

Test results are presented as received in an Appendix to the Geoenvironmental Report.

Atterberg limits & moisture content

The Liquid and Plastic Limits of samples of natural in-situ clay are determined using the cone penetrometer method and the rolling thread test. These tests enable determination of an average Plasticity Index (PI) for each "type" of clay, although judgement is applied where variable results are reported.

PI can be related to shrinkability (low, medium or high) and then to minimum founding depth. Lithos typically only consider a soil to be shrinkable if the proportion finer than 63µm is >35%. PI results are compared against guidance given in the NHBC Standards, Chapter 4.2 (revised April 2003), which advocates the use of modified Plasticity Index (I'p), defined as:

I'p = Ip * (%< 425µm/100)

i.e. if PI is 30%, but the soil contains 80% < 425µm, then: I'p = 30 * 80/100 = 24%.

It should be noted that in accordance with the requirements of BS 1377, the % passing the 425µm sieve is routinely reported by testing labs. Lithos apply engineering judgment where PI results are spread over a range of classifications. Consideration is given to:

- The average values for each particular soil type (ie differentiate between residual soil and alluvium)
- The number of results in each class and
- The actual values

Unless the judgment strongly indicates otherwise, Lithos typically adopts a conservative approach and recommends assumption of the higher classification.

Soluble sulphate and pH

Sulphates in soil and groundwater are the chemical agents most likely to attack sub-surface concrete, resulting in expansion and softening of the concrete to a mush. Another common cause of concrete deterioration is groundwater acidity.

The rate of chemical attack depends on the concentration of aggressive ions and their replenishment at the reaction surface. The rate of replenishment is related to the presence and mobility of groundwater.

Lithos refer to BRE Special Digest 1 (SD1) "Concrete in aggressive ground. Part 1: Assessing the aggressive chemical environment" (2005). SD 1 provides definitions of:

- The nature of the site (greenfield, brownfield or pyritic)
- The groundwater regime (static, mobile or highly mobile)
- The design sulphate class (DS class) and
- The aggressive chemical environment for concrete (ACEC class)

Lithos reports clearly state each of the above for the site being considered.

The concentrations of sulphate in aqueous soil/fill extracts are determined in the laboratory using the gravimetric method. The results are expressed in terms of SO_4 for direct comparison with BS 5328:1997. The pH value of each sample was determined by the electrometric method.

SD1 also discusses determination of "representative" sulphate concentration from a number of tests. Essentially if <10 samples of a given soil-type have been tested, the highest measured sulphate concentration should be taken. If >10 samples have been tested, the mean of the highest 20% of the sulphate test results can be taken. With respect to groundwater, the highest sulphate concentration should always be taken.

With respect to pH (soil & groundwater) the value used is the lowest value if <10 samples have been tested and the mean of the lowest 20% if >10 samples have been tested.

Oedometer (Consolidation) tests

Oedometer tests measure a soil's consolidation properties, and are performed by applying different loads to a soil sample and measuring the deformation response. Typically the sample is subject to 5 incremental pressures (4 loading & 1 unloading), and the convention is for each subsequent pressure to be double the previous pressure. BS1377 suggests the initial pressure should be:

a) For stiff soils the effective overburden pressure*
b) For firm soils "somewhat less" than the effective overburden pressure
c) For soft soils "appreciably less" than the effective overburden pressure, usually 25 kPa or less
d) For very soft soils very low, typically 5 kPa or 10 kPa

* Effective overburden pressure (kNm^{-2}) = depth (m) x soil bulk unit weight (kNm^{-3})

Results from these tests are used to predict how a soil in the field will deform in response to a change in effective stress.

Triaxial tests

This test measures the mechanical properties of a soil by placing the sample between two parallel platens which apply stress in one (usually vertical) direction, with fluid used to apply a confining pressure in the perpendicular directions. During the test, the surrounding fluid is pressurized, and then stress on the platens is increased until the material in the cylinder fails.

From triaxial test data, it is possible to extract fundamental material parameters, including its angle of shearing resistance, apparent cohesion, and dilatancy angle. These parameters are then used in computer models to predict how the material will behave in a larger-scale engineering application.

Quick (single stage, Unconsolidated, Undrained tests) are most appropriate for foundation design. This is because load is applied relatively quickly, and shear strength of the clay will be lowest initially; after the applied load causes some consolidation of the ground (after drainage results in dissipation of short-term excess pore water pressure), the in-situ clays will become progressively stronger and hence the factor of safety will increase. Confining pressure is specified as equivalent to overburden pressure (kNm^{-2}).

Foundations on granular soils would use effective shear strength parameters (c' and phi') to assess safe bearing capacity, as the soil would fully drain quickly. These effective shear strength parameters could be determined from Consolidated Undrained (or sometimes the more expensive Consolidated Drained) triaxial tests, but often correlations to the SPT are used.

Unconsolidated Undrained triaxial tests are most appropriate for assessment of the stability of fill slopes on clays. Similar to foundations, the application of load gradually increases the strength of the clays and hence the critical case is the short term undrained condition.

Consolidated Undrained (or sometimes Consolidated Drained) triaxial tests are most appropriate for assessment of the stability of cut slopes in clays. This is because unloading of the ground leads to short term reduction in pore pressures that approximately balance the unloading, hence the soil strength is largely unchanged. Over time the reduced pore pressures suck water in, which leads in to the progressive increase in pore pressure and loss of strength. The fully drained state is critical, which must be modelled using effective strength parameters and a reasonable estimate of the long term water table conditions.

Slopes formed in granular soils would use effective shear strength parameters (c' and phi') to assess safe bearing capacity, as the soil would fully drain quickly. These effective shear strength parameters could be determined from Consolidated Undrained (or sometimes the more expensive Consolidated Drained) triaxial tests, but often correlations to the SPT are used.

Determination of analytical suite

An assessment of potential contaminants associated with the former usages of the site is undertaken with reference to CLR 8 "Potential contaminants for the assessment of land" and the relevant DETR Industry Profile(s).

Common contaminants

Common Inorganic Contaminants include:

- Metals, most notably cadmium, copper, chromium, mercury, lead, nickel, and zinc
- Semi-metals, most notably arsenic, selenium, and (water soluble) boron
- Non-metals, most notably sulphur
- Inorganic anions, most notably cyanides (free & complex), sulphates, sulphides, and nitrates

With respect to the terminology used by most analytical laboratories:

Total cyanide = Free cyanide + Complex cyanide

Total cyanide (CN) is determined by acid extraction; whereas free cyanide is the water soluble fraction. Complex cyanide is "bound" in compounds and is hard to breakdown. Laboratory determination of complex CN involves subjecting the sample to UV digestion for determination of both free and total CN.

Thiocyanate (SCN) is a different species combined with sulphur.

Elemental sulphur (S) and free sulphur are the same. Total sulphur is all forms, including that present in sulphates (SO_4), sulphides etc.

There are 2 forms of chromium (Cr), chromium VI and chromium III. Chromium VI is the more toxic of these. In soils, total chromium is determined by a strong aqua regia acid digestion. Chromium VI is an empirical method based on a water extract test.

Common Organic Contaminants include hydrocarbons, phenols, and polychlorinated biphenyls.

Petroleum is a mixture of hydrocarbons produced from the distillation of crude oil, and includes aliphatics (alkanes, alkenes and cycloalkanes), aromatics (benzene and derivatives) and hydrocarbon-like compounds containing minor amounts of oxygen, sulphur or nitrogen. Petroleum hydrocarbons can be grouped based on the carbon number range:

- GRO – Gasoline Range Organics (typically C_6 to C_{10}). Also referred to as PRO – Petroleum Range Organics
- DRO – Diesel Range Organics (typically C_{10} to C_{28})
- LRO - Lubricating Oil Range Organics (typically C_{28} to C_{40})
- MRO – Mineral Oil Range Organics (typically C_{18} to C_{44})

However, it should be borne in mind that the terms "GRO" and "DRO" analysis are purely descriptive terms, the exact definition of which varies. Total Petroleum Hydrocarbons (TPH) is also a poorly defined term; some testing laboratories regard TPH as hydrocarbons ranging from C_5-C_{40}, whereas others define TPH as C_{10}-C_{30}.

The composition of a TPH plume migrating through the ground can vary significantly; this is primarily dictated by the nature of the source (eg petrol, diesel, engine oil etc). Furthermore, different hydrocarbons are affected differently by weathering processes, and this can result in further variation in the chemical composition of the TPH.

Gasoline contains light aliphatic hydrocarbons (especially within the C_4 to C_5 range) that are volatile. The aromatic hydrocarbons in gasoline are primarily benzene, toluene, ethylbenzene and xylenes, referred to as BTEX. Small amounts of polycyclic aromatic hydrocarbons (PAHs) such as benzo(a)pyrene may also be present. Diesel and light fuel oils have higher molecular weights than gasoline. Consequently, they are less volatile and less water soluble. About 25 to 35% is composed of aromatic hydrocarbons. BTEX concentrations are generally low.

Heavy Fuel Oils are typically dark in colour and considerably more viscous than water. They contain 15 to 40% aromatic hydrocarbons. Polar nitrogen, sulphur and oxygen-containing compounds (NSO) compounds are also present. Lubricating Oils are relatively viscous and insoluble in groundwater. They may contain 10 to 30% aromatics, including the heavier PAHs. NSO compounds are also common.

Polycyclic Aromatic Hydrocarbons (PAHs) have more than two fused benzene rings as a structural characteristic. PAH compounds are present in both petrol and diesel, although in significantly lower concentrations than in coal tars. Certain PAH compounds are carcinogenic (benzo(a)pyrene) and\or mobile in the environment (naphthalene).

Volatile Organic Compounds (VOCs) are organic chemicals, and most are liquids that readily evaporate on exposure to air. Examples include benzene, toluene, xylene, chloroform etc. Semi-Volatile Organic Compounds (sVOCs) include phenol and benzo(a)pyrene, and have relatively low boiling points. Both groups of chemicals are readily absorbed through skin and some, such as benzene, are believed to be linked to tumour growth.

Phenols are compounds that have a hydroxyl group (-OH) attached to an aromatic ring (ie include a benzene ring and an –OH group). Most are colourless solids. A solution of phenol in water is known as carbolic acid, and is a powerful antiseptic. However, phenol vapour is toxic, and skin contact can result in burns.

Polychlorinated Biphenyls (PCBs) were used in pre-1974 transformers as dielectric fluids. PCB's are of increasing toxicity relative to the degree of chlorination. Acute symptoms of PCB poisoning are irritation of the respiratory tract leading to coughing and shortness of breath. Nausea, vomiting and abdominal pain are caused by ingestion of PCB's.

Dioxins and furans (polychlorinated dibenzodioxins and polychlorinated dibenzofurans) are some of the most toxic chemicals known; in the environment, they tend to bio-accumulate in the food chain. Dioxin is a general term that describes a group of hundreds of chemicals that are highly persistent in the environment. The most toxic compound is 2,3,7,8-tetrachlorodibenzo-p-dioxin or TCDD.

Dioxin is formed by burning chlorine-based chemical compounds with hydrocarbons. The major source of dioxin in the environment comes from waste-burning incinerators and also from backyard burn-barrels. Dioxin pollution is also affiliated with paper mills which use chlorine bleaching in their process and with the production of Polyvinyl Chloride (PVC) plastics and with the production of certain chlorinated chemicals (like many pesticides).

Methods of analysis (organic compounds)

TPH by GC-FID is an analytical technique which only detects hydrocarbons (aliphatic and aromatic) in the range C_{10} to C_{40} (volatiles, heavy tars, humic material and sulphur are not detected). The laboratory can provide a broad, 'banded' breakdown of the TPH results into gasoline range organics (GRO), diesel range organics (DRO) and heavier lubricating oil range organics (LRO), or fully speciated results with the reporting of hydrocarbon concentrations in 14 specific carbon bandings based upon behavioural characteristics, e.g. aliphatic C_6 to C_8, aromatic C_{10} to C_{12} etc.

Speciated VOC (by GC-MS) analysis quantifies the concentrations of 30 USA-EPA priority compounds. These include chlorinated alkanes and alkenes (in the molecular weight range chloroethane to tetrachloroethane); trimethylbenzenes; dichlorobenzenes; and the 4 BTEX compounds (benzene, ethyl-benzene, toluene & xylene).

Speciated sVOC by (GC-MS) analysis quantifies the concentrations of a variety of organic compounds, including the 16 USA-EPA priority PAHs, phenols, 7 USA EPA priority PCB congeners, herbicides & pesticides.

Note: PAHs are hydrocarbons and consequently (where present) will be picked-up when scheduling TPH by GC-FID.

Note: Risk assessment models require physiochemical properties (solubilities, toxicities etc) of compounds in order to model their behaviour in the environment. These physiochemical properties cannot be derived from a single "TPH", "GRO" or "DRO" value. However, the carbon banded fractions can be used in risk assessment models.

Current UK guidance

The UK approach to contaminated land is set out in Contaminated Land Report No. 11 (2004) "Model Procedures for the Management of Land Contamination". The approach is based upon risk assessment, where risk is defined as the combination of the probability of occurrence of a defined hazard and the magnitude of the consequences of the occurrence.

In the context of land contamination, there are three essential elements to any risk: (1) a contaminant source; (2) a receptor (eg controlled water or people); and (3) a pathway linking (1) and (2). Risk can only exist where all three elements combine to create a pollutant linkage. Risk assessment requires the formulation of a conceptual model which supports the identification and assessment of pollutant linkages.

Lithos adopt a tiered approach to risk assessment, consistent with UK guidance and best practice. The initial step of such a risk assessment (or Tier 1) is the comparison of site data with appropriate UK guidance levels, Lithos risk-derived screening values, or remedial targets. It should be noted that exceedance of Tier 1 does not necessarily mean that remedial action will be required.

Soil screening values used by Lithos

In March 2002 DEFRA and the Environment Agency published a series of technical papers (R&D Publications CLR 7, 8, 9 and 10) outlining the UK approach to the assessment of risk to human health from land contamination. In 2008 CLR 7, 9 and 10 and all corresponding SGV and Tox reports were withdrawn and superseded by new guidance including:

- Guidance on Comparing Soil Contamination Data with a Critical Concentration - CL:AIRE and CIEH, May 2008
- Evaluation of models for predicting plant uptake of chemicals from soil - Science Report – SC050021/SR
- Human health toxicological assessment of contaminants in soil - Science Report: SC050021/SR2
- Updated technical background to the CLEA model - Science Report: SC050021/SR3
- CLEA Software Handbook (Version 1.071), Science report: SC050021/SR4
- Compilation of data for priority organic pollutants for derivation of Soil Guideline Values - Science Report: SC050021/SR7

The approach set out in these documents represents current scientific knowledge and thinking; and includes the Contaminated Land Exposure Model (CLEAv1.06). The Environment Agency are in the process of using this updated approach to regenerate a selection of Soil Guideline Values (SGVs).

CLEA SGVs were derived for standard land use scenarios predominantly in the context of Part IIA, using a conceptual site model (CSM) defined in SR3. Lithos have incorporated amendments to the CSM used to derive SGVs, that more accurately reflect redevelopment within the planning regime; consequently, Lithos have not adopted any published SGV as a screening value.

The CLEA conceptual site model assumes a source located in a sandy loam, with 6% soil organic matter (SOM) - equivalent to 3.5% total organic carbon (TOC). However, where the average TOC value for a particular soil type is significantly lower than the 3.5%, evaluation of Lithos Screening Values should be undertaken and a site specific risk assessment will usually be required. Other CLEA default characteristics adopted by Lithos are:

Sandy Loam characteristics (source)	Default values adopted
Total porosity (fraction)	0.53
Water filled porosity (fraction)	0.33
Air filled porosity (fraction)	0.2

Lithos have derived Screening Values for four different CSMs (scenarios); these are:

A - Residential with gardens, but no cover (or only up to 300mm)

B - Residential with gardens and 600mm 'clean' cover

C - Residential apartments with landscaping (i.e. no home grown produce)

D - Commercial/industrial with landscaping

E – Importation of soil cover

The exposure pathways considered for each scenario are detailed in the table below.

Scenario	Land use	Pathways	Justification
A	Residential with garden, but no cover (or only up to 300mm)	• Direct ingestion of soil • Dermal contact • Consumption of vegetables & soil attached to vegetables • Inhalation of indoor vapours and dust • Inhalation of outdoor vapours and dust	Minimal cover – insufficient to break any pathways therefore all exposure pathways are relevant.
B	Residential with garden minimum 600mm cover	• Inhalation of indoor vapours • Inhalation of outdoor vapours	The 600mm cover removes the risk from all pathways other than inhalation.
C	Residential apartments with landscaped areas and minimum 300mm cover	• Direct ingestion of soil • Dermal contact • Inhalation of indoor vapours and dust • Inhalation of outdoor vapours and dust	All pathways applicable due to possible exposure from landscaped areas. However consumption of home grown produce not included as unlikely to be grown in landscaped areas. Where vegetables are to be grown site specific QRA may be required.
D	Commercial/ industrial with landscaped areas no cover	• Direct ingestion of soil • Dermal contact • Inhalation of indoor vapours and dust • Inhalation of outdoor vapours and dust	All pathways applicable due to possible exposure from landscaped areas. Assumed the commercial development consists of offices to provide a conservative assessment.
E	Importation of soil for cover in garden and landscaped areas	• Direct ingestion of soil • Dermal contact • Consumption of vegetables & soil attached to vegetables • Inhalation of outdoor vapours and dust	Material used as cover to break existing pathways therefore all direct and indirect pathways relevant; however cover is not placed below plots therefore indoor inhalation is not relevant.

Lithos have assumed the source of contamination is directly below the building foundations; i.e. a depth to source of 0.15m as opposed to the CLEA default of 0.65m. This assumption provides for a more conservative approach than the UK default. This adjustment has been included to account for sites where made ground is re-engineered to enable new buildings to be established on raft foundations. In such situations contamination may lie directly beneath the foundation.

The Soil Screening Values referred to in this document are not intended to be used when considering potential risks associated with:

- Existing land uses in the context of Part IIA of the Environment Protection Act 1990;
- End uses such as allotments, sports fields, children's playgrounds, care homes, hospitals etc; and
- Controlled waters.

In December 2013 Defra published the results of research project SP1010 – Development of Category 4 Screening Levels (C4SLs) for Assessment of Land Affected by Contamination. The objective of this project was provide technical guidance in support of Defra's revised Statutory Guidance for Part 2A of the Environmental Protection Act 1990 (Part 2A). The revised Statutory Guidance, published in April 2012, introduced a new four-category system for classifying land under Part 2A where Category 1 includes land where the level of risk is clearly unacceptable, and Category 4 includes land where the level of risk posed is acceptably low. Project SP1010 aimed to deliver:

- A methodology for deriving C4SLs for four generic land-uses comprising residential, commercial, allotments and public open space; and
- Demonstration of the methodology, via derivation of C4SLs for 6 substances – arsenic, cadmium, chromium IV, lead, benzene & benzo(a)pyrene.

The methodology for deriving both the previous Soil Guideline Values and the new Category 4 Screening Levels is based on the Environment Agency's Contaminated Land Exposure Assessment (CLEA) methodology. Development of C4SLs has been achieved by modifying the toxicological and\or exposure parameters used within CLEA (while maintaining current exposure parameters).

The Part 2A Statutory Guidance was developed on the basis that C4SLs could be used under the planning regime. However, policy responsibility for the National Planning Policy Framework falls to the Department for Communities and Local Government. Defra anticipate that, where they exist, C4SLs will be used as generic screening criteria, and Lithos consider C4SLs to be suitable for use as Tier 1 Screening Values. Lithos have discussed this matter with both NHBC and YAHPAC (collection of Yorkshire & Humberside local authorities) and received confirmation that they are satisfied with this approach.

With respect to inorganic determinands, Lithos derived Tier 1 values for the five Scenarios A to E are presented below:

Inorganic contaminant	Tier 1 assessment criteria (mg/kg) for Scenarios A to E							Comments/notes
	SGV*	C4SL*	A	B	C	D	E	
As	32	37	37	Use (A) in SI Report for initial "screen". If >5 x A, then consider increase of cover to 1,000mm	40	640	37	C4SL adopted
Cd	10	26	26		149	410	26	C4SL adopted
Cr			3,000		3,000	30,000	3,000	Assumes Cr is CrIII
Pb	450	200	200		310	2,330	200	C4SL adopted
Ni	130		127		127	1,700	127	Assessment of health risk only
Se	350		350		595	13,000	434	
Hg	170		169		238	3,640	199	Assumes in an inorganic compound
B			5		5	5	5	Based on phytotoxic risks as plants are the more sensitive receptor (Cu is pH dependant)
Cu			80-200		80-200	80-200	80-200	
Zn			200		200	200	200	

With respect to organic determinands, Lithos derived Tier 1 values for the five Scenarios A to E are presented below:

Organic contaminant (all sourced via CLEA)	Tier 1 assessment criteria (mg/kg) for Scenarios A to E							Comments/notes
	SGV*	C4SL*	A	B	C	D	E	
Benzene	0.33	0.87	0.9	0.9	3.3	98	N/A	C4SL adopted
Toluene	610		600	3,000	2,700	5,000	N/A	Calculated value over 10,000
Ethyl Benzene	350		350	932	843	5,000	N/A	
Xylenes	240		246	327	321	5,000	N/A	
Phenol	420		412	2,400	519	5,000	N/A	
PCBs			2	8	2	38	N/A	Based on toxicity of EC7
Benzo(a)pyrene		5	5	25	5.3	76	5	C4SL adopted. Where source is not a coal tar
Naphthalene			8	9	9	1,000	12	
Gasoline Range Organics			30	34	34	5,000	45	See 3-step assessment of TPH below
Diesel Range Organics			151	156	154	5,000	219	
Lubricating Range Org			1,000	5,000	2,000	5,000	1,000	

* *For a residential end use*

The significance of PAHs can be determined by considering indicator compounds. In most cases benzo(a)pyrene (BaP) is adopted as an indicator due to the amount of toxicological data available and has been used by various authoritative bodies to assess the carcinogenic risk of PAHs in food. A surrogate marker approach can be used to estimate the toxicity of a mixture of PAHs in soil using toxicity data for individual indicator compounds within that mixture. Exposure to the surrogate marker is assumed to represent exposure to all PAHs in that matrix. The surrogate marker approach relies on a number of assumptions:

- Surrogate marker (bap) must be present in all soil samples
- Profile of the different pah relative to bap should be similar in all samples
- PAH profile in the soil samples should be similar to that used in the pivotal toxicity study[1]

[1] SP1010 Appendix E, Provisional C4SIs for benzo(a)pyrene as a surrogate marker for PAHs, CL:AIRE 2013

To assess the PAH profile in a soil sample, the ratio of the seven genotoxic PAHs (benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, chrysene, dibenz[a,h]anthracene and indeno[1,2,3-c,d]pyrene), relative to BaP, should be calculated. The ratio relative to BaP should lie within an order of magnitude above and below the mean ratio to BaP.

Naphthalene should also be considered separately against its generic screen. Whilst classed as a PAH, naphthalene is more volatile and mobile in the environment than most other PAHs. As such the significance of naphthalene cannot be considered within the surrogate marker approach.

Similarly, TPH cannot be assessed as a single "total" value, and reference has been made to the Environment Agency's document P5-080/TR3, "The UK approach for evaluating human health risks from petroleum hydrocarbons in soils". This document supports the assumptions and recommendations made by the US Total Petroleum Hydrocarbons Criteria Working Group (TPHCWG). The TPHCWG have broken down "TPH" into representative constituent fractions or "EC Bandings". The TPHCWG have derived a series of physiochemical and toxicological parameters for each of the bandings.

The significance of speciated TPH results can be assessed by following the 3 steps outlined in the tables below.

Step	Result	Action
1. Consider indicator compounds: Are BTEX, naphthalene, benzo(a)pyrene above their respective Tier 1 values?	Yes	Remediation or dQRA required
	No	Proceed to Step 2
2. Consider individual TPH fractions: are they above respective screening values?	Yes	Remediation or dQRA required
	No	Proceed to Step 3
3. Assess Cumulative effects: Is the calculated Hazard Index for each source >1	Yes	Remediation or dQRA required
	No	TPH compounds pose no significant risk

Step 1 - Assessing indicator compounds

TPH fraction Indicator compound	End use specific screening value (mg/kg)			
	A: Residential no cover	B: Residential with 600mm cover	C: Residential no gardens	D: Commercial \ industrial
Benzene	0.9	0.9	3.3	98
Toluene	600	3,000	2,700	5,000
Ethyl Benzene	350	932	843	5,000
Xylenes	246	327	321	5,000
Naphthalene	8	9	9	1,000
Benzo(a)pyrene	5	25	5.3	76

Step 2 - Assessing individual TPH fractions

TPH fraction		End use specific screening value (mg/kg)			
		A: Residential no cover	B: Residential with 600mm cover	C: Residential with no gardens	D: Commercial/ industrial
Aliphatic 5-6	GRO	41	41	42	5,000^ per fraction
Aliphatic 6-8	GRO	125	125	125	
Aliphatic 8-10	GRO	31	31	32	
Aliphatic 10-12	DRO	151	156	154	
Aliphatic 12-16	DRO	500^	500^	500^	
Aliphatic 16-21	DRO	1,000^	5,000#	1,000^	
Aliphatic 21-35	LRO	1,000^	5,000#	1,000^	
Aromatic 5-7	GRO	100	123	122	
Aromatic 7-8	GRO	30	34	34	
Aromatic 8-10	GRO	47	50	50	
Aromatic 10-12	DRO	215	287	266	
Aromatic 12-16	DRO	689	1,000*	1,000*	
Aromatic 16-21	DRO	1,000^	5,000#	1,000^	
Aromatic 21-35	LRO	1,000^	5,000#	1,000^	

* Calculated Screening Value exceeded soil saturation limit and could indicate free product, therefore calculated soil saturation limit adopted as a target

^ Calculated Screening Value close to soil saturation limit, screening value selected by Lithos considering visual and olfactory impacts.

Five times the screening value for Scenario A.

Step 3 - Assessing Cumulative Effects

$$HI = \sum_{F_i=1}^{16} HQ\ F_i = \frac{Measured\ concentration\ F_i\ (mg\,kg^{-1})}{SGV\ F_i\ (mg\,kg^{-1})}$$

where HI = Hazard Index
HQ = Hazard Quotient
F_i = Fraction $_i$
SGV = Soil Guideline Value

Other screening values used by Lithos

Tier 1 risk assessment of hazardous gas is undertaken through reference to the following documents (and further information is presented in Generic Note No. 5 – Hazardous Gas):

- Approved Document C, Building Regulations 2000
- Boyle & Witherington (2007) – Guidance on evaluation on development proposals on sites where methane and carbon dioxide are present, incorporating "traffic lights". Report Ref. 10627-R01-(02), for NHBC
- CIRIA C665 (2007) – Assessing risks posed by hazardous ground gases to buildings
- BS 8485:2015 – Code of Practice for the characterisation & remediation from ground gas in affected developments

With respect to the assessment of potential phytotoxic effects of contaminants, Lithos refer to "The Soil Code" (MAFF, 1998) for copper and zinc. The CLEA SGV is adopted for nickel due to its human health effects.

The potential risk to building materials is considered through reference to relevant BRE Digests, with particular emphasis on BRE Special Digest 1, 'Concrete in aggressive ground', 2005.

With respect to the interpretation of the calorific values, at present there are no accepted methods to assess whether a sample is combustible and under what circumstances it might smoulder. Some guidance is given in ICRCL Note 61/84 "Notes on the fire hazards of contaminated land" which states that: "*In general … it seems likely that materials whose CV's exceed 10MJ/kg are almost certainly combustible, while those with values below 2MJ/kg are unlikely to burn*".

Tier 1 groundwater risk assessments are undertaken by comparing leachate or groundwater concentrations with the appropriate water quality standard. Tier 1 Screening Values have been discussed with the Environment Agency, and typically those in bold below are adopted.

Analyte	Source of Tier 1 Screening Value (µg/l)			
	Surface water (Abstraction for drinking) 1996	Water Supply Regulations 2000	Water Framework Directive	EA Advice
Arsenic	50	10	50	
Selenium	10	10		
Cadmium	5	5	1.5	
Chromium	50	50	32	
Copper	50	2,000	28	
Lead	50	10	7.2	
Nickel		20	20	
Zinc	3,000		125	
Boron		1,000		
Mercury	1	1	0.07	
Petroleum Hydrocarbons				10
1,1,1-Trichloroethane			100	
1,1 Dichloroethane				100
1,2-Dichloroethane		3	10	
1,1-Dichloroethene				100
Benzene		1	10	
Ethylbenzene				10
Tetrachloroethene		10	10	
Toluene			50	
Trichloroethene		10	10	
Vinyl Chloride		0.5		
Trichloromethane			2.5	
Xylenes			30	
Chloroethane				100

Waste classification & WAC

In the context of waste soils generated by remediation and\or groundworks activities on brownfield sites, the following definitions (from the Landfill Regulations 2002) apply:

- Inert (e.g. uncontaminated 'natural' soil, bricks, concrete, tiles & ceramics)
- Non-Hazardous (e.g. soil excavated from a contaminated site which contains dangerous substances, but at concentrations below prescribed thresholds)
- Hazardous (e.g. soil excavated from a contaminated site which contains dangerous substances at concentrations above prescribed thresholds)

Dangerous substances include compounds containing a variety of determinants commonly found in contaminated soils on brownfield sites, for example arsenic, lead, chromium, benzene etc.

Landfill operators require Waste Acceptance Criteria (WAC) laboratory data, if soil waste is classified as hazardous, and such waste must have been subjected to pre-treatment. However, subject to WAC testing it may be possible to classify it as stable, non-reactive hazardous waste, which can be placed within a dedicated cell within the non-hazardous landfill.

Lithos typically only include WAC analysis in site investigation proposals and reports, if significant off-site disposal (of soil classified as hazardous waste) is anticipated, for example where redevelopment proposals include basement construction etc. If off-site disposal of soils classified as hazardous waste during redevelopment is anticipated, then WAC analysis should be scheduled at an early stage in the remediation programme. However, organic compounds (BTEX, TPH, PAH etc) are the most common contaminants that result in soils being classed as hazardous, and these contaminants can often be dealt with by alternative technologies (eg by bioremediation or stabilisation) and consequently retention on site is often possible.

It should be noted that non-hazardous soil waste can go to a non-hazardous landfill facility; no further testing (eg WAC) is required.

Possible action in event of Tier 1 exceedance

Should any of the Tier 1 criteria detailed above be exceeded, then three potential courses of action are available. (The first is only applicable in terms of human health, but the second and third could also be applied to groundwater or landfill gas).

1. Undertake further statistical analysis following the approach set out in "*Guidance on Comparing Soil Contamination Data* with *a Critical Concentration - CL:AIRE and CIEH, May 2008*" in order to determine whether contaminant concentrations of inorganic contaminants within soil \ fill actually present a risk (only applicable to assessing the risk to human health).
2. Carry out a more detailed quantitative risk assessment in order to determine whether contamination risks actually exist.
3. Based on a qualitative risk assessment, advocate an appropriate level of remediation to "break" the pollutant linkage - for example the removal of the contaminated materials or the provision of a clean cover.

Prior to undertaking any statistical analysis the issue of the averaging area requires further consideration. The CL:AIRE \ CIEH document still refers to CLR 7, which suggests averaging area should reflect receptor behaviour and therefore might be a single garden, or an open area used by the local community as a play area. This approach to averaging areas is considered applicable within the context of Part IIA of the Environmental Protection Act (EPA) 1990, in terms of an existing residential development.

However, Lithos consider the concept of a single garden as an averaging area to be inappropriate with respect to brownfield redevelopment, which is regulated by the planning regime. In this context, contamination across the entire site needs to be characterised by reference to the Conceptual Site Model. Consequently, Lithos gather and analyse sample results by fill type, and \ or by former use in a given sub-area of the site, before undertaking statistical analysis; ie the averaging area is associated with the extent of a particular fill type, or an area affected by spillage \ leakage.

In terms of brownfield redevelopment, this is considered a more appropriate methodology which provides a more representative sample population for statistical analysis. As such the entire site is considered in terms of the proposed end use, be this residential with, or without gardens.

Analysis by soil \ fill type is appropriate for essentially immobile contaminants associated with a particular fill type, for example arsenic in colliery spoil, metals in ash & clinker, sulphate in plaster-rich demolition rubble etc.

Analysis by former use is appropriate where more mobile contaminants have entered the ground, for example diesel associated with leakage from a former fuel tank, downward migration of leachable metals through granular materials, various soluble contaminants present in a wastewater leaking into the ground via a fractured sewer etc. In these circumstances, it may be appropriate to undertake statistical analysis of sample results from a variety of different soil \ fill types. However, consideration would have to be given to factors such as porosity which might influence impregnation of a mobile contaminant into the soil mass, ie contamination would normally be more pervasive and significant in granular soils than cohesive soils

Background

Soakaways have been the traditional way to dispose of stormwater from buildings and paved areas remote from a public sewer or watercourse. In recent years, soakaways have been used within urban, fully-sewered areas to limit the impact on discharge of new upstream building works, and to avoid costs of sewer up-grading outside a development.

Soakaways are increasingly seen as a more widely applicable option alongside other means of stormwater control and disposal. Soakaways must store the immediate stormwater run-off and allow for its efficient infiltration into the adjacent soil. They must discharge their stored water sufficiently quickly to provide the necessary capacity to receive run-off from a subsequent storm. The time taken for discharge depends upon the soakaway shape and size, and the surrounding soil's infiltration characteristics. Soakaways can be constructed in many different forms and from a range of materials.

BRE Digest 365, DG365: 1991 describes design and construction procedures, explains how to calculate rainfall design values and soil infiltration rates, and gives design examples. Further advice is provided in NHBC Standards Chapter 5.3 (Section 9 & Appendix F), Building Regulations Section 3 of Approved Document H (Drainage & Waste Disposal), and Chapter 13 of CIRIA's SUDS Manual (C753:2015).

Soakaways should generally be built on land lower than or sloping away from buildings and be sited at least 5m from the foundations of a building.

BRE365 states that 'Groundwater should not rise to the level of the base of the soakaway during annual variations in the water table' this is further reinforced in Chapter 13 of CIRIA C753:2015 which states that: "*A minimum distance of 1m between the base of the infiltration system and the maximum likely groundwater level should always be adopted. This is to minimise the risk of groundwater rising into the infiltration component and reducing the available storage volume, to protect the functionality of the infiltration process by ensuring a sufficient depth of unsaturated material and to protect the groundwater from any contamination in the run-off*". There may be a requirement to install groundwater monitoring wells at a site in order to monitor seasonal variations in groundwater level at least over a wet winter period.

Soakaways should not be sited on sloping sites, an assessment should also be made to ensure that infiltrating water will not cause a rise in groundwater levels, waterlogging of downhill areas or springs, and that slopes are not made unstable.

Made ground (and ground within 5m of deep fill) is not generally regarded as suitable for soakaways, due to the potential for inundation settlement and the leaching of contaminants.

Chalk: CIRIA C574:2002 notes that concentrated ingress of water into the chalk can initiate dissolution, particularly in low-density chalk. For this reason, soakaways should be sited well away from foundations for structures, roads or railways:-

- in areas where dissolution features are known to be prevalent, soakaways should be avoided but, if unavoidable, should be sited at least 20m away from foundations etc
- where the chalk is of low density (weak), or where density is not known, soakaways should be sited at least 10m away from foundations
- where the chalk is of medium density, or higher (moderately weak), soakaways should be sited at least 5m away from foundations

Test methodology

Lithos undertake soakaway tests in general accordance with BRE Digest 365 "Soakaway Design". The BRE Digest recommends that each soakaway pit is filled and allowed to drain three times to near empty; the three fillings to be on the same or consecutive days. However, each test can take over 2 hours to complete and therefore pits are often only filled and allowed to drain on one occasion, due to the time constraints imposed on the investigation

Three filling\drainage cycles are more important where drainage is primarily via fissures, most notably within a rock mass. Initial drainage within the rock mass may be high, as the fissures fill with water, giving the impression (if only one cycle is undertaken) that soakaways would be a suitable drainage solution. If infiltration through the matrix of the rock is low, then drainage from the test pit becomes slow as the fissures become saturated.

For non-fissile, granular soils infiltration is via the matrix, and consequently one filling\drainage cycle is generally considered sufficient. Soakaway pits are typically excavated to a depth of about 2.5m using a mechanical excavator equipped with a 0.3m wide bucket. The soakaway test pits are rapidly filled with water to the top of the test section. The fall in water level is then monitored at regular intervals.

Infiltration rates

Infiltration rates for each soakaway test are calculated (where possible) in accordance with BRE Digest 365. This design takes into account the time of emptying the soakaway pit between 25% and 75% of its effective depth. The effective depth is calculated from the starting water level to the soakaway pit base. Where the water level did not fall to 25% effective depth, the data was interpolated in order to obtain a representative infiltration rate.

Soakaway design

Soakaway design should be carried out by a suitably qualified and experienced Drainage Engineer, in accordance with BRE Digest 365 using the infiltration rates calculated from soakaway testing during a ground investigation.

It is generally assumed that soakaways become impracticable on residential developments when:

- A chamber type design requires a square pit with side length in excess of 1.8m, or an effective depth greater than 1.5m.
- A trench type design requires a length greater than about 10m, or an effective depth greater than 1.5m.

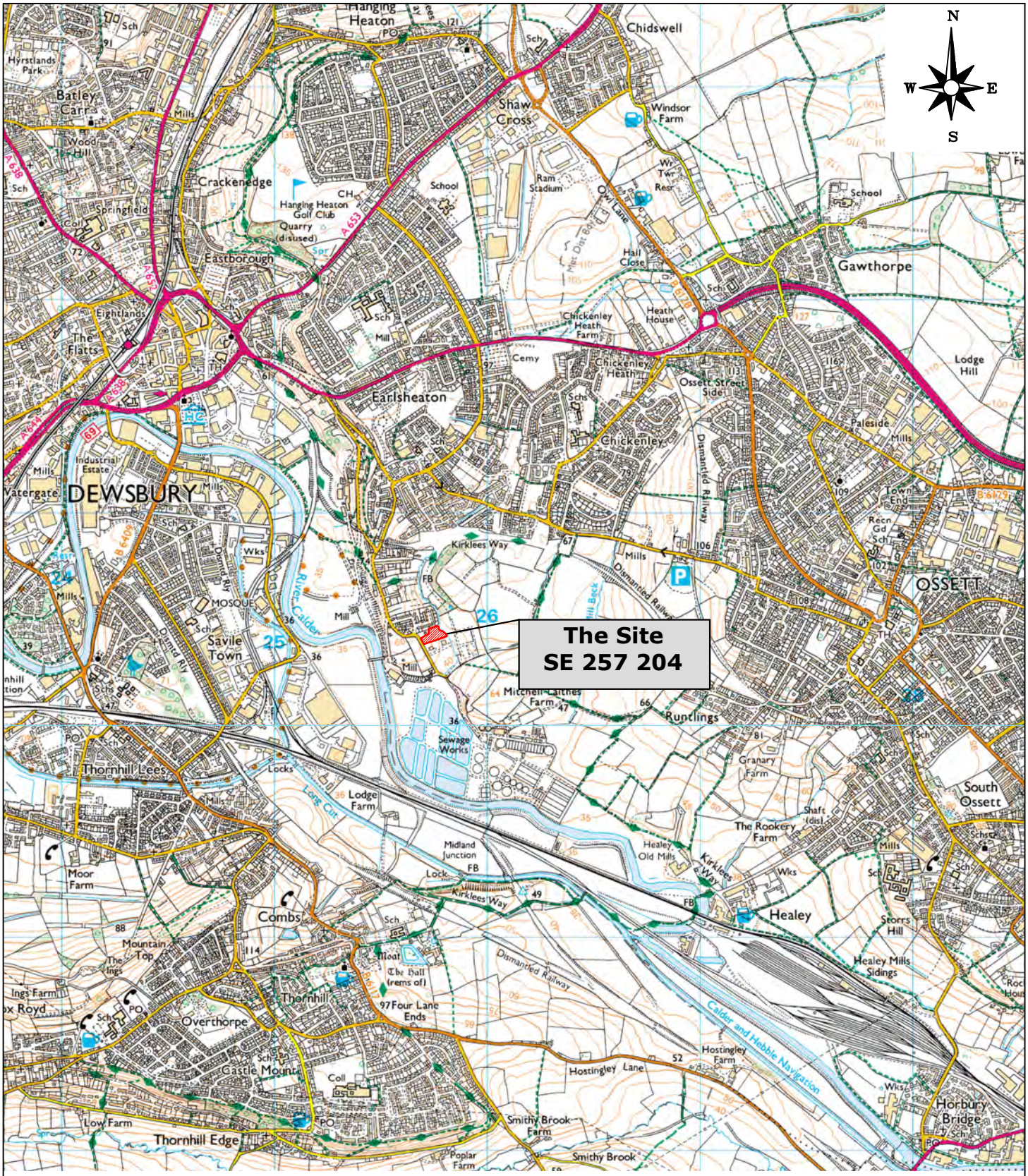
Increasing the soakaway effective depth might offer a solution, but consideration should be given to:

- Standing groundwater level
- Depth to base of permeable strata
- Cost of excavation

Soakaway percolation in some rock types is predominately via the vertical joints within the rock mass. The relatively small-scale soakaway test pits may not intercept such joints and this can result in variable test results. However, it is likely that the larger surface area of a completed soakaway within the development will intercept such joints.

Appendix B

Drawings



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CLIENT	BRITOLOGY LTD
JOB TITLE	LONG LANE, EARLSHEATON
DRAWING TITLE	SITE LOCATION PLAN
DRAWN	GLM
DATE	23/08/2019
CHECKED	ASw
DATE	23/08/2018
STATUS	FOR COMMENT ☐ FOR APPROVAL ☐ DRAFT ☐ FINAL ☑
SCALE	1:25 000
SHEET	A4
DRAWING NO.	2986/1
REVISION	

NOTES

APPROXIMATE SITE BOUNDARY

REPRODUCED FROM DRAWING 'LONG LANE, EARLSHEATON, DEWSBURY, PROPOSED SITE PLAN' REF. 0067_LON_SK103, ISSUED BY ELEVEN52 ARCHITECTS IN MAY 2020

REV.	DESCRIPTION	DATE
B	UPDATED WITH REVISED LAYOUT	01/06/2020
A	UPDATED WITH REVISED LAYOUT	07/05/2020

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CLIENT

BRITOLOGY LTD

JOB TITLE

LONG LANE,
EARLSHEATON

DRAWING TITLE

PROPOSED SITE LAYOUT

DRAWN	DATE	STATUS
GLM	23/08/2018	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
ASw	23/08/2018	DRAFT ☐
		FINAL ☑

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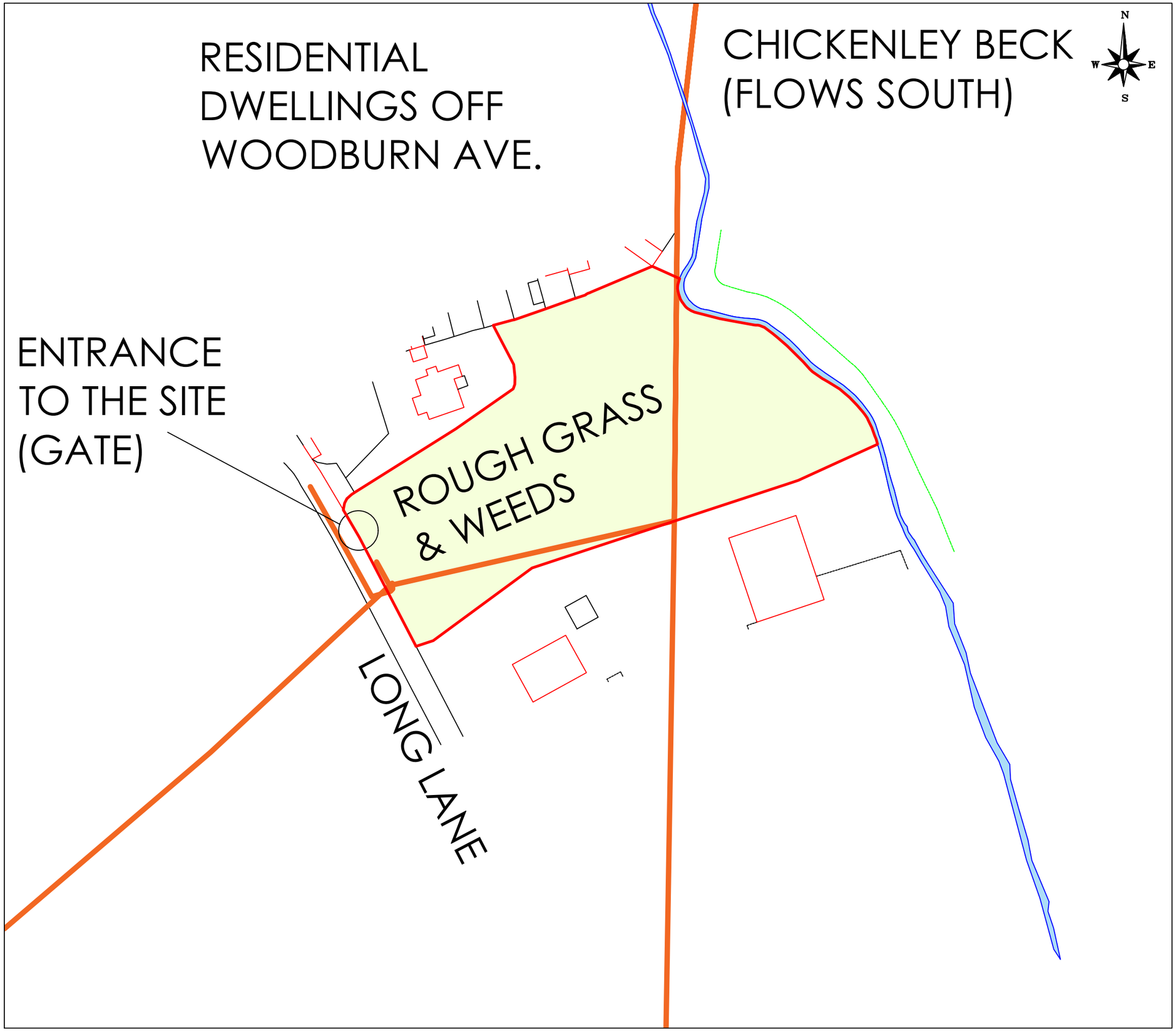

NOTES

- GRASS & OVERGROWN AREAS
- WATERCOURSE
- LINE OF OVERHEAD ELECTRICAL UTILITY
- APPROXIMATE SITE BOUNDARY

REV.	DESCRIPTION	DATE

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CLIENT

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JOB TITLE

LONG LANE,
EARLSHEATON

DRAWING TITLE

SITE FEATURES

DRAWN	DATE	STATUS
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CHECKED	DATE	FOR APPROVAL ☐
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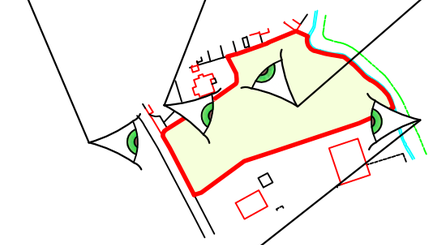

NOTES

GRASS & OVERGROWN AREAS

APPROXIMATE SITE BOUNDARY

LOCATION & ORIENTATION OF PHOTOGRAPH

REV.	DESCRIPTION	DATE

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JOB TITLE

LONG LANE,
EARLSHEATON

DRAWING TITLE

SITE PHOTOGRAPHS

DRAWN	DATE	STATUS
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		FOR APPROVAL ☐
		DRAFT ☐
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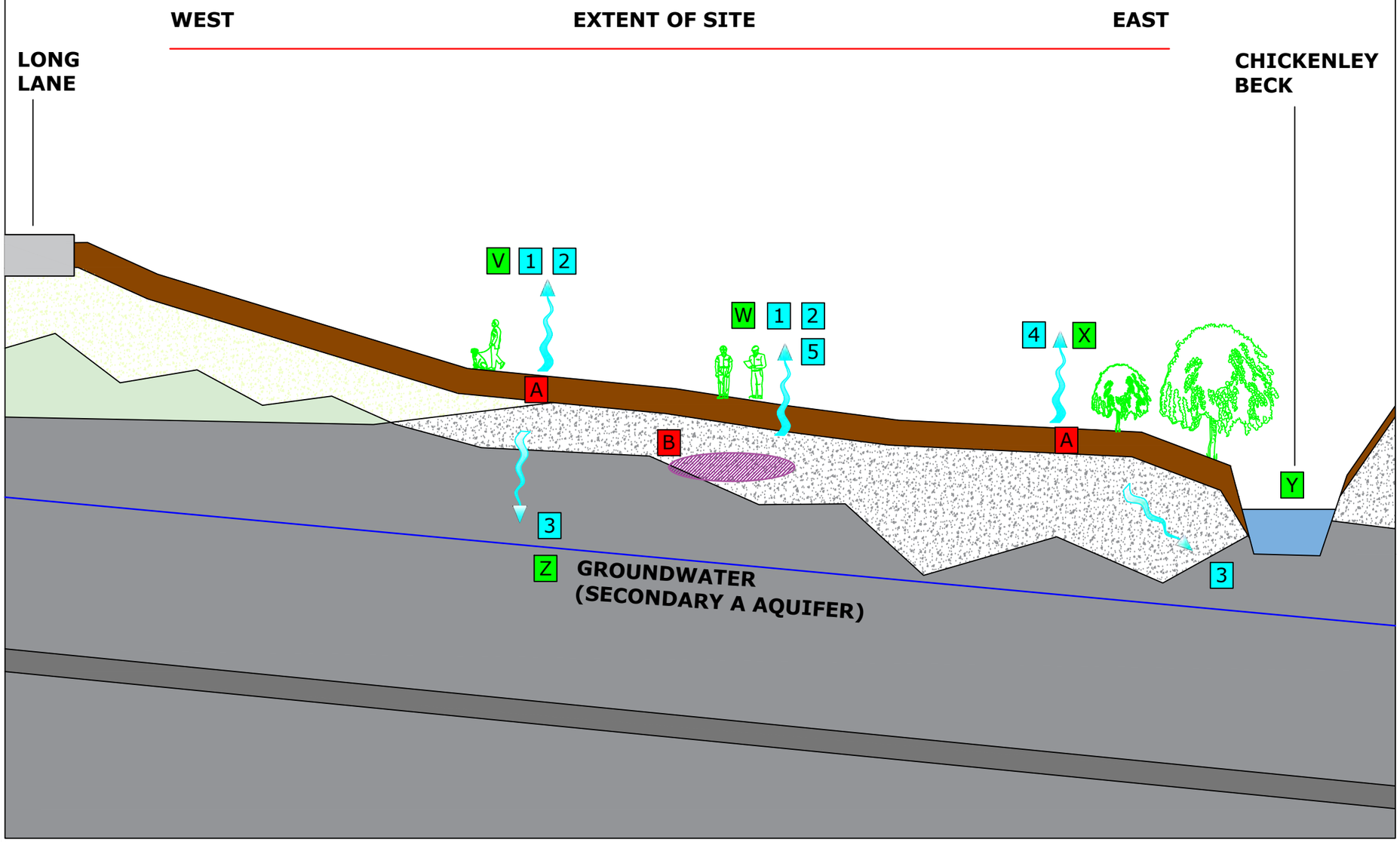

KEY

- TOPSOIL
- WEATHERED BEDROCK
- THORNHILL ROCK SANDSTONE
- MIDDLE COAL MEASURES
- JOAN COAL SEAM

SOURCES

- A FARMING RELATED CONTAMINATION (INORGANICS)
- B LEAKAGE/SPILLAGE (ORGANICS)

PATHWAYS

- 1 DERMAL CONTACT
- 2 INGESTION/INHALATION
- 3 LEACHING OF CONTAMINANTS
- 4 UPTAKE BY PLANTS
- 5 VOLATILISATION

RECEPTORS

- V END USERS (RESIDENTS)
- W SITE WORKERS
- X VEGETATION
- Y SURFACE WATERS
- Z GROUNDWATER

NOTES

REV.	DESCRIPTION	DATE

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CLIENT: BRITOLOGY LTD

JOB TITLE: LONG LANE, EARLSHEATON

DRAWING TITLE: PRELIMINARY CONCEPTUAL SITE MODEL

DRAWN	DATE	STATUS
GLM	30/08/2018	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
ASw	30/08/2018	DRAFT ☐
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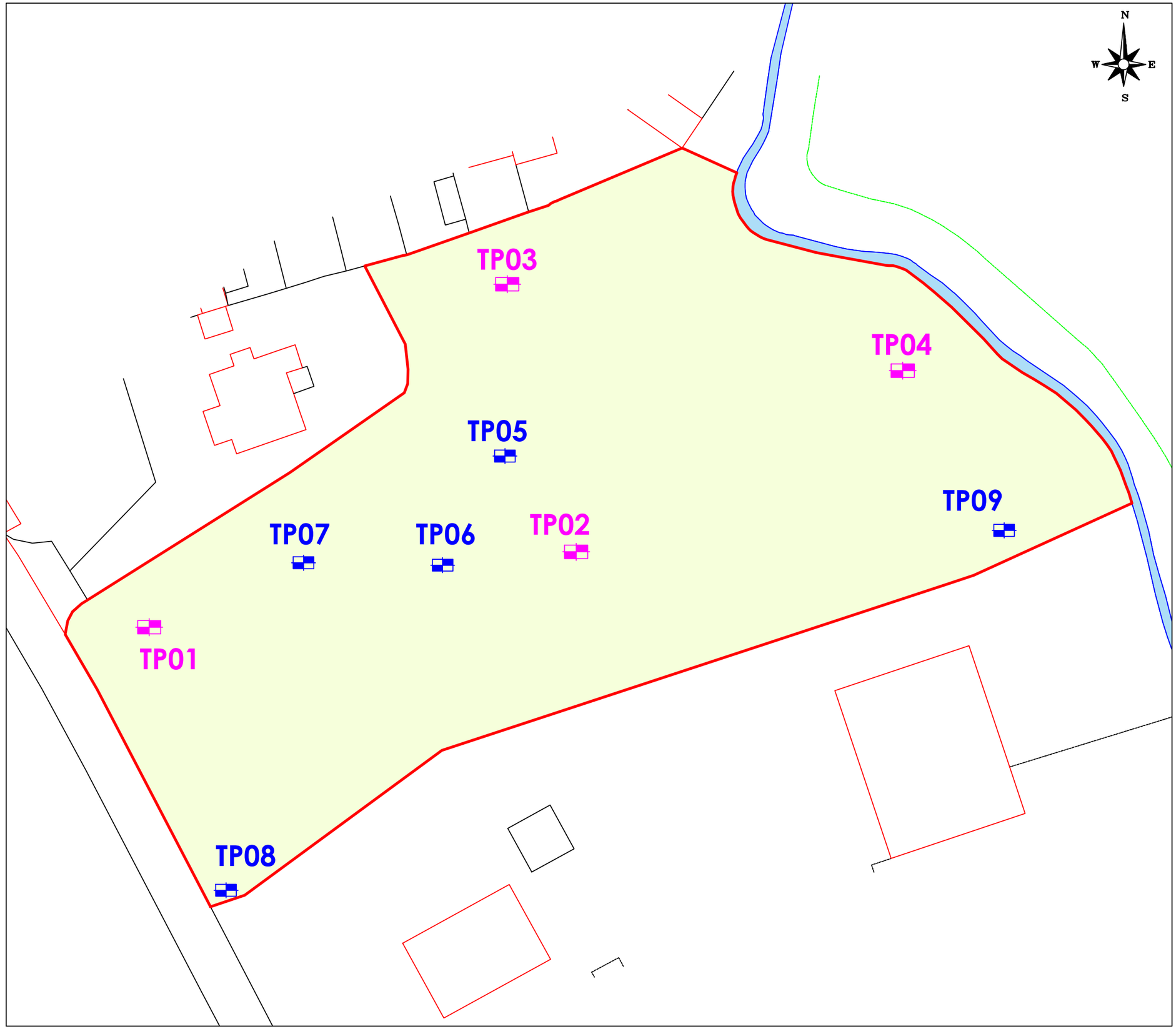


NOTES

- TRIAL PIT LOCATION
- SOAKAWAY TEST LOCATION
- LINE OF ELECTRICAL UTILITY
- APPROXIMATE SITE BOUNDARY

REV.	DESCRIPTION	DATE

LITHOS CONSULTING

info@lithos.co.uk
www.lithos.co.uk

Tel 01937 545330

CLIENT

BRITOLOGY LTD

JOB TITLE

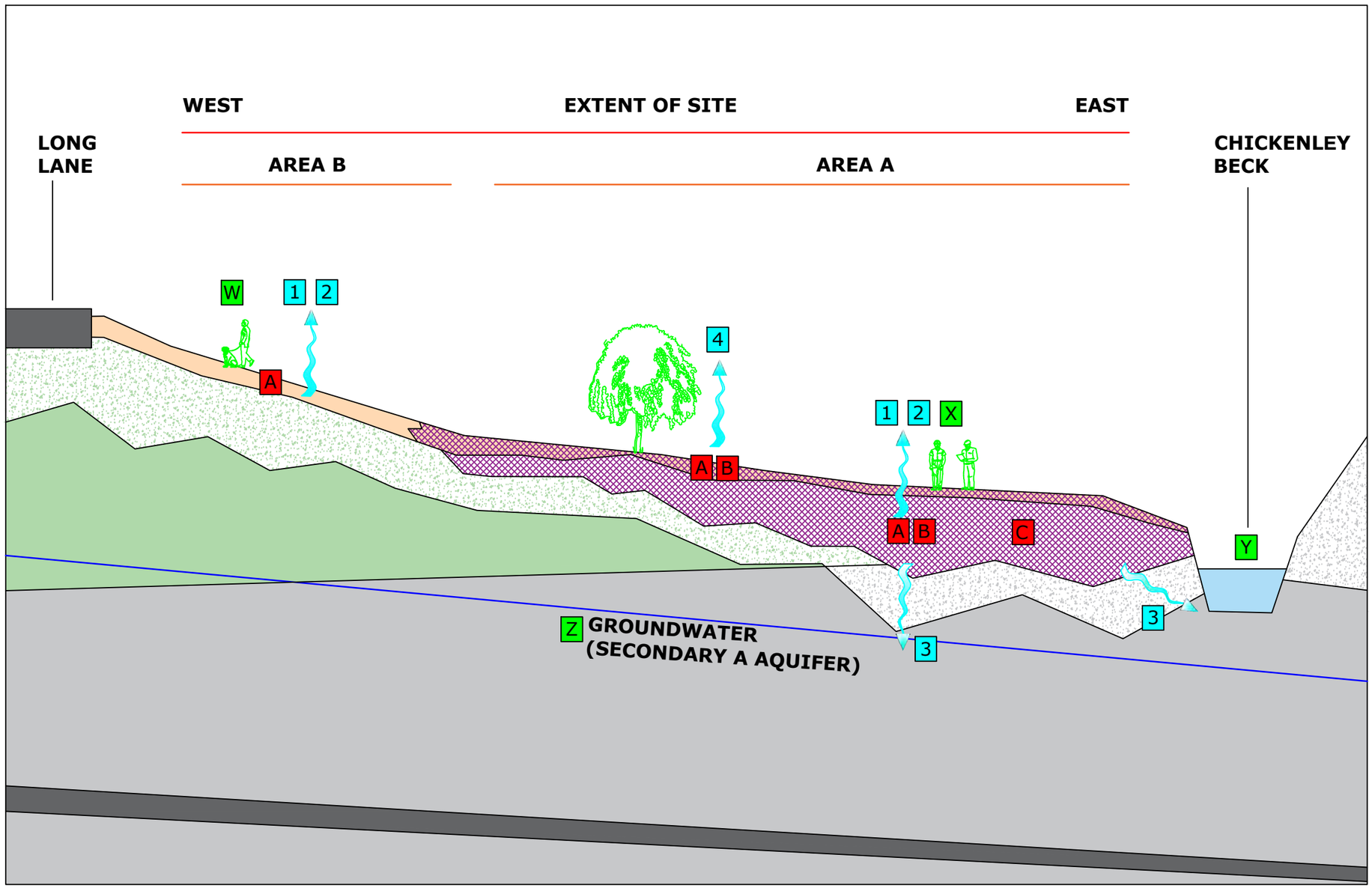
LONG LANE,
EARLSHEATON

DRAWING TITLE

EXPLORATORY HOLE LOCATIONS

DRAWN	DATE	STATUS
GLM	03/09/2018	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
ASw	03/09/2018	DRAFT ☐
		FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
1:500	A3	2986/6	



KEY	SOURCES	PATHWAYS	RECEPTORS
TOPSOIL	A INORGANICS (METALS)	1 DERMAL CONTACT	V END USERS (RESIDENTS)
MADE GROUND TOPSOIL	B ORGANICS (PAH)	2 INGESTION/INHALATION	W SITE WORKERS
ASH & CLINKER (FORMER TIP)	C COMBUSTIBILITY	3 LEACHING OF CONTAMINANTS	X VEGETATION
GRANULAR RESIDUAL SOIL		4 UPTAKE BY PLANTS	Y SURFACE WATERS
THORNHILL ROCK SANDSTONE		5 VOLATILISATION	Z GROUNDWATER
MIDDLE COAL MEASURES (INTERBEDDED MUDSTONE, SILTSTONE & SANDSTONE)			
JOAN COAL SEAM			

NOTES

REV.	DESCRIPTION	DATE

LITHOS CONSULTING

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Tel 01937 545330

CLIENT

BRITOLOGY LTD

JOB TITLE

LONG LANE, EARLSHEATON

DRAWING TITLE

REVISED CONCEPTUAL SITE MODEL

DRAWN	DATE	STATUS
GLM	01/10/2018	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
ASw	01/10/2018	DRAFT ☐
		FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
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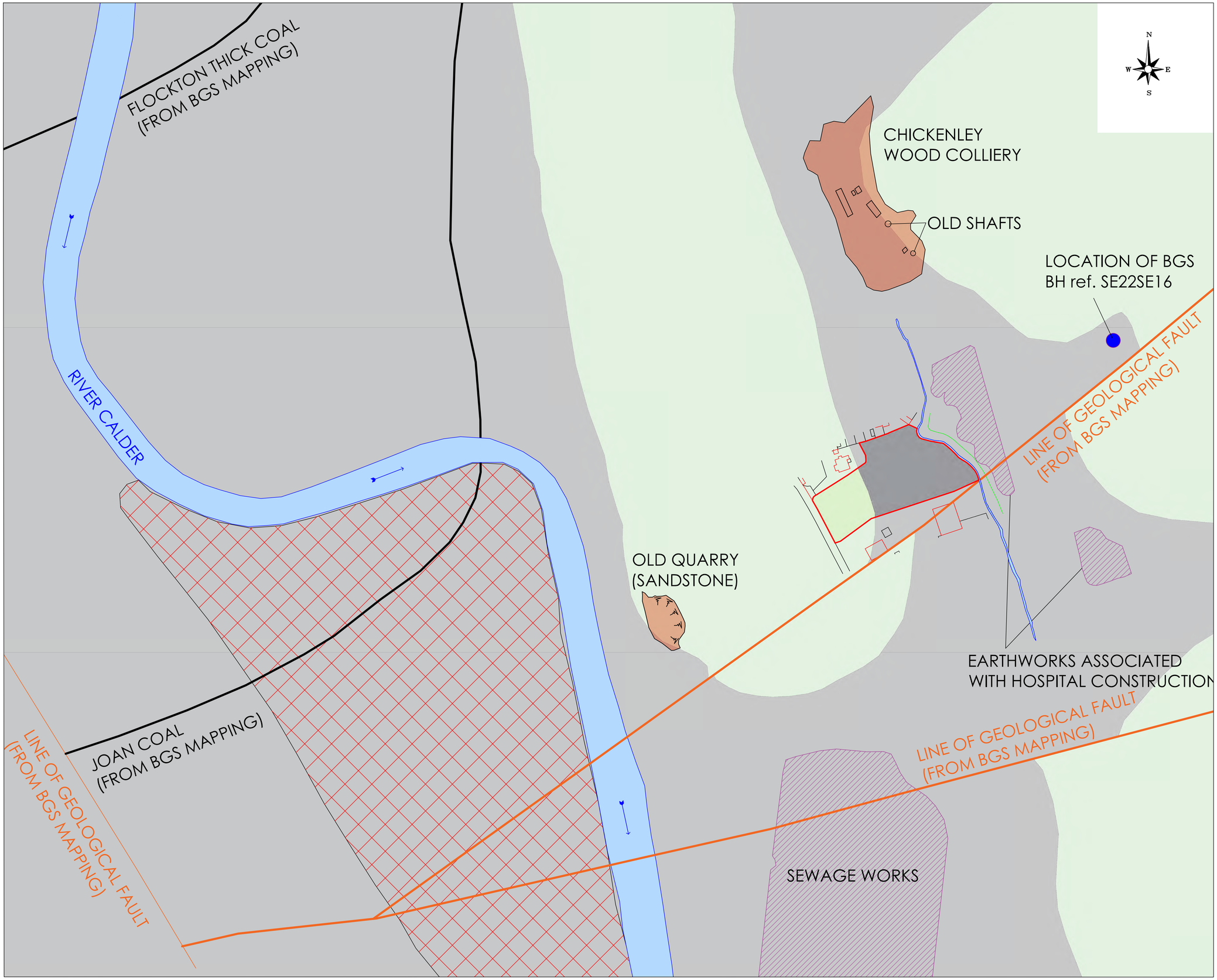

NOTES

- THORNHILL ROCK SANDSTONE
- MIDDLE COAL MEASURES (INTERBEDDED SANDSTONE, MUDSTONE & SILTSTONE)
- APPROXIMATE LINE OF GEOLOGICAL FAULT
- APPROXIMATE LINE OF COAL OUTCROP
- HISTORICAL QUARRY/COLLIERY
- AREA OF LANDFILL
- AREA OF HISTORICAL EARTHWORKS
- APPROXIMATE SITE BOUNDARY

REV	DESCRIPTION	DATE

LITHOS CONSULTING
info@lithos.co.uk
www.lithos.co.uk
Tel 01937 545330

CLIENT: BRITOLOGY LTD

JOB TITLE: LONG LANE, EARLSHEATON

DRAWING TITLE: GEOLOGICAL & HISTORICAL SITE FEATURES

DRAWN	DATE	STATUS
GLM	30/08/2018	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
ASw	30/08/2018	DRAFT ☐
		FINAL ☑

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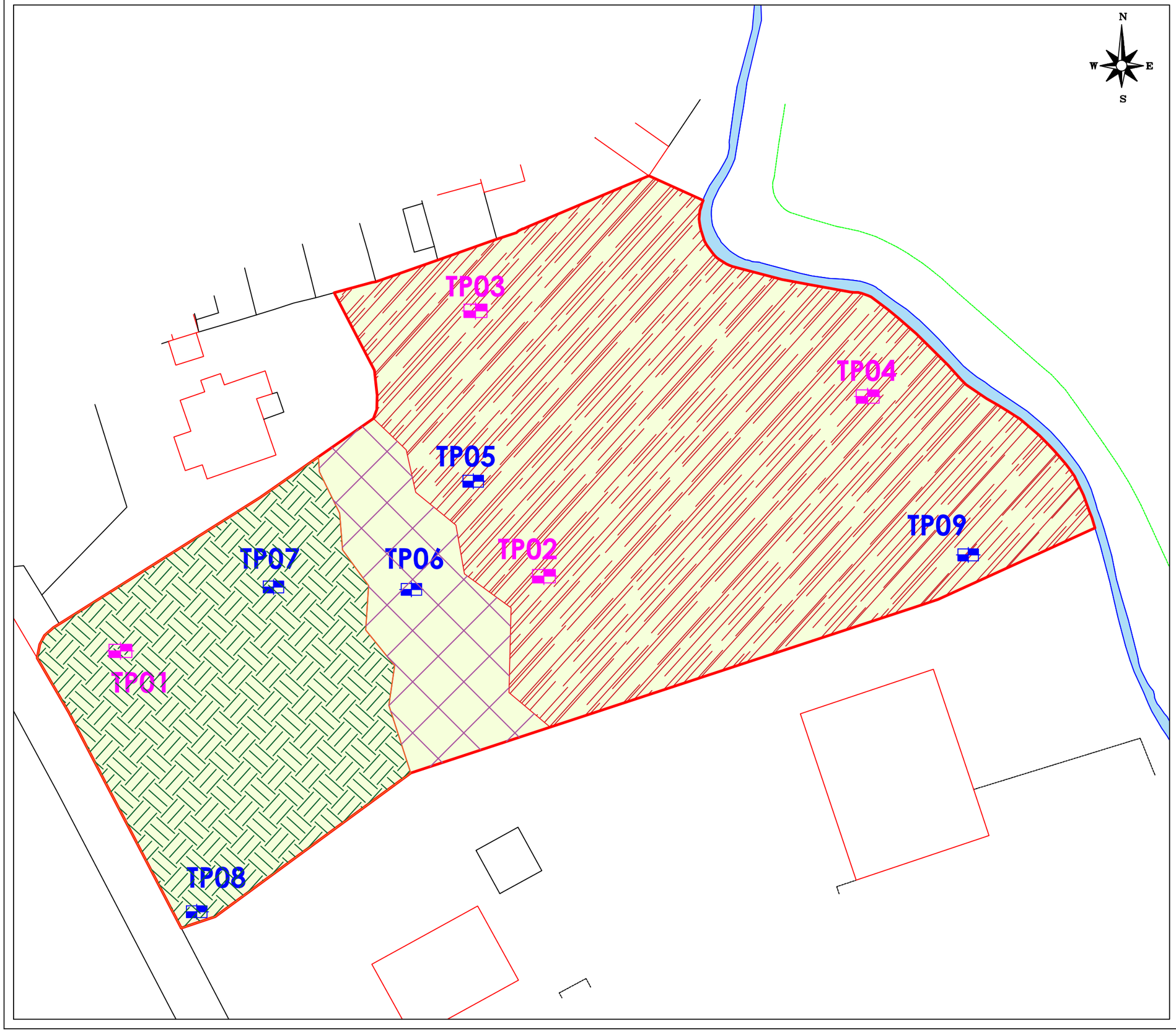

NOTES

- TRIAL PIT LOCATION
- SOAKAWAY TEST LOCATION
- FOOTPRINT OF FORMER TIP (ASH & CLINKER) WITH TOTAL MADE GROUND TO >1,000mm; CORRESPONDS TO AREA A
- FOOTPRINT OF FORMER TIP (ASH & CLINKER) WITH TOTAL MADE GROUND TO <1,000mm; CORRESPONDS TO AREA A
- AREA BEYOND FOOTPRINT OF FORMER TIP. CORRESPONDS TO AREA B
- APPROXIMATE SITE BOUNDARY

REV.	DESCRIPTION	DATE

LITHOS CONSULTING

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Tel 01937 545330

CLIENT

BRITOLOGY LTD

JOB TITLE

LONG LANE,
EARLSHEATON

DRAWING TITLE

GROUND CONDITIONS & SITE AREAS

DRAWN	DATE	STATUS
GLM	01/10/2018	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
ASw	01/10/2018	DRAFT ☐
		FINAL ☑

SCALE	SHEET	DRAW NG NO.	REVISION
1:500	A3	2986/9	

NOTES

- BUILDING WITH ANTICIPATED FOUNDATION DEPTH OF 600mm
- BUILDING WITH ANTICIPATED FOUNDATION DEPTH OF 600mm TO 1,000mm
- BUILDING WITH ANTICIPATED FOUNDATION DEPTH OF >1,000mm
- APPROXIMATE SITE BOUNDARY

REPRODUCED FROM DRAWING 'LONG LANE, EARLSHEATON, DEWSBURY, PROPOSED SITE PLAN' REF. 0067_LON_SK103, ISSUED BY ELEVEN52 ARCHITECTS IN MAY 2020

REV.	DESCRIPTION	DATE
B	UPDATED WITH REVISED LAYOUT	01/06/2020
A	UPDATED WITH REVISED LAYOUT	07/05/2020

LITHOS CONSULTING

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CLIENT

BRITOLOGY LTD

JOB TITLE

LONG LANE, EARLSHEATON

DRAWING TITLE

EXPLORATORY HOLE LOCATIONS

DRAWN	DATE	STATUS
GLM	03/09/2018	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
ASw	03/09/2018	DRAFT ☐
		FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
1:500	A3	2986/10	B

Appendix C

Commission

004/2986/REG

19th August 2018

Registered in England 07068066

Parkhill
Wetherby
West Yorkshire
LS22 5DZ

T 01937 545 330

www.lithos.co.uk

Mr J Scott
Britology Limited
8 Craig-Y-Don
Earlsheaton
West Yorkshire
WF12 8BJ

Dear Jonathan

Long Lane, Earlsheaton

Further to your recent invitation, please find attached our proposal for undertaking a site investigation on the above land. We understand that your proposed development will include traditional 2 storey domestic dwellings with associated gardens, POS and adoptable roads and sewers; an illustrative masterplan showing 15 units has been provided.

Review of the information supplied suggests that the site consists of a single parcel of land of approximately 0.62 hectares east of Long Lane. Review of Google Maps suggests the site is rough pasture, with Chickenley Beck flowing south along the eastern boundary.

Brief review of Old Maps and Environment Agency data suggests the site:

- Appears to have remained undeveloped throughout its history;
- Is not located within 250m of a known landfill site; and,
- Is not within a groundwater source protection zone.

Brief examination of the relevant geological map suggests the site is directly underlain by Coal Measures bedrock in the vicinity of Thornhill Rock. This site is located within a Coal Mining Development Low Risk Area (within the defined coalfield, but no known defined risks have been recorded by the Coal Authority; there may still be unrecorded issues), therefore a mining report will be obtained (however, at this stage an intrusive mining investigation is considered unlikely to be required). There is an area of High Risk just beyond the site's southern boundary.

The scope of works outlined in this letter should enable us to assess abnormal development issues, associated with ground. However, the nature of site investigation is such that it is not always possible to foresee all the potential issues. Consequently, it is sometimes necessary to recommend additional work, but where this occurs we will inform you immediately, provide costs, and seek your further instruction. We have reviewed available internet data and our geological maps in order to minimise the likelihood of further work.

We will need a Promap or topo survey in CAD format, to provide a base plan for technical drawings etc. If you do not have one, we could obtain at cost plus £ .

This proposal allows for the following works:

Desk study: Environmental search data and historical maps (obtained from Landmark or Groundsure), will be reviewed in order to determine whether past land uses have had any effect on the proposed development. In addition, published geological plans of the area will be examined.

We will also visit site to undertake a walkover survey.

Fieldwork: We have allowed for a day's trial pitting with all pits to be supervised and logged by an experienced geoenvironmental engineer.

Based on anticipated ground, soakaways are considered might provide a satisfactory solution for surface water drainage, and testing would remove any ambiguity with respect to Yorkshire Water queries. If required, soakaway tests could be undertaken (at the same time as the pitting) for an additional fee of about £

Representative soil samples of natural and man-made ground, including any contaminated samples, will be taken during the works. In-situ shear strengths of any cohesive soils encountered will be determined by the use of a hand-held shear vane.

We will make every effort to compact arisings and 'sweep' them over each pit. However, you should be aware that on completion of the investigation, "graves" of spoil (each about 3m long by 1m wide) unsuitable for trafficking, will be left up to 400mm proud at each trial pit location. At this stage, no allowance has been made for any further reinstatement such as removal of excess arisings, replacement of turf.

If the pitting encounters significant thicknesses of made ground or very soft/loose deposits (neither considered likely), boreholes may be required to obtain geotechnical data from greater depth. We will advise you of any need for boreholes within 2 days of completion of the pitting.

This investigation should yield sufficient data to enable a foundation zoning plan, and possibly a detailed Foundation Schedule. However, if ground conditions are found to be more variable than anticipated, a 'tighter' grid of pits will be necessary prior to preparation of a detailed Foundation Schedule. This proposal does not allow for the preparation of a detailed Foundation Schedule, but we will provide a quote on completion of the site investigation if requested.

This site is greenfield and therefore highly unlikely to be underlain by significant thicknesses of made ground. Furthermore, we are not aware of any other sources of hazardous gas (shallow mine workings, landfill sites etc) within influencing distance of the site. Consequently, at this stage, we have not allowed for undertaking a hazardous gas risk assessment but we will review the need for this in light of desk study data and the ground conditions actually encountered.

This proposal has been put together without a visit to the site and it has been assumed that access is available for a JCB-type excavator.

Testing: This will comprise routine geotechnical soils analysis, including 8 moisture content & Atterberg limits, and 8 pH & water-soluble sulphate.

At this stage routes, we will simply estimate CBR values from strata descriptions and classification test results.

The site is understood to be essentially Greenfield, and therefore testing of potentially contaminated samples should only be required if made ground is encountered in the exploratory holes. However, we have allowed for analysis of topsoil (6 samples) to confirm its suitability for re-use. The test suite will include heavy metals and speciated PAH. Visible contaminants, sharps and the clay/sand/silt content of 2 topsoil samples will be determined to check compliance with BS3882 requirements.

Within in our proposal we have allowed for the screening (ID) of 6 samples for asbestos. In the event that positive IDs are reported, it is likely that we will need to schedule further analysis (asbestos quantification), in order to determine the significance of the results. Asbestos quantification is currently a relatively expensive test and consequently we have not allowed for it at this stage. We will inform you immediately after receipt of results if we consider asbestos quantification is required.

Reporting & timescales: In order to provide you with sufficient information to enable assessment of abnormal costs at the earliest opportunity we will issue a concise overview report within 3 days of fieldwork completion.

On completion of the desk study, fieldwork and laboratory testing a comprehensive bound, factual and interpretative report will be issued. This will contain detailed engineering records, laboratory test results, copies of all relevant correspondence and drawings of the site. The report will include qualitative risk assessment with respect to both controlled waters and human health. The report will also include consideration of foundation types.

Fieldwork could be commenced within 3 weeks of receipt of your written instruction to proceed. Our comprehensive geoenvironmental appraisal report will be issued within 4 weeks of fieldwork completion.

A copy of the final report will be issued to the relevant regulatory authorities on receipt of written instruction from yourselves.

Invoicing: The attached proposal provides a breakdown of the costs associated with this project. This breakdown is for information only and the proposal can be regarded as a lump sum price of £ plus VAT. Variation will only occur in the event that a given item is not undertaken or that substantial additional works are recommended, in which case we will inform you immediately, provide costs for the required works, and seek your prior consent.

Our proposal allows for submission of the report to the Local Authority and NHBC, and for submission of a single piece of subsequent correspondence with each regulator to address any queries they may have. Any further meetings, correspondence etc, would be chargeable.

We will submit our invoice for this project with the final report.

Health, safety & welfare: The works outlined above will be carried out in accordance with Lithos' task- and site- specific Risk Assessments and Method Statements.

Details of welfare will be included within the Method Statements, however, this investigation is expected to be completed within a working day and therefore it is not considered reasonably practicable to provide formal welfare facilities, and our proposal makes no allowance for so doing.

Utility plans are required in order to protect operatives from the hazards associated with striking buried services and avoid potentially substantial disruption\repair costs. We will make every effort not to damage any services (including review of utility plans and use of a CAT detector). However, Lithos cannot accept liability for damage to any underground services that are not accurately marked on plans made available to us prior to commencement of our field investigation, or have not been accurately marked on the ground by a responsible third party (e.g. utility company, site owner).

Most developers have copies of the necessary utility plans (including electricity, gas, water, drainage & telecom), and it would be appreciated if you could forward these prior to the proposed fieldworks. However, if you do not have the necessary plans, Lithos will obtain them direct from each of the utility companies.

Under the CDM Regulations 2015, Lithos must be provided with pre-construction information already in your possession, or information that can reasonably be obtained through sensible enquiry. This information must be relevant to the project, have an appropriate level of detail, and be proportionate to the nature of the risks.

Terms & conditions: This work will be undertaken in accordance with our Standard Terms and Conditions, a copy of which are enclosed.

At the time of writing, we understand that our report is solely for Britology's benefit. However, it is anticipated that eventually a third party (the Developer) will wish to rely on our report. We confirm that we will assign, free of charge, the benefit of our Report(s) to the Developer on receipt of an instruction from Britology. In the event that both Britology and the Developer require reliance, or if more than one Developer requires reliance, a warranty will be required. We confirm that we will consent to a request from Britology to enter a collateral warranty, provided it is our approved standard form, and subject to payment of a fee to cover our legal and incidental costs. We will

require approval from our insurers if more than one beneficiary requires a warranty, or if the proposed warranty is not Lithos' approved standard form.

It is hoped the above is sufficient for your present needs. However, should you require any further information, please contact the undersigned.

Yours sincerely

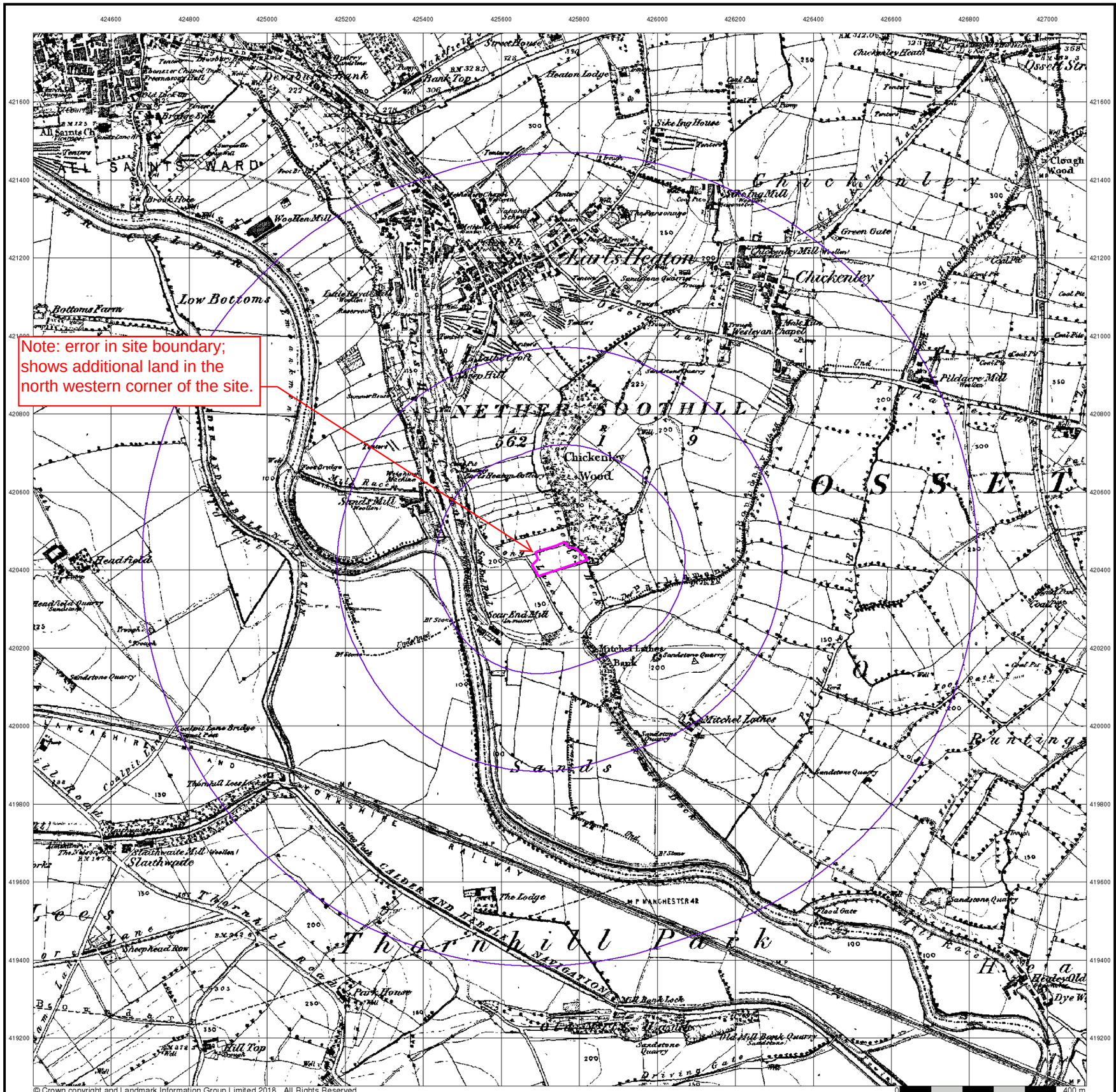
Redacted

Mark Perrin
Director
for and on behalf of
LITHOS CONSULTING LIMITED

Redacted

Appendix D

Historical OS Plans



LITHOS CONSULTING

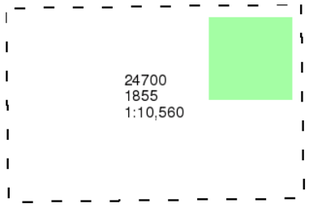
Yorkshire

Published 1855

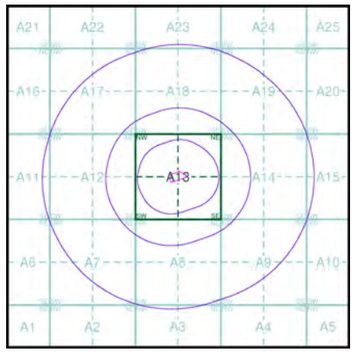
Source map scale - 1:10,560

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas; these maps were used to update the 1:10,560 maps. The published date given therefore is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas. In the late 1940`s, a Provisional Edition was produced, which updated the 1:10,560 mapping from a number of sources. The maps appear unfinished - with all military camps and o her strategic sites removed. These maps were initially overprinted with the National Grid. In 1970, the first 1:10,000 maps were produced using the Transverse Mercator Projection. The revision process continued un il recently, with new editions appearing every 10 years or so for urban areas.

Map Name(s) and Date(s)



Historical Map - Slice A



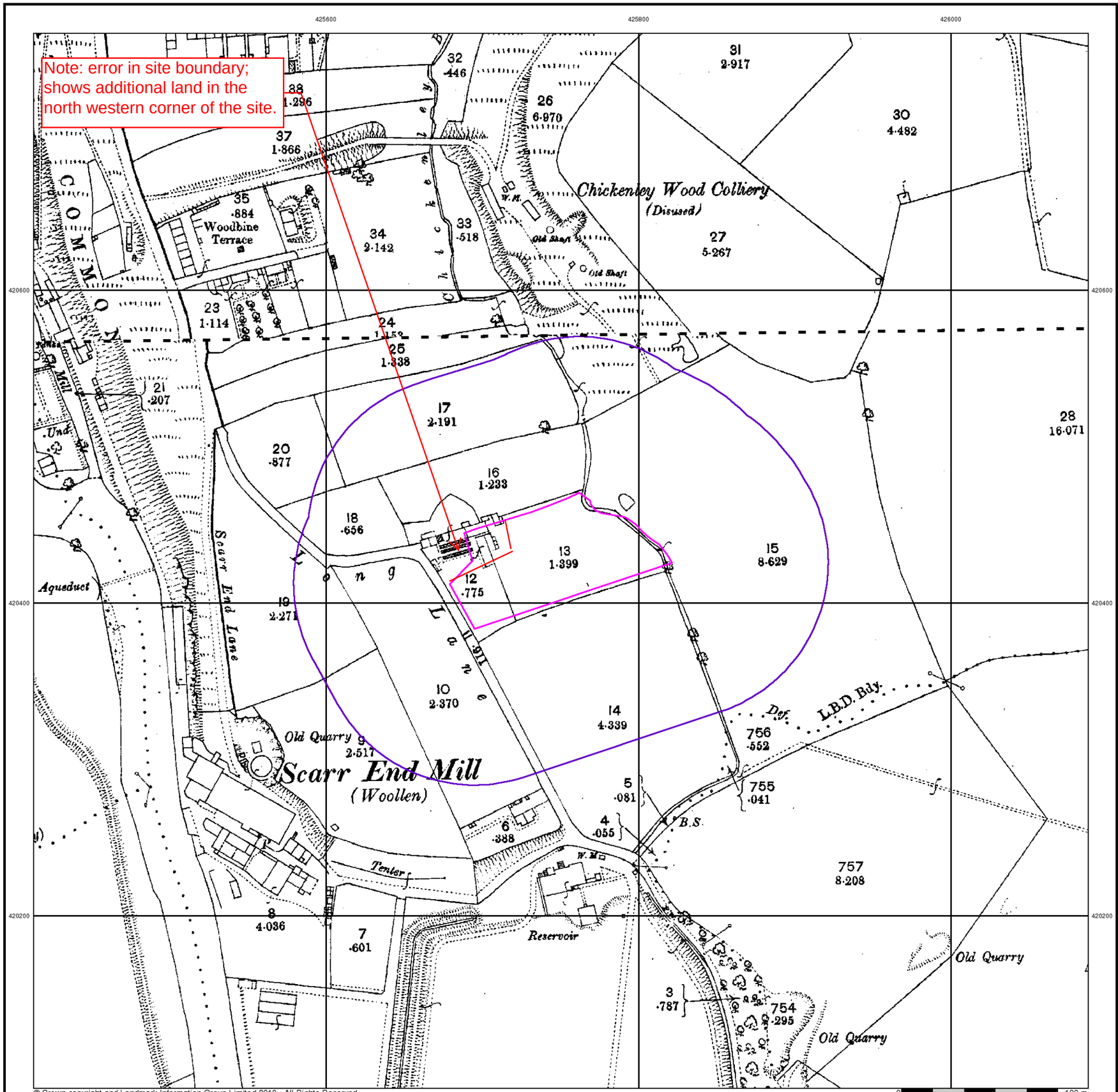
Order Details

Order Number:	177675673_1_1
Customer Ref:	PO13460/JW/2986
National Grid Reference:	425750, 420430
Slice:	A
Site Area (Ha):	0.68
Search Buffer (m):	1000

Site Details

Long Lane, Earlsheaton, WF12 8LJ

Landmark INFORMATION GROUP
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck co uk



LITHOS CONSULTING

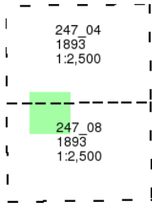
Yorkshire

Published 1893

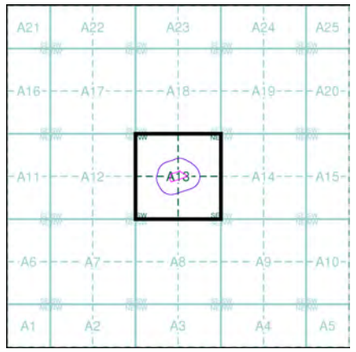
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cul ivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, wi h independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



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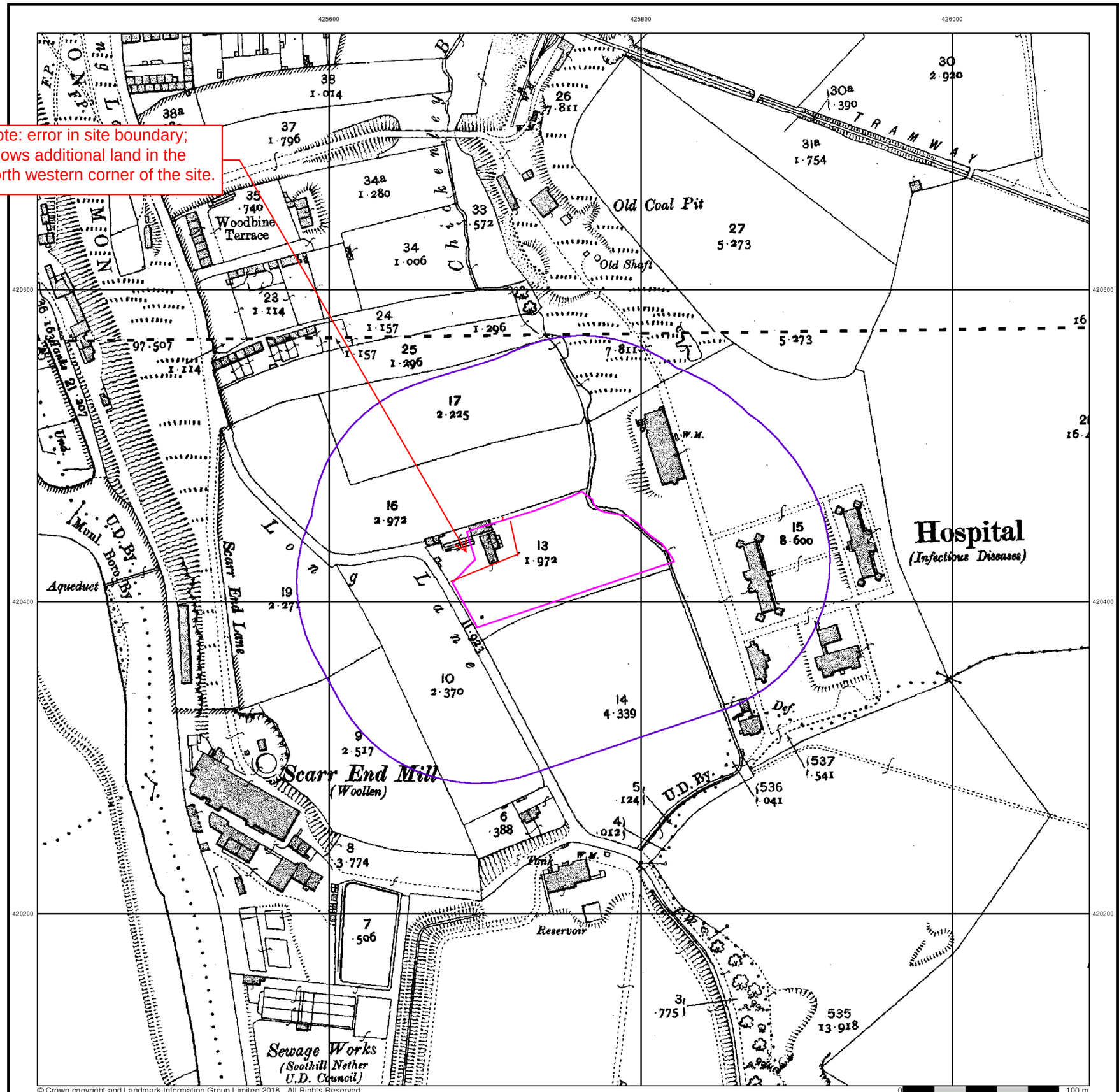
National Grid Reference:	425750, 420430
Slice:	A
Site Area (Ha):	0.68
Search Buffer (m):	100

Site Details

Long Lane, Earlsheaton, WF12 8LJ

Landmark INFORMATION GROUP
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck co uk



LITHOS CONSULTING

Yorkshire

Published 1907

Source map scale - 1:2,500

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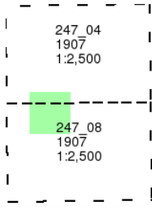
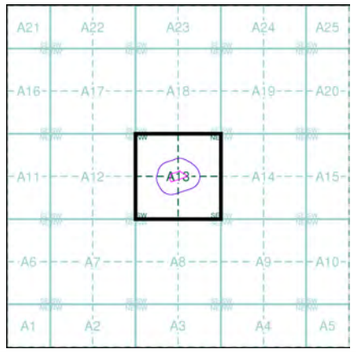
Map Name(s) and Date(s)



Historical Map - Segment A13



Order Details

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Customer Ref:	PO13460/JW/2986
National Grid Reference:	425750, 420430
Slice:	A
Site Area (Ha):	0.68
Search Buffer (m):	100

Site Details

Long Lane, Earlsheaton, WF12 8LJ

Landmark INFORMATION GROUP
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck co uk

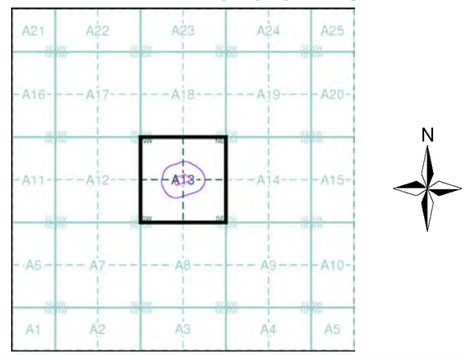
LITHOS CONSULTING

Historical Aerial Photography

Published 1999

This aerial photography was produced by Getmapping, these vertical aerial photographs provide a seamless, full colour survey of the whole of Great Britain

Historical Aerial Photography - Segment A13



Order Details

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Customer Ref:	PO13460/JW/2986
National Grid Reference:	425750, 420430
Slice:	A
Site Area (Ha):	0.68
Search Buffer (m):	100

Site Details

Long Lane, Earlsheaton, WF12 8LJ

Landmark INFORMATION GROUP

Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck co uk

Appendix E

Search Responses & other Correspondence

Envirocheck® Report:

Datasheet

Order Details:

Order Number:
177675673_1_1

Customer Reference:
PO13460/JW/2986

National Grid Reference:
425750, 420430

Slice:
A

Site Area (Ha):
0.68

Search Buffer (m):
1000

Site Details:

Long Lane
Earlsheaton
WF12 8LJ

Client Details:

Mr M Perrin
Lithos Consulting Ltd
Parkhill
Walton Road
Wetherby
LS22 5DZ

Contents

Introduction

The Environment Act 1995 has made site sensitivity a key issue, as the legislation pays as much attention to the pathways by which contamination could spread, and to the vulnerable targets of contamination, as it does the potential sources of contamination.
For this reason, Landmark's Site Sensitivity maps and Datasheet(s) place great emphasis on statutory data provided by the Environment Agency/Natural Resources Wales and the Scottish Environment Protection Agency; it also incorporates data from Natural England (and the Scottish and Welsh equivalents) and Local Authorities; and highlights hydrogeological features required by environmental and geotechnical consultants. It does not include any information concerning past uses of land. The datasheet is produced by querying the Landmark database to a distance defined by the client from a site boundary provided by the client.
In the attached datasheet the National Grid References (NGRs) are rounded to the nearest 10m in accordance with Landmark's agreements with a number of Data Suppliers.

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Summary

Data Type	Page Number	On Site	0 to 250m	251 to 500m	501 to 1000m (*up to 2000m)
Agency & Hydrological					
BGS Groundwater Flooding Susceptibility	pg 1	Yes	Yes	Yes	n/a
Contaminated Land Register Entries and Notices					
Discharge Consents	pg 2		4	7	50
Prosecutions Relating to Controlled Waters			n/a	n/a	n/a
Enforcement and Prohibition Notices					
Integrated Pollution Controls					
Integrated Pollution Prevention And Control	pg 17			1	6
Local Authority Integrated Pollution Prevention And Control					
Local Authority Pollution Prevention and Controls	pg 19				8
Local Authority Pollution Prevention and Control Enforcements					
Nearest Surface Water Feature	pg 20	Yes			
Pollution Incidents to Controlled Waters	pg 20			1	23
Prosecutions Relating to Authorised Processes					
Registered Radioactive Substances					
River Quality	pg 24		1		2
River Quality Biology Sampling Points	pg 25				1
River Quality Chemistry Sampling Points					
Substantiated Pollution Incident Register	pg 25			2	5
Water Abstractions	pg 26				(*24)
Water Industry Act Referrals					
Groundwater Vulnerability	pg 32	Yes	n/a	n/a	n/a
Drift Deposits			n/a	n/a	n/a
Bedrock Aquifer Designations	pg 32	Yes	n/a	n/a	n/a
Superficial Aquifer Designations			n/a	n/a	n/a
Source Protection Zones					
Extreme Flooding from Rivers or Sea without Defences	pg 32	Yes		n/a	n/a
Flooding from Rivers or Sea without Defences	pg 32	Yes	Yes	n/a	n/a
Areas Benefiting from Flood Defences	pg 32		Yes	n/a	n/a
Flood Water Storage Areas	pg 32		Yes	n/a	n/a
Flood Defences	pg 32		Yes	n/a	n/a
OS Water Network Lines	pg 32	1	7	4	42

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Summary

Data Type	Page Number	On Site	0 to 250m	251 to 500m	501 to 1000m (*up to 2000m)
Waste					
BGS Recorded Landfill Sites	pg 39		1		1
Historical Landfill Sites	pg 39		1		4
Integrated Pollution Control Registered Waste Sites					
Licensed Waste Management Facilities (Landfill Boundaries)					
Licensed Waste Management Facilities (Locations)	pg 40		1	1	6
Local Authority Landfill Coverage		1	n/a	n/a	n/a
Local Authority Recorded Landfill Sites					
Potentially Infilled Land (Non-Water)	pg 42		1	5	7
Potentially Infilled Land (Water)	pg 43			2	7
Registered Landfill Sites	pg 44				3
Registered Waste Transfer Sites	pg 45				1
Registered Waste Treatment or Disposal Sites	pg 45				2
Hazardous Substances					
Control of Major Accident Hazards Sites (COMAH)					
Explosive Sites					
Notification of Installations Handling Hazardous Substances (NIHHS)	pg 46				1
Planning Hazardous Substance Consents	pg 46				1
Planning Hazardous Substance Enforcements					

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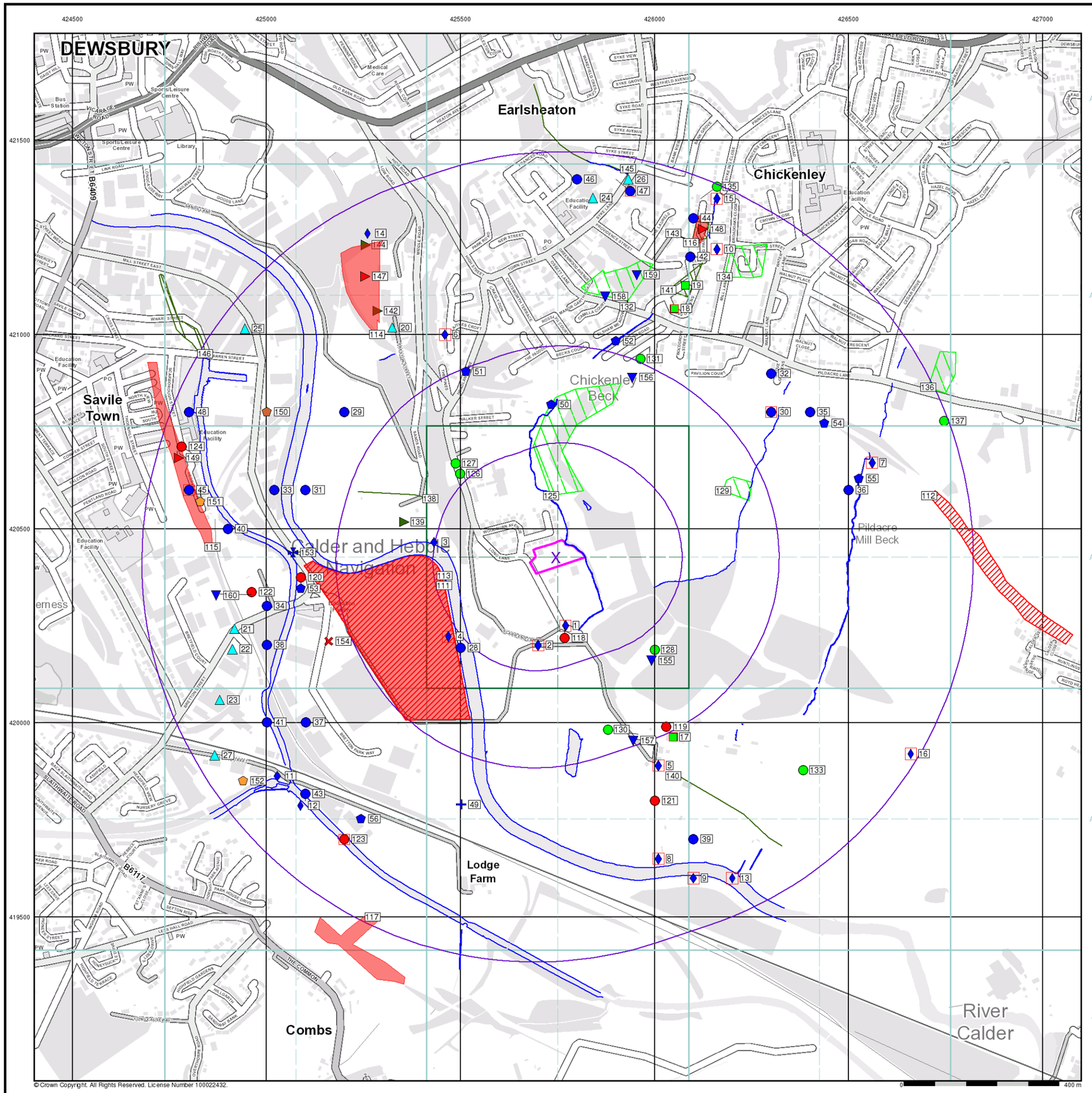
Summary

Data Type	Page Number	On Site	0 to 250m	251 to 500m	501 to 1000m (*up to 2000m)
Geological					
BGS 1:625,000 Solid Geology	pg 47	Yes	n/a	n/a	n/a
BGS Estimated Soil Chemistry	pg 47	Yes	Yes	Yes	Yes
BGS Recorded Mineral Sites	pg 50			3	3
BGS Urban Soil Chemistry					
BGS Urban Soil Chemistry Averages					
CBSCB Compensation District			n/a	n/a	n/a
Coal Mining Affected Areas	pg 51	Yes	n/a	n/a	n/a
Mining Instability	pg 51	Yes	n/a	n/a	n/a
Man-Made Mining Cavities					
Natural Cavities					
Non Coal Mining Areas of Great Britain				n/a	n/a
Potential for Collapsible Ground Stability Hazards	pg 51	Yes		n/a	n/a
Potential for Compressible Ground Stability Hazards	pg 51		Yes	n/a	n/a
Potential for Ground Dissolution Stability Hazards				n/a	n/a
Potential for Landslide Ground Stability Hazards	pg 51	Yes	Yes	n/a	n/a
Potential for Running Sand Ground Stability Hazards	pg 52		Yes	n/a	n/a
Potential for Shrinking or Swelling Clay Ground Stability Hazards	pg 52	Yes		n/a	n/a
Radon Potential - Radon Affected Areas	pg 52	Yes	n/a	n/a	n/a
Radon Potential - Radon Protection Measures	pg 52	Yes	n/a	n/a	n/a
Industrial Land Use					
Contemporary Trade Directory Entries	pg 53	1	4	1	129
Fuel Station Entries					
Points of Interest - Commercial Services	pg 65		2	1	21
Points of Interest - Education and Health					
Points of Interest - Manufacturing and Production	pg 67			6	33
Points of Interest - Public Infrastructure	pg 70			2	9
Points of Interest - Recreational and Environmental	pg 71				2
Gas Pipelines					
Underground Electrical Cables					

Summary

Data Type	Page Number	On Site	0 to 250m	251 to 500m	501 to 1000m (*up to 2000m)
Sensitive Land Use					
Ancient Woodland					
Areas of Adopted Green Belt	pg 72	1	1		
Areas of Unadopted Green Belt					
Areas of Outstanding Natural Beauty					
Environmentally Sensitive Areas					
Forest Parks					
Local Nature Reserves					
Marine Nature Reserves					
National Nature Reserves					
National Parks					
Nitrate Sensitive Areas					
Nitrate Vulnerable Zones					
Ramsar Sites					
Sites of Special Scientific Interest					
Special Areas of Conservation					
Special Protection Areas					
World Heritage Sites					



LITHOS CONSULTING

General

Specified Site
Specified Buffer(s)
Bearing Reference Point
Map ID
Several of Type at Location

Agency and Hydrological

Contaminated Land Register Entry or Notice (Location)
Contaminated Land Register Entry or Notice
Discharge Consent
Enforcement or Prohibition Notice
Integrated Pollution Control
Integrated Pollution Prevention Control
Local Authority Integrated Pollution Prevention and Control
Local Authority Pollution Prevention and Control
Local Authority Pollution Prevention and Control Enforcement
Pollution Incident to Controlled Waters
Prosecution Relating to Authorised Processes
Prosecution Relating to Controlled Waters
Registered Radioactive Substance
River Network or Water Feature
River Quality Sampling Point
Substantiated Pollution Incident Register
Water Abstraction
Water Industry Act Referral

Hazardous Substances

COMAH Site
Explosive Site
NIHHS Site
Planning Hazardous Substance Consent
Planning Hazardous Substance Enforcement

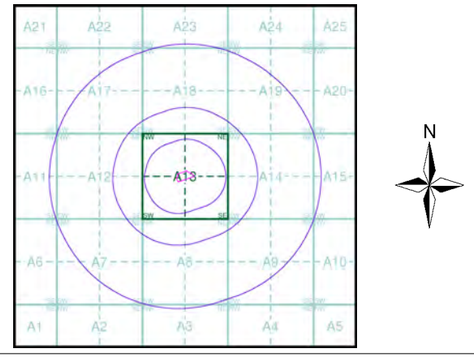
Geological

BGS Recorded Mineral Site

Waste

BGS Recorded Landfill Site (Location)
BGS Recorded Landfill Site
EA Historic Landfill (Buffered Point)
EA Historic Landfill (Polygon)
Integrated Pollution Control Registered Waste Site
Licensed Waste Management Facility (Landfill Boundary)
Licensed Waste Management Facility (Location)
Local Authority Recorded Landfill Site (Location)
Local Authority Recorded Landfill Site
Potentially Infilled Land (Non-water)
Potentially Infilled Land (Non-water)
Potentially Infilled Land (Non-water)
Potentially Infilled Land (Water)
Potentially Infilled Land (Water)
Potentially Infilled Land (Water)
Registered Landfill Site
Registered Landfill Site (Location)
Registered Landfill Site (Point Buffered to 100m)
Registered Landfill Site (Point Buffered to 250m)
Registered Waste Transfer Site (Location)
Registered Waste Transfer Site
Registered Waste Treatment or Disposal Site (Location)
Registered Waste Treatment or Disposal Site

Site Sensitivity Map - Slice A



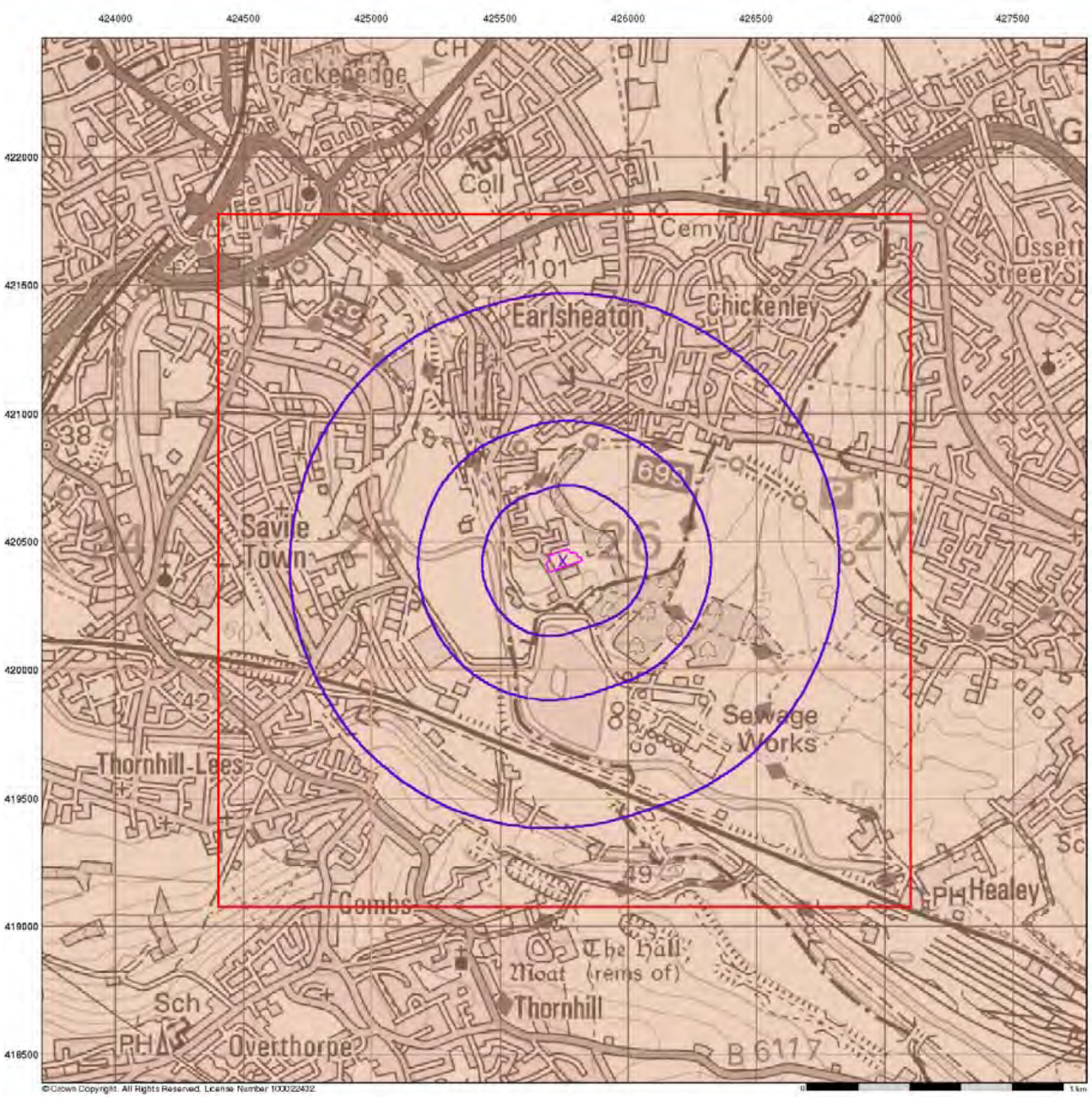
Order Details

Order Number:	177675673_1_1
Customer Ref:	PO13460/JW/2986
National Grid Reference:	425750, 420430
Slice:	A
Site Area (Ha):	0.68
Search Buffer (m):	1000

Site Details

Long Lane, Earlsheaton, WF12 8LJ

Landmark INFORMATION GROUP
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www envirocheck co uk



LITHOS CONSULTING

Bedrock Aquifer Designation

General

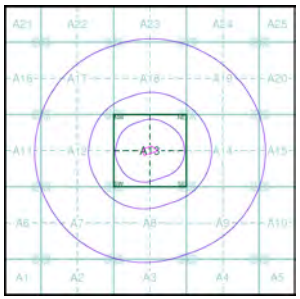
Specified Site | Specified Buffer(s) | Bearing Reference Point | Slice | Map ID

Agency and Hydrological

Geological Classes

- Principal Aquifer
- Secondary A Aquifer
- Secondary B Aquifer
- Secondary Undifferentiated
- Unproductive Strata
- Unknown
- Unknown (Lakes and Landslip)

Site Sensitivity Context Map - Slice A

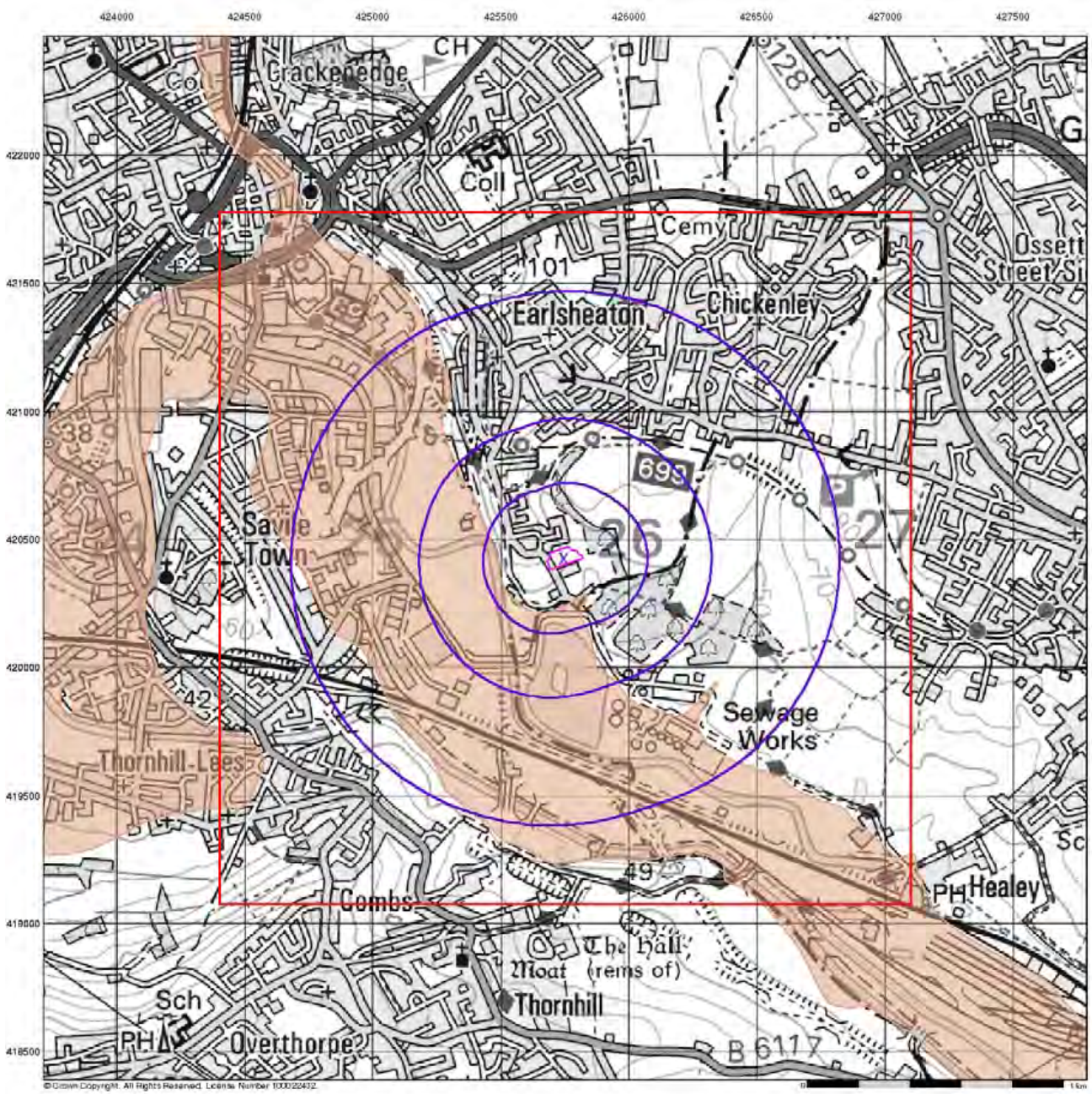


Order Details

Order Number:	177675673_1_1
Customer Ref:	PO13460/JW/2986
National Grid Reference:	425750, 420430
Slice:	A
Site Area (Ha):	0 68
Search Buffer (m):	1000

Site Details

Long Lane, Earlsheaton, WF12 8LJ



LITHOS CONSULTING

Superficial Aquifer Designation

General

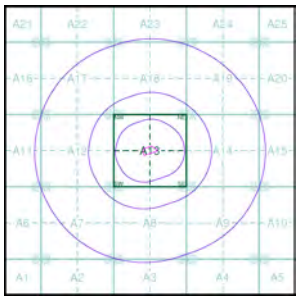
Specified Site | Specified Buffer(s) | Bearing Reference Point | Slice | Map ID

Agency and Hydrological

Geological Classes

- Principal Aquifer
- Secondary A Aquifer
- Secondary B Aquifer
- Secondary Undifferentiated
- Unproductive Strata
- Unknown
- Unknown (Lakes and Landslip)

Site Sensitivity Context Map - Slice A

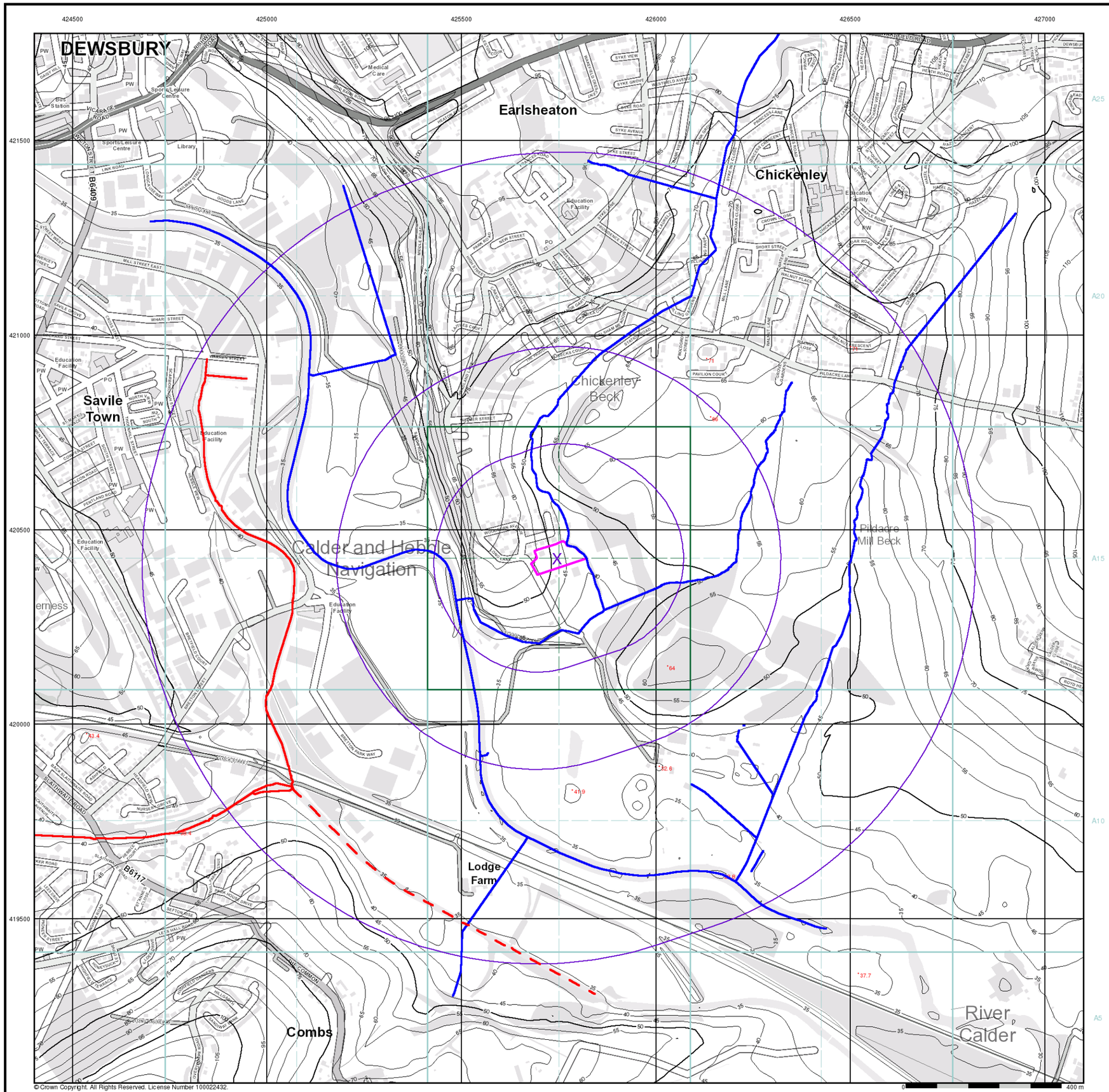


Order Details

Order Number:	177675673_1_1
Customer Ref:	PO13460/JW/2986
National Grid Reference:	425750, 420430
Slice:	A
Site Area (Ha):	0 68
Search Buffer (m):	1000

Site Details

Long Lane, Earlsheaton, WF12 8LJ



LITHOS CONSULTING

General

- Specified Site
- Specified Buffer(s)
- Bearing Reference Point

OS Water Network Data

- Canal
- Reservoir
- Foreshore
- Marsh
- Tidal River
- Inland River
- Drain
- Other
- Lake
- Transfer
- Lock Or Flight Of Locks
- Sea

Contours (height in meters)

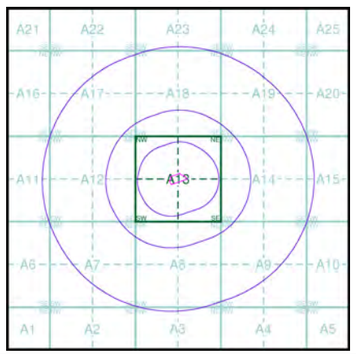
Standard Contour 105 100 95

Master Contour

Spot Height 167.3

- MLW Mean Low Water
- MHW Mean High Water

OS Water Network Map - Slice A



Order Details

Order Number:	177675673_1_1
Customer Ref:	PO13460/JW/2986
National Grid Reference:	425750, 420430
Slice:	A
Site Area (Ha):	0.68
Search Buffer (m):	1000

Site Details

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Tel: 0844 844 9952
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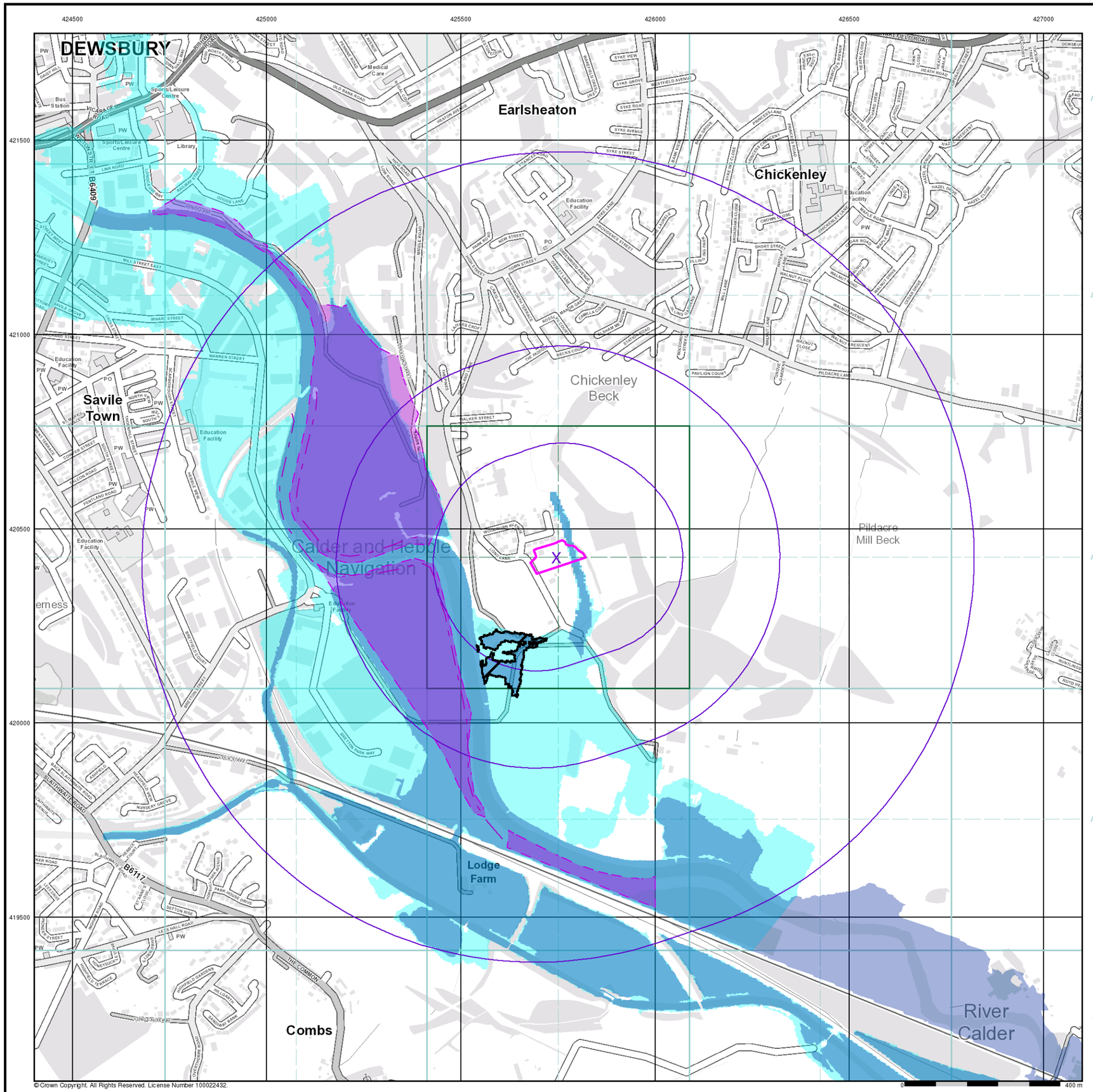
Web: www envirocheck co uk



LITHOS CONSULTING

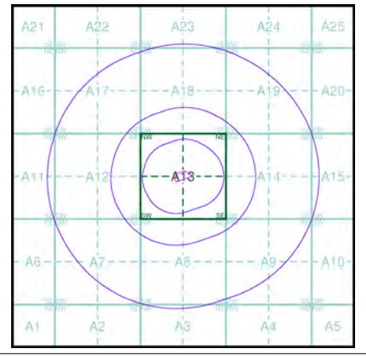
General

- Specified Site
- Specified Buffer(s)
- X Bearing Reference Point

Agency and Hydrological (Flood)

- Extreme Flooding from Rivers or Sea without Defences (Zone 2)
- Flooding from Rivers or Sea without Defences (Zone 3)
- Area Benefiting from Flood Defence
- Flood Water Storage Areas
- Flood Defence

Flood Map - Slice A



Order Details

Order Number:	177675673_1_1
Customer Ref:	PO13460/JW/2986
National Grid Reference:	425750, 420430
Slice:	A
Site Area (Ha):	0.68
Search Buffer (m):	1000

Site Details

Long Lane, Earlsheaton, WF12 8LJ

Landmark INFORMATION GROUP
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www envirocheck co uk

The Coal Authority

Consultants

Coal Mining Report

Long Lane
Earlsheaton
Dewsbury
WF12 8LJ

Date of enquiry:	**22 August 2018**
Date enquiry received:	**22 August 2018**
Issue date:	**22 August 2018**
Our reference:	**51001918130001**
Your reference:	**PO13458/JW/2986**

Consultants

Coal Mining Report

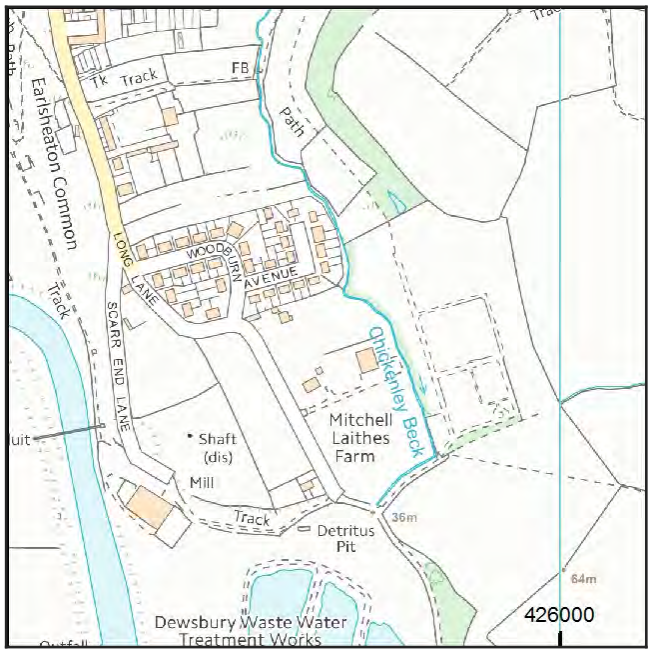
This report is based on and limited to the records held by the Coal Authority at the time the report was produced.

Client name

LITHOS CONSULTING LTD

Enquiry address

Long Lane
Earlsheaton
Dewsbury
WF12 8LJ



Approximate position of property

How to contact us

0345 762 6848 (UK)
+44 (0)1623 637 000 (International)

200 Lichfield Lane
Mansfield
Nottinghamshire
NG18 4RG

www.groundstability.com

@coalauthority
/company/the-coal-authority
/thecoalauthority
/thecoalauthority

Section 1 – Mining activity and geology

Past underground mining

Colliery	Seam	Mineral	Coal Authority reference	Depth (m)	Direction to working	Dipping rate of seam worked (degrees)	Dipped direction of seam worked	Extraction thickness (cm)	Year last mined
unnamed	BLACK BED	Coal	62NX	308	North-East	2.6	South	66	1953

Probable unrecorded shallow workings

None.

Spine roadways at shallow depth

No spine roadway recorded at shallow depth.

Mine entries

None recorded within 100 metres of the enquiry boundary.

Abandoned mine plan catalogue numbers

The following abandoned mine plan catalogue numbers intersect with some, or all, of the enquiry boundary:

M88		

Please contact us on 0345 762 6848 to determine the exact abandoned mine plans you require based on your needs.

Outcrops

Seam name	Mineral	Seam workable	Distance to outcrop (m)	Direction to outcrop	Bearing of outcrop
UNNAMED	Coal	Yes	14.0	South	172

Geological faults, fissures and breaklines

Please refer to the 'Summary of findings' map (on separate sheet) for details of any geological faults, fissures or breaklines either within or intersecting the enquiry boundary.

Fault under or close to the property recorded.

Opencast mines

None recorded within 500 metres of the enquiry boundary.

Coal Authority managed tips

None recorded within 500 metres of the enquiry boundary.

Section 2 – Investigative or remedial activity

Please refer to the 'Summary of findings' map (on separate sheet) for details of any activity within the area of the site boundary.

Site investigations
None recorded within 50 metres of the enquiry boundary.

Remediated sites
None recorded within 50 metres of the enquiry boundary.

Coal mining subsidence
The Coal Authority has not received a damage notice or claim for the subject property, or any property within 50 metres of the enquiry boundary, since 31st October 1994.

There is no current Stop Notice delaying the start of remedial works or repairs to the property.

The Coal Authority is not aware of any request having been made to carry out preventive works before coal is worked under section 33 of the Coal Mining Subsidence Act 1991.

Mine gas
None recorded within 500 metres of the enquiry boundary.

Mine water treatment schemes
None recorded within 500 metres of the enquiry boundary.

Section 3 – Licensing and future mining activity

Future underground mining
None recorded.

Coal mining licensing
None recorded within 200 metres of the enquiry boundary.

Court orders
None recorded.

Section 46 notices
No notices have been given, under section 46 of the Coal Mining Subsidence Act 1991, stating that the land is at risk of subsidence.

Withdrawal of support notices
The property is in an area where notices to withdraw support were given in 1950 and 1951.

The property is not in an area where a notice has been given under section 41 of the Coal Industry Act 1994, cancelling the entitlement to withdraw support.

Payments to owners of former copyhold land
The property is not in an area where a relevant notice has been published under the Coal Industry Act 1975/Coal Industry Act 1994.

Section 4 – Further information

The following potential risks have been identified and as part of your risk assessment should be investigated further.

Development advice

The site is within an area of historical coal mining activity. Should you require advice and/or support on understanding the mining legacy, its risks to your development or what next steps you need to take, please contact us.

For further information on specific site or ground investigations in relation to any issues raised in Section 4, please call us on 0345 762 6848 or email us at groundstability@coal.gov.uk.

Section 5 – Data definitions

The datasets used in this report have limitations and assumptions within their results. For more guidance on the data and the results specific to the enquiry boundary, please **call us on 0345 762 6848** or **email us at groundstability@coal.gov.uk.**

Past underground coal mining

Details of all recorded underground mining relative to the enquiry boundary. Only past underground workings where the enquiry boundary is within 0.7 times the depth of the workings (zone of likely physical influence) allowing for seam inclination, will be included.

Probable unrecorded shallow workings

Areas where the Coal Authority believes there to be unrecorded coal workings that exist at or close to the surface (less than 30 metres deep).

Spine roadways at shallow depth

Connecting roadways either, working to working, or, surface to working, both in-seam and cross measures that exist at or close to the surface (less than 30 metres deep), either within or within 10 metres of the enquiry boundary.

Mine entries

Details of any shaft or adit either within, or within 100 metres of the enquiry boundary including approximate location, brief treatment details where known, the mineral worked from the mine entry and conveyance details where the mine entry has previously been sold by the Authority or its predecessors British Coal or the National Coal Board.

Abandoned mine plan catalogue numbers

Plan numbers extracted from the abandoned mines catalogue containing details of coal and other mineral abandonment plans deposited via the Mines Inspectorate in accordance with the Coal Mines Regulation Act and Metalliferous Mines Regulation Act 1872. A maximum of 9 plan extents that intersect with the enquiry boundary will be included. This does not infer that the workings and/or mine entries shown on the abandonment plan will be relevant to the site/property boundary.

Outcrops

Details of seam outcrops will be included where the enquiry boundary intersects with a conjectured or actual seam outcrop location (derived by either the British Geological Survey or the Coal Authority) or intersects with a defined 50 metres buffer on the coal (dip) side of the outcrop. An indication of whether the Coal Authority believes the seam to be of sufficient thickness and/or quality to have been worked will also be included.

Geological faults, fissures and breaklines

Geological disturbances or fractures in the bedrock. Surface fault lines (British Geological Survey derived data) and fissures and breaklines (Coal Authority derived data) intersecting with the enquiry boundary will be included. In some circumstances faults, fissures or breaklines have been known to contribute to surface subsidence damage as a consequence of underground coal mining.

Opencast mines
Opencast coal sites from which coal has been removed in the past by opencast (surface) methods and where the enquiry boundary is within 500 metres of either the licence area, site boundary, excavation area (high wall) or coaling area.

Coal Authority managed tips
Locations of disused colliery tip sites owned and managed by the Coal Authority, located within 500 metres of the enquiry boundary.

Site investigations
Details of site investigations within 50 metres of the enquiry boundary where the Coal Authority has received information relating to coal mining risk investigation and/or remediation by third parties.

Remediated sites
Sites where the Coal Authority has undertaken remedial works either within or within 50 metres of the enquiry boundary following report of a hazard relating to coal mining under the Coal Authority's Emergency Surface Hazard Call Out procedures.

Coal mining subsidence
Details of alleged coal mining subsidence claims made since 31 October 1994 either within or within 50 metres of the enquiry boundary. Where the claim relates to the enquiry boundary confirmation of whether the claim was accepted, rejected or whether liability is still being determined will be given. Where the claim has been discharged, whether this was by repair, payment of compensation or a combination of both, the value of the claim, where known, will also be given.

Details of any current 'Stop Notice' deferring remedial works or repairs affecting the property/site, and if so the date of the notice.

Details of any request made to execute preventative works before coal is worked under section 33 of the Coal Mining Subsidence Act 1991. If yes, whether any person withheld consent or failed to comply with any request to execute preventative works.

Mine gas
Reports of alleged mine gas emissions received by the Coal Authority, either within or within 500 metres of the enquiry boundary that subsequently required investigation and action by the Coal Authority to mitigate the effects of the mine gas emission.

Mine water treatment schemes
Locations where the Coal Authority has constructed or operates assets that remove pollutants from mine water prior to the treated mine water being discharged into the receiving water body.

These schemes are part of the UK's strategy to meet the requirements of the Water Framework Directive. Schemes fall into 2 basic categories: Remedial – mitigating the impact of existing pollution or Preventative – preventing a future pollution incident.

Mine water treatment schemes generally consist of one or more primary settlement lagoons and one or more reed beds for secondary treatment. A small number are more specialised process treatment plants.

Future underground mining
Details of all planned underground mining relative to the enquiry boundary. Only those future workings where the enquiry boundary is within 0.7 times the depth of the workings (zone of likely physical influence) allowing for seam inclination will be included.

Coal mining licensing
Details of all licenses issued by the Coal Authority either within or within 200 metres of the enquiry boundary in relation to the under taking of surface coal mining, underground coal mining or underground coal gasification.

Court orders
Orders in respect of the working of coal under the Mines (Working Facilities and Support) Acts of 1923 and 1966 or any statutory modification or amendment thereof.

Section 46 notices
Notice of proposals relating to underground coal mining operations that have been given under section 46 of the Coal Mining Subsidence Act 1991.

Withdrawal of support notices
Published notices of entitlement to withdraw support and the date of the notice. Details of any revocation notice withdrawing the entitlement to withdraw support given under Section 41 of the Coal Industry Act 1994.

Payment to owners of former copyhold land
Relevant notices which may affect the property and any subsequent notice of retained interests in coal and coal mines, acceptance or rejection notices and whether any compensation has been paid to a claimant.

The Coal Authority

Summary of findings

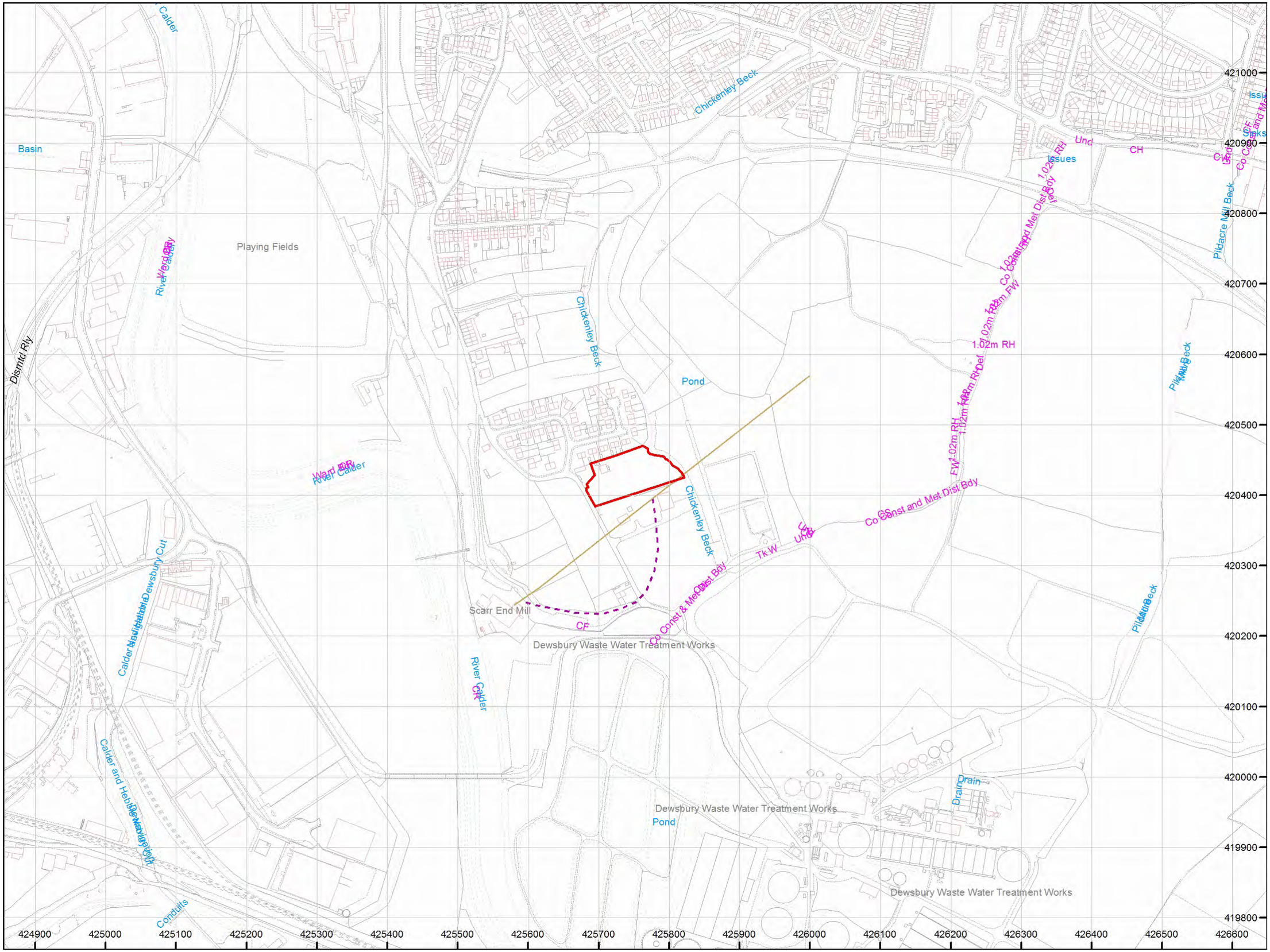
The map highlights any specific surface or subsurface features within or near to the boundary of the site.

Key

Approximate position of the enquiry boundary shown

Outcrop (Conjectured)

Geological faults



How to contact us
0345 762 6848 (UK)
+44 (0)1623 637 000 (International)
www.groundstability.com

1. MINERAL S 62256/16 MINERAL SE 22 \ 41

(621) ~~We 600) 3/33 200)~~ 6 22 Gp. 147 M.R.Co.Ltd.

~~Ref. No. 586~~

Earlsheaton

SECTION OF Shaft at Bank Top Colliery, Earlsheaton

F

Maps: One-inch 37 Six-inch 24 NE County Yorks.

Height above O.D. 310 Latitude Longitude

Communicated by Mines Dept. Plan 2984 Date of sinking

Made by Dip of Strata

SE 258 205

	Thickness.	Depth from Surface.
Middle Coal Measures	165 0	165 0
↓ Main Coal	2 -	
Measures	49 6	214 6
↑ Lower Coal Measures Cannel Coal	10	
Measures	52 6	267
Flockton Coal	2 2	
Measures	10	277

C8C
262PP

1. MINERAL

(621) ~~Wt. 5993 —S.33 2000 6/22~~ Gp. 147 M.R.Co.Ltd.

MINERAL SE22 SE 16

SECTION OF Shaft at Bank Top Colliery Earlsheaton

2583 2051

F

Maps : One-inch 77 Six-inch 247NE County Yorks.

Height above O.D. 310 Latitude Longitude

Communicated by Mines Dept. Plan 2984 Date of sinking 1877/29

Made by Dip of Strata

GEOLOGICAL SURVEY OFFICE YORK

	Thickness.			Depth from Surface. (Pit Hill)		
Measures	50.29	165	0	50.29	165	0
Joan Coal	0.61	2	-			
Measures	15.09	49	6	65.38	214	6
Cannel Coal	0.25		10			
Measures	16.0	52	6	81.38	267	
Flockton Coal	0.66	2	2			
Measures	3.05	10		84.43	277	

Appendix F

Trial Pit Logs

LITHOS CONSULTING

Trial Pit Log

Trialpit No
TP01
Sheet 1 of 1

Project Name: Long Lane	Project No. 2986	Co-ords: - Level:	Date 31/08/2018
Location: Earlsheaton		Dimensions (m): 2.3 × 0.6, Depth 2.80	Scale 1:25
Client: Britology Ltd			Logged GLM

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.10	J,K&T		0.30			Brownish grey silty slightly gravelly SAND. Gravel is subangular fine to medium of sandstone. Some rootlets. (TOPSOIL)
	0.60	D					Yellowish brown clayey slightly sandy subangular fine to coarse GRAVEL of sandstone. With low subangular tabular sandstone cobble content. (GRANULAR RESIDUAL SOIL)
	2.40	D		2.00			Strong greyish brown fine grained SANDSTONE. Recovered as slightly clayey slightly sandy subangular fine to coarse gravel of sandstone. (THORNHILL ROCK SANDSTONE)
				2.80			*2.8m Unable to excavate further into sandstone.* End of pit at 2.80 m

Remarks: 1. Prior to excavation a CAT utilities scan was undertaken. 2. Excavation backfilled with arisings upon completion. 3. Groundwater was not encountered during excavation.

Stability: 1. Trial pit remained stable during excavation.

AGS

LITHOS CONSULTING

Trial Pit Log

Trialpit No **TP02**

Sheet 1 of 1

Project Name: Long Lane	Project No. 2986	Co-ords: - Level:	Date 31/08/2018
Location: Earlsheaton		Dimensions (m): 2.3 × 0.8, Depth 2.60	Scale 1:25
Client: Britology Ltd			Logged GLM

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.10	J,K&T		0.25			MADE GROUND: Greyish brown dry friable sandy CLAY. Rare angular to subangular fine to medium gravel of pottery and sandstone. Some rootlets. (MADE GROUND TOPSOIL)
	0.50	J,K&T		1.00			MADE GROUND: Purplish brown gravelly ASH. Gravel is very angular to subangular fine to medium of pottery, clinker, glass and occasional coal, brick, mudstone and bone. (TIPPED ASH)
	1.40	D		2.00			Yellowish brown slightly clayey slightly sandy subangular fine to coarse GRAVEL of sandstone. (GRANULAR RESIDUAL SOIL)
				2.60			Strong greyish brown fine grained SANDSTONE. Recovered as slightly clayey slightly sandy subangular fine to coarse gravel of sandstone. (THORNHILL ROCK SANDSTONE)
							2.6mUnable to excavate further into bedrock. End of pit at 2.60 m

1 2 3 4 5

Remarks: 1. Prior to excavation a CAT utilities scan was undertaken. 2. Excavation backfilled with arisings upon completion. 3. Groundwater was not encountered during excavation.

Stability: 1. Trial pit remained stable during excavation.

AGS

LITHOS CONSULTING

Trial Pit Log

Trialpit No **TP03**

Sheet 1 of 1

Project Name: Long Lane	Project No. 2986	Co-ords: - Level:	Date 31/08/2018
Location: Earlsheaton		Dimensions (m): 2.3 × 0.8, Depth 3.10	Scale 1:25
Client: Britology Ltd			Logged GLM

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.10	J,K&T		0.25			MADE GROUND: Greyish brown dry friable very sandy gravelly SILT. Gravel is angular to subangular fine to medium of pottery and coal. Some rootlets. (MADE GROUND TOPSOIL)
	0.40	J,K&T		1.10			MADE GROUND: Purplish brown gravelly ASH. Gravel is very angular to subangular fine to coarse of clinker, pottery, glass, coal and occasional mudstone, brick and bone. (TIPPED ASH)
	1.30	D		1.50			Amended following geotechnical testing to: Very gravelly silty/clayey SAND. Original field description read: Firm yellowish brown very sandy clayey SILT (GRANULAR RESIDUAL SOIL)
				2.80			Light brown fine SAND. (GRANULAR RESIDUAL SOIL)
	3.00	D		3.10			Medium strong lightly yellow fine grained SANDSTONE. Recovered as angular medium to coarse gravel of sandstone. (THORNHILL ROCK SANDSTONE) *3.1m Unable to excavate further into bedrock.* End of pit at 3.10 m

Remarks: 1. Prior to excavation a CAT utilities scan was undertaken. 2. Excavation backfilled with arisings upon completion. 3. Groundwater was not encountered during excavation.

Stability: 1. Trial pit remained stable during excavation.

AGS

LITHOS CONSULTING

Trial Pit Log

Trialpit No
TP04
Sheet 1 of 1

Project Name: Long Lane	Project No. 2986	Co-ords: - Level:	Date 31/08/2018
Location: Earlsheaton		Dimensions (m): 2.3 × 0.8, Depth 3.20	Scale 1:25
Client: Britology Ltd			Logged GLM

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.50	J,K&T					MADE GROUND: Purplish brown very ashy angular to subangular fine to medium GRAVEL of clinker and occasional pottery, glass, coal and mudstone. (TIPPED ASH)
				1.60			
	1.90	D	HVP=78				Amended following geotechnical testing to: Sandy clayey slightly silty SAND. Original field description read: Stiff yellowish brown friable slightly sandy silty CLAY. (GRANULAR RESIDUAL SOIL)
				2.70			
	2.90	D					Medium strong yellowish grey fine grained SANDSTONE with closely interbedded SILTSTONE. Recovered as angular tabular medium to coarse gravel of sandstone and siltstone. (COAL MEASURES)
				3.20			*3.2m Unable to excavate further into bedrock.* End of pit at 3.20 m

1 2 3 4 5

Remarks: 1. Prior to excavation a CAT utilities scan was undertaken. 2. Excavation backfilled with arisings upon completion. 3. Groundwater was not encountered during excavation.

Stability: 1. Trial pit remained stable during excavation.

AGS

LITHOS CONSULTING

Trial Pit Log

Trialpit No **TP05**

Sheet 1 of 1

Project Name: Long Lane	Project No. 2986	Co-ords: - Level:	Date 31/08/2018
Location: Earlsheaton		Dimensions (m): 2.3 × 0.8, Depth 3.20	Scale 1:25
Client: Britology Ltd			Logged GLM

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.30	J,K&T					MADE GROUND: Purplish brown very ashy angular to subrounded fine to medium GRAVEL of clinker, pottery, glass and occasional brick, coal, bone and shell. (TIPPED ASH)
				1.60			Amended following geotechnical testing to: Slightly gravelly slightly silty slightly clayey SAND. Original field description read: Yellowish brown very sandy slightly gravelly SILT. Gravel is subangular fine of sandstone. (GRANULAR RESIDUAL SOIL)
	2.30	D					
				2.80			Medium strong greyish yellow fine grained SANDSTONE. Recovered as angular tabular medium to coarse gravel of sandstone. (THORNHILL ROCK SANDSTONE)
				3.20			*3.2m Unable to excavate further into bedrock.* End of pit at 3.20 m

1 2 3 4 5

Remarks: 1. Prior to excavation a CAT utilities scan was undertaken. 2. Excavation backfilled with arisings upon completion. 3. Groundwater was not encountered during excavation.

Stability: 1. Trial pit remained stable during excavation.

AGS

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Trial Pit Log

Trialpit No **TP06**

Sheet 1 of 1

Project Name: Long Lane	Project No. 2986	Co-ords: - Level:	Date 31/08/2018
Location: Earlsheaton		Dimensions (m): 2.3 × 0.8, Depth 2.40	Scale 1:25
Client: Britology Ltd			Logged GLM

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.10	J,K&T		0.25			MADE GROUND: Greyish brown dry friable very silty SAND. Occasional rootlets. (MADE GROUND TOPSOIL)
				0.50			MADE GROUND: Purplish brown very gravelly ASH. Gravel is angular to subrounded fine to medium of clinker, pottery and occasional coal and glass. Occasional rootlets. (TIPPED ASH)
	0.70	D		1.80			Yellowish brown slightly clayey slightly sandy angular tabular medium to coarse GRAVEL of sandstone. With low angular tabular sandstone cobble content. (GRANULAR RESIDUAL SOIL)
				2.40			Medium strong yellowish grey fine grained SANDSTONE. Recovered as angular medium gravel of sandstone. (THORNHILL ROCK SANDSTONE)
							2.4m Unable to excavate further into bedrock. End of pit at 2.40 m

1 2 3 4 5

Remarks: 1. Prior to excavation a CAT utilities scan was undertaken. 2. Excavation backfilled with arisings upon completion. 3. Groundwater was not encountered during excavation.

Stability: 1. Trial pit remained stable during excavation.

AGS

LITHOS CONSULTING

Trial Pit Log

Trialpit No
TP07
Sheet 1 of 1

Project Name: Long Lane	Project No. 2986	Co-ords: - Level:	Date 31/08/2018
Location: Earlsheaton		Dimensions (m): 2.3 × 0.8, Depth 2.00	Scale 1:25
Client: Britology Ltd			Logged GLM

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.10	J,K&T					Greyish brown dry friable very sandy SILT. Rare subangular fine gravel of sandstone. Occasional rootlets. (TOPSOIL)
				0.30			Yellowish brown slightly clayey slightly sandy angular tabular GRAVEL of sandstone. (GRANULAR RESIDUAL SOIL)
	0.60	D					*From 1.0m with a high angular tabular sandstone cobble content.*
				1.50			Strong yellowish grey fine grained SANDSTONE. Recovered as angular tabular coarse gravel of sandstone. (THORNHILL ROCK SANDSTONE)
				2.00			*2.0m Unable to excavate further into bedrock.* End of pit at 2.00 m

1 2 3 4 5

Remarks: 1. Prior to excavation a CAT utilities scan was undertaken. 2. Excavation backfilled with arisings upon completion. 3. Groundwater was not encountered during excavation.

Stability: 1. Trial pit remained stable during excavation.

AGS

LITHOS CONSULTING

Trial Pit Log

Trialpit No
TP08
Sheet 1 of 1

Project Name: Long Lane	Project No. 2986	Co-ords: - Level:	Date 31/08/2018
Location: Earlsheaton		Dimensions (m): 2.3 × 0.8, Depth 2.10	Scale 1:25
Client: Britology Ltd			Logged GLM

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
	0.10	J,K&T		0.30			Brownish grey silty slightly gravelly SAND. Gravel is subangular fine to medium of sandstone. Some rootlets. (TOPSOIL)
				0.90			Yellowish brown sandy angular tabular medium to coarse GRAVEL of sandstone. (GRANULAR RESIDUAL SOIL)
				1.80			Light yellowish brown sandy angular to subangular coarse GRAVEL of sandstone. With medium angular tabular sandstone cobble content. (GRANULAR RESIDUAL SOIL)
				2.10			Medium strong light yellow fine grained SANDSTONE. Recovered as angular medium to coarse gravel of sandstone. (THORNHILL ROCK SANDSTONE) *2.1m Unable to excavate further into bedrock.* End of pit at 2.10 m

Remarks: 1. Prior to excavation a CAT utilities scan was undertaken. 2. Excavation backfilled with arisings upon completion. 3. Groundwater was not encountered during excavation.

Stability: 1. Trial pit remained stable during excavation.

AGS

LITHOS CONSULTING

Trial Pit Log

Trialpit No
TP09
Sheet 1 of 1

Project Name: Long Lane	Project No. 2986	Co-ords: - Level:	Date 31/08/2018
Location: Earlsheaton		Dimensions (m): 2.3 × 0.8, Depth 3.10	Scale 1:25
Client: Britology Ltd			Logged GLM

Water Strike	Samples and In Situ Testing: Depth	Type	Results	Depth (m)	Level (m)	Legend	Stratum Description
				0.30			MADE GROUND: Greyish brown sandy SILT. Rare angular fine to medium gravel of pottery, glass and siltstone. Occasional rootlets. (MADE GROUND TOPSOIL)
	0.50	J,K&T					MADE GROUND: Purplish brown ASH and very angular to subrounded fine to medium GRAVEL of clinker and occasional pottery, glass, coal, brick and sandstone. Rare gravel sized fragments of wood and leather. (TIPPED ASH)
				1.30			Amended following geotechnical testing to: Slightly silty slightly clayey SAND. Original field description read: Stiff yellowish brown very sandy CLAY. (GRANULAR RESIDUAL SOIL)
			HVP=80				
	2.00	D					
				2.90			Medium strong thinly bedded SILTSTONE with thin beds of fine grained sandstone. Recovered as slightly clayey slightly sandy angular tabular medium to coarse GRAVEL of siltstone and sandstone. (COAL MEASURES)
				3.10			*3.1m Unable to excavate further into bedrock.* End of pit at 3.10 m

1 2 3 4 5

Remarks: 1. Prior to excavation a CAT utilities scan was undertaken. 2. Excavation backfilled with arisings upon completion. 3. Groundwater was not encountered during excavation.

Stability: 1. Trial pit remained stable during excavation.

AGS

Appendix G

Chemical Test Results

Chemtest
The right chemistry to deliver results
Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

Final Report

Report No.:	18-26681-1
Initial Date of Issue:	20-Sep-2018
Client	Lithos Consulting
Client Address:	Walton Road Wetherby LS22 5DZ
Contact(s):	Alan Swales
Project	2986 Long Lane, Earlsheaton

Quotation No.:		**Date Received:**	04-Sep-2018
Order No.:	PO13525/2986/ASw	**Date Instructed:**	10-Sep-2018
No. of Samples:	11		
Turnaround (Wkdays):	5	**Results Due:**	14-Sep-2018
Date Approved:	20-Sep-2018		

Approved By:

Redacted

Robert Monk, Technical Manager

Chemtest
The right chemistry to deliver results

Results - Leachate

Project: 2986 Long Lane, Earlsheaton

Client: Lithos Consulting		**Chemtest Job No.:**			18-26681	18-26681	18-26681
Quotation No.:		**Chemtest Sample ID.:**			682395	682399	682406
		Sample Location:			TP02	TP04	TP09
		Sample Type:			SOIL	SOIL	SOIL
		Top Depth (m):			0.50	0.50	0.50
		Date Sampled:			31-Aug-2018	31-Aug-2018	31-Aug-2018
Determinand	**Accred.**	**SOP**	**Units**	**LOD**			
pH	U	1010		N/A	9.1	8.0	7.4
Arsenic (Dissolved)	U	1450	µg/l	1.0	84	33	10
Boron (Dissolved)	U	1450	µg/l	20	< 20	31	< 20
Cadmium (Dissolved)	U	1450	µg/l	0.080	< 0.080	< 0.080	< 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0	9.3	2.6	< 1.0
Copper (Dissolved)	U	1450	µg/l	1.0	3.0	3.8	2.9
Mercury (Dissolved)	U	1450	µg/l	0.50	< 0.50	< 0.50	< 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0
Lead (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	2.2
Selenium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	3.6

Chemtest
The right chemistry to deliver results

Results - Soil

Project: 2986 Long Lane, Earlsheaton

Client: Lithos Consulting				**Chemtest Job No.:**	18-26681	18-26681	18-26681	18-26681	18-26681	18-26681	18-26681	18-26681
Quotation No.:				**Chemtest Sample ID.:**	682393	682394	682395	682396	682397	682399	682401	682402
				Sample Location:	TP01	TP02	TP02	TP03	TP03	TP04	TP05	TP06
				Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
				Top Depth (m):	0.10	0.10	0.50	0.10	0.40	0.50	0.30	0.10
				Date Sampled:	31-Aug-2018	31-Aug-2018	31-Aug-2018	31-Aug-2018	31-Aug-2018	31-Aug-2018	31-Aug-2018	31-Aug-2018
				Asbestos Lab:	COVENTRY	COVENTRY	COVENTRY	COVENTRY	COVENTRY	COVENTRY	COVENTRY	COVENTRY
Determinand	**Accred.**	**SOP**	**Units**	**LOD**								
ACM Type	U	2192		N/A	-	-	-	-	-	-	-	-
Asbestos Identification	U	2192	%	0.001	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected
Moisture	N	2030	%	0.020	7.0	5.7	12	9.9	9.7	8.5	13	6.2
Soil Colour	N	2040		N/A	Brown,	Brown,	Brown,	Brown,	Brown,	Brown	Brown,	Brown,
Other Material	N	2040		N/A	Stones	Stones,	Stones	Stones,	Stones,	Stones,	Stones,	Stones,
Soil Texture	N	2040		N/A	Sand,	Sand,	Sand,	Sand,	Sand,	Sand,	Clay,	Clay,
pH	M	2010		N/A	7.8	7.4	7.6	7.4	7.6	7.6	7.7	7.5
Boron (Hot Water Soluble)	M	2120	mg/kg	0.40	0.44	0.54	0.58	0.70	0.80	0.75	0.73	0.60
Magnesium (Water Soluble)	N	2120	g/l	0.010			< 0.010			< 0.010		
Sulphate (2:1 Water Soluble) as SO4	M	2120	g/l	0.010			0.013			< 0.010		
Calorific Value	N	2140	MJ/kg	0.10			29			33		
Chloride (Water Soluble)	M	2220	g/l	0.010			< 0.010			0.011		
Nitrate (Water Soluble)	N	2220	g/l	0.010			< 0.010			< 0.010		
Arsenic	M	2450	mg/kg	1.0	31	160	140	170	350	200	230	150
Cadmium	M	2450	mg/kg	0.10	0.46	0.41	0.17	0.55	1.4	0.54	0.47	0.49
Chromium	M	2450	mg/kg	1.0	33	52	23	34	47	47	45	45
Copper	M	2450	mg/kg	0.50	65	140	120	180	310	230	530	180
Mercury	M	2450	mg/kg	0.10	0.55	0.90	0.56	1.5	4.8	1.4	1.7	1.8
Nickel	M	2450	mg/kg	0.50	28	45	43	47	81	54	60	52
Lead	M	2450	mg/kg	0.50	190	260	210	750	1100	500	510	500
Selenium	M	2450	mg/kg	0.20	0.71	1.3	0.86	1.2	2.1	1.3	1.3	1.3
Zinc	M	2450	mg/kg	0.50	160	180	110	320	610	330	330	260
Chromium (Trivalent)	N	2490	mg/kg	1.0	33	52	23	34	47	47	45	45
Chromium (Hexavalent)	N	2490	mg/kg	0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Total Organic Carbon	M	2625	%	0.20	5.3	11	8.6	18	27	17	19	8.9
TPH >C6-C10	N	2670	mg/kg	1.0			< 1.0			< 1.0		
TPH >C10-C21	N	2670	mg/kg	1.0			< 1.0			36		
TPH >C21-C40	N	2670	mg/kg	1.0			< 1.0			50		
Total TPH >C6-C40	M	2670	mg/kg	10			< 10			86		
Naphthalene	M	2800	mg/kg	0.10	8.4	3.4	< 0.10	12	4.3	130	6.3	2.7
Acenaphthylene	N	2800	mg/kg	0.10	3.2	0.29	< 0.10	1.9	0.24	2.2	0.28	0.56
Acenaphthene	M	2800	mg/kg	0.10	3.5	0.11	< 0.10	1.9	0.18	32	0.38	0.57
Fluorene	M	2800	mg/kg	0.10	5.2	0.23	< 0.10	2.5	0.24	15	0.34	0.57
Phenanthrene	M	2800	mg/kg	0.10	45	4.0	1.4	23	3.8	100	6.5	8.2
Anthracene	M	2800	mg/kg	0.10	4.5	0.47	< 0.10	3.1	0.45	16	0.73	1.4
Fluoranthene	M	2800	mg/kg	0.10	36	3.7	0.27	19	2.6	100	5.9	12
Pyrene	M	2800	mg/kg	0.10	30	3.7	0.26	16	2.4	88	5.5	10
Benzo[a]anthracene	M	2800	mg/kg	0.10	11	1.1	< 0.10	5.7	0.92	47	2.3	4.0

Chemtest
The right chemistry to deliver results

Results - Soil

Project: 2986 Long Lane, Earlsheaton

Client: Lithos Consulting			**Chemtest Job No.:**		18-26681	18-26681	18-26681	18-26681	18-26681	18-26681	18-26681	18-26681
Quotation No.:			**Chemtest Sample ID.:**		682393	682394	682395	682396	682397	682399	682401	682402
			Sample Location:		TP01	TP02	TP02	TP03	TP03	TP04	TP05	TP06
			Sample Type:		SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
			Top Depth (m):		0.10	0.10	0.50	0.10	0.40	0.50	0.30	0.10
			Date Sampled:		31-Aug-2018	31-Aug-2018	31-Aug-2018	31-Aug-2018	31-Aug-2018	31-Aug-2018	31-Aug-2018	31-Aug-2018
			Asbestos Lab:		COVENTRY	COVENTRY	COVENTRY	COVENTRY	COVENTRY	COVENTRY	COVENTRY	COVENTRY
Determinand	**Accred.**	**SOP**	**Units**	**LOD**								
Chrysene	M	2800	mg/kg	0.10	17	1.9	< 0.10	8.3	1.3	58	3.0	5.7
Benzo[b]fluoranthene	M	2800	mg/kg	0.10	15	1.7	< 0.10	7.8	1.2	50	2.9	5.5
Benzo[k]fluoranthene	M	2800	mg/kg	0.10	6.7	0.63	< 0.10	3.6	0.39	20	1.0	2.0
Benzo[a]pyrene	M	2800	mg/kg	0.10	10	0.92	< 0.10	5.8	0.71	37	1.8	3.6
Indeno(1,2,3-c,d)Pyrene	M	2800	mg/kg	0.10	7.4	0.64	< 0.10	4.0	0.49	20	1.2	3.0
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	1.1	< 0.10	< 0.10	0.54	< 0.10	4.7	0.17	0.38
Benzo[g,h,i]perylene	M	2800	mg/kg	0.10	7.4	0.78	< 0.10	4.5	0.55	22	1.5	2.8
Total Of 16 PAH's	N	2800	mg/kg	2.0	210	24	< 2.0	120	20	740	40	63

Chemtest
The right chemistry to deliver results

Results - Soil

Project: 2986 Long Lane, Earlsheaton

Client: Lithos Consulting		**Chemtest Job No.:**			18-26681	18-26681	18-26681
Quotation No.:		**Chemtest Sample ID.:**			682403	682404	682406
				Sample Location:	TP07	TP08	TP09
				Sample Type:	SOIL	SOIL	SOIL
				Top Depth (m):	0.10	0.10	0.50
				Date Sampled:	31-Aug-2018	31-Aug-2018	31-Aug-2018
				Asbestos Lab:	COVENTRY	COVENTRY	COVENTRY
Determinand	**Accred.**	**SOP**	**Units**	**LOD**			
ACM Type	U	2192		N/A	-	-	-
Asbestos Identification	U	2192	%	0.001	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected
Moisture	N	2030	%	0.020	6.0	6.2	23
Soil Colour	N	2040		N/A	Brown	Brown,	Brown
Other Material	N	2040		N/A	Stones	Stones,	Stones
Soil Texture	N	2040		N/A	Clay,	Clay,	Clay,
pH	M	2010		N/A	7.9	7.9	7.5
Boron (Hot Water Soluble)	M	2120	mg/kg	0.40	0.40	0.46	0.58
Magnesium (Water Soluble)	N	2120	g/l	0.010			< 0.010
Sulphate (2:1 Water Soluble) as SO4	M	2120	g/l	0.010			0.016
Calorific Value	N	2140	MJ/kg	0.10			29
Chloride (Water Soluble)	M	2220	g/l	0.010			< 0.010
Nitrate (Water Soluble)	N	2220	g/l	0.010			< 0.010
Arsenic	M	2450	mg/kg	1.0	46	40	590
Cadmium	M	2450	mg/kg	0.10	0.45	0.34	0.44
Chromium	M	2450	mg/kg	1.0	38	42	33
Copper	M	2450	mg/kg	0.50	78	72	470
Mercury	M	2450	mg/kg	0.10	0.72	0.63	0.92
Nickel	M	2450	mg/kg	0.50	30	26	42
Lead	M	2450	mg/kg	0.50	350	170	570
Selenium	M	2450	mg/kg	0.20	1.0	0.90	2.1
Zinc	M	2450	mg/kg	0.50	170	140	190
Chromium (Trivalent)	N	2490	mg/kg	1.0	38	42	33
Chromium (Hexavalent)	N	2490	mg/kg	0.50	< 0.50	< 0.50	< 0.50
Total Organic Carbon	M	2625	%	0.20	5.2	4.6	9.6
TPH >C6-C10	N	2670	mg/kg	1.0			< 1.0
TPH >C10-C21	N	2670	mg/kg	1.0			5.7
TPH >C21-C40	N	2670	mg/kg	1.0			20
Total TPH >C6-C40	M	2670	mg/kg	10			26
Naphthalene	M	2800	mg/kg	0.10	1.9	0.79	3.3
Acenaphthylene	N	2800	mg/kg	0.10	0.97	0.18	< 0.10
Acenaphthene	M	2800	mg/kg	0.10	2.6	0.15	0.20
Fluorene	M	2800	mg/kg	0.10	1.9	< 0.10	< 0.10
Phenanthrene	M	2800	mg/kg	0.10	25	2.5	2.1
Anthracene	M	2800	mg/kg	0.10	2.9	0.43	0.16
Fluoranthene	M	2800	mg/kg	0.10	25	4.1	1.6
Pyrene	M	2800	mg/kg	0.10	23	4.3	1.3
Benzo[a]anthracene	M	2800	mg/kg	0.10	8.6	1.6	0.37

Chemtest
The right chemistry to deliver results

Results - Soil

Project: 2986 Long Lane, Earlsheaton

Client: Lithos Consulting			**Chemtest Job No.:**		18-26681	18-26681	18-26681
Quotation No.:			**Chemtest Sample ID.:**		682403	682404	682406
			Sample Location:		TP07	TP08	TP09
			Sample Type:		SOIL	SOIL	SOIL
			Top Depth (m):		0.10	0.10	0.50
			Date Sampled:		31-Aug-2018	31-Aug-2018	31-Aug-2018
			Asbestos Lab:		COVENTRY	COVENTRY	COVENTRY
Determinand	**Accred.**	**SOP**	**Units**	**LOD**			
Chrysene	M	2800	mg/kg	0.10	13	2.3	0.50
Benzo[b]fluoranthene	M	2800	mg/kg	0.10	12	2.6	0.42
Benzo[k]fluoranthene	M	2800	mg/kg	0.10	5.2	0.84	0.10
Benzo[a]pyrene	M	2800	mg/kg	0.10	8.7	1.3	0.20
Indeno(1,2,3-c,d)Pyrene	M	2800	mg/kg	0.10	7.3	1.2	< 0.10
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	1.1	0.12	< 0.10
Benzo[g,h,i]perylene	M	2800	mg/kg	0.10	6.6	1.3	0.17
Total Of 16 PAH's	N	2800	mg/kg	2.0	150	24	10

Test Methods

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2040	Soil Description(Requirement of MCERTS)	Soil description	As received soil is described based upon BS5930
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2140	Calorific Value	Calorific Value	Bomb Calorimeter
2192	Asbestos	Asbestos	Polarised light microscopy / Gravimetry
2220	Water soluble Chloride in Soils	Chloride	Aqueous extraction and measuremernt by 'Aquakem 600' Discrete Analyser using ferric nitrate / mercuric thiocyanate.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2490	Hexavalent Chromium in Soils	Chromium [VI]	Soil extracts are prepared by extracting dried and ground soil samples into boiling water. Chromium [VI] is determined by 'Aquakem 600' Discrete Analyser using 1,5-diphenylcarbazide.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2670	Total Petroleum Hydrocarbons (TPH) in Soils by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO*TPH C8–C40	Dichloromethane extraction / GC-FID
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS
640	Characterisation of Waste (Leaching)	Waste material including soil, sludges and granular waste	ComplianceTest for Leaching of Granular Waste Material and Sludge

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

Appendix H

Geotechnical Test Results

TERRA TEK
SITE INVESTIGATION & LABORATORY SERVICES

Lithos Consulting Ltd
Parkhill
Walton Road
Wetherby
Leeds
LS22 5DZ
For the attention of Matt Thompson

Report No: B21835
Issue No 01

LABORATORY TEST REPORT

Project Name	**LONG LANE**		
Project Number	**B21835**	Date samples received	03/09/2018
Your Ref	2986	Date written instructions received	03/09/2018
Purchase Order	PO 13489	Date testing commenced	03/09/2018

Please find enclosed the results as summarised below

Figure / Table	Test Quantity	Description	ISO 17025 Accredited
1	~	Summary of Geotechnical Tests	See report
2	7	BRE Suite - Soil	Yes
3-6	4	Atterberg Limit	Yes
7-10	4	Particle Size Distribution	Yes
App S1	~	Sample Descriptions - Soil	N/A
App S2	~	Deviating Samples - Soil	N/A
App S3	~	Summary of In-House Analytical Test Methods - Soil	N/A

Remarks :

Issued by : Stephen Langman Date of Issue : 11/09/2018

Redacted

Approved Signatories :
G Wilson (JMD/Laboratories Director), S Langman (Laboratory Coordinator)

Key to symbols used in this report
S/C : Testing was sub-contracted

Unless we are notified to the contrary, samples will be disposed after a period of one month from this date.
The results reported relate to samples received in the laboratory only.
All results contained in this report are provisional unless signed by an approved signatory
This report should not be reproduced except in full without the written approval of the laboratory.
Under multisite accreditation the testing contained in this report may have been performed at another Terra Tek laboratory.
The enclosed results remain the property of Terra Tek Limited and we reserve the right to withdraw
our report if we have not received cleared funds in accordance with our standard terms and conditions
Only those results indicated in this report are UKAS accredited and any opinions or interpretations expressed are outside the scope of UKAS accreditation.
Feedback on the this report may be left via our website www.terratek.co.uk/contact-us

mCERTS UKAS TESTING 0126 25 YEARS 1990-2015

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Head Office : 62 Rochsolloch Road, Airdrie, ML6 9BG

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES

Site: LONG LANE

Client: Lithos Consulting Ltd

Engineer:

Contract No 2986

Sample Identification							Atterberg limits						Density		Total Stress			
Exploratory Hole	Depth m	Sample Ref	Sample Type	Lab Sample ID	Non Engineering Sample Description	Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index	Percentage retained 425µm %	Atterberg Classification	Particle Density Mg/m³	Bulk Mg/m³	Dry Mg/m³	Shear Strength kPa	Apparent Cohesion C kPa	Angle of Shearing Resistance Phi	Other Tests
TP01	0.60		D	453764														BRE SD1 Suite
TP01	2.40		D	453768														BRE SD1 Suite
TP03	1.30		D	453760	Brown silty clayey SAND with much gravel. Gravel is fine to coarse.	13	38	16	22	45	CI							PSD,BRE SD1 Suite
TP04	1.90		D	453761	Brown fine to coarse GRAVEL with some silty slightly clayey sand.	14	30	17	13	71	CL							PSD
TP04	2.90		D	453759														BRE SD1 Suite
Notes: Opinions and interpretations are outside the scope of UKAS accreditation					UKAS Accredited Test Y/N	Test details are given on the 'Notes on Laboratory Procedures' sheet												See individual report sheets
						Y	Y	Y	Y	Y	-	Y	Y	Y	Y	Y	Y	

Originator: PM

Approved: Redacted 11/09/2018

SUMMARY OF GEOTECHNICAL TESTS

Figure 1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES

Site: LONG LANE

Client: Lithos Consulting Ltd

Engineer:

Contract No 2986

Sample Identification							Atterberg limits						Density		Total Stress			
Exploratory Hole	Depth m	Sample Ref	Sample Type	Lab Sample ID	Non Engineering Sample Description	Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index	Percentage retained 425µm %	Atterberg Classification	Particle Density Mg/m³	Bulk Mg/m³	Dry Mg/m³	Shear Strength kPa	Apparent Cohesion C kPa	Angle of Shearing Resistance Phi	Other Tests
TP05	2.30		D	453762	Brown silty slightly clayey SAND with some gravel. Gravel is fine to coarse.	11	31	18	13	37	CL							PSD,BRE SD1 Suite
TP06	0.70		D	453766														BRE SD1 Suite
TP07	0.60		D	453767														BRE SD1 Suite
TP09	2.00		D	453763	Brown fine to coarse GRAVEL with much slightly silty slightly clayey sand.	9.3	35	18	17	86	CL							PSD
Notes: Opinions and interpretations are outside the scope of UKAS accreditation					UKAS Accredited Test Y/N	Test details are given on the 'Notes on Laboratory Procedures' sheet												See individual report sheets
						Y	Y	Y	Y	Y	-	Y	Y	Y	Y	Y	Y	

Originator: PM

Approved: Redacted

SUMMARY OF GEOTECHNICAL TESTS

Figure 1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES

Site: LONG LANE

Client: Lithos Consulting Ltd

Engineer:

Contract No **2986**

Sample Identification				Lab Sample ID	Sulphate (water soluble in 2:1 extract) as SO4 g/l	pH
Hole	Depth m	Sample Ref	Sample Type			
TP01	0.60		D	453764	<0.01	6.8
TP01	2.40		D	453768	<0.01	6.9
TP03	1.30		D	453760	0.02	7.6
TP04	2.90		D	453759	0.05	7.3
TP05	2.30		D	453762	0.03	7.6
TP06	0.70		D	453766	0.01	7.8
TP07	0.60		D	453767	<0.01	7.5
				Limits of Detection	0.01	~
				Terra Tek Analysis Method	TP169	TP019
				Accreditation M=Mcerts U=UKAS N=No accreditation	M	M

Originator: TH

Checked & Approved: Redacted

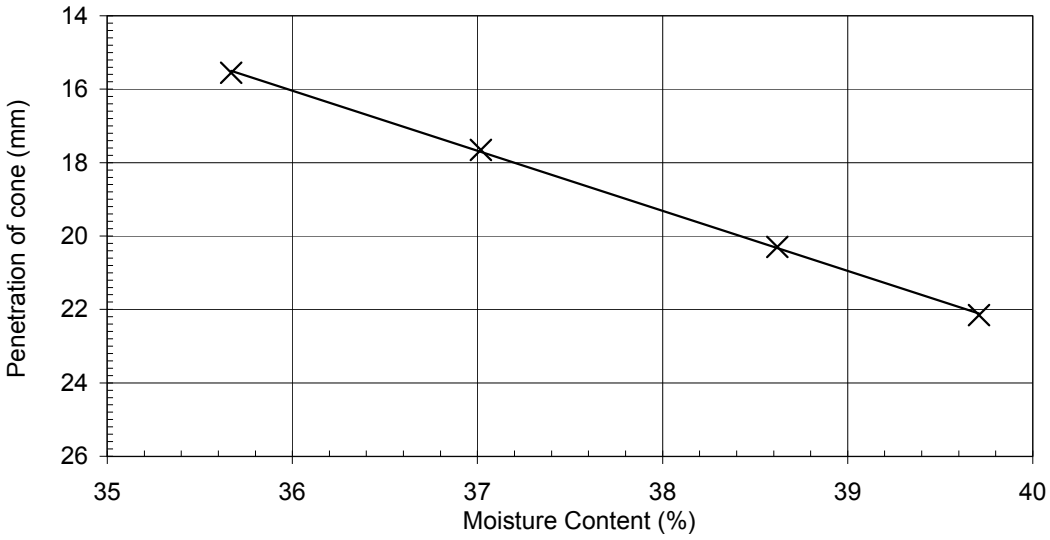
BRE SD1 SUITE - SOIL

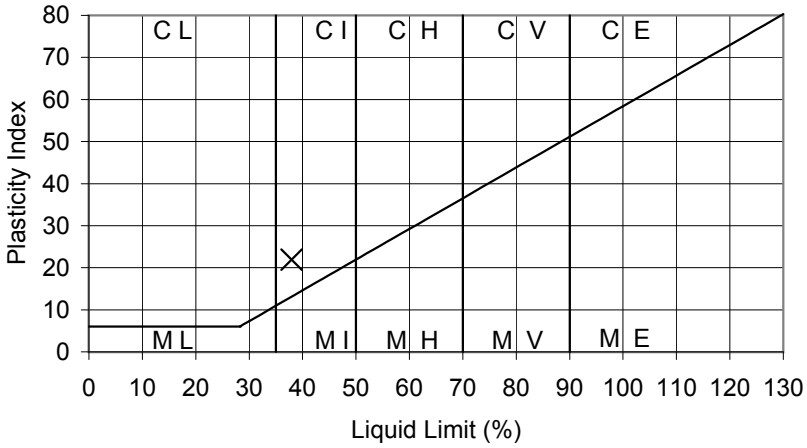
Figure 2

Sheet 1 of 1

Non Engineering Description : Brown silty clayey SAND with much gravel. Gravel is fine to coarse.

Preparation : Sample washed and air dried





Results :

As Received Moisture Content : (BS1377:Part 2:Clause 3:1990)	13	%
Percentage retained on 425µm sieve :	45	%
Liquid Limit :	38	%
Plastic Limit :	16	%
Plasticity Index :	22	
Equivalent moisture content of material passing 425µm sieve :	24	%
Liquidity Index :	0.36	

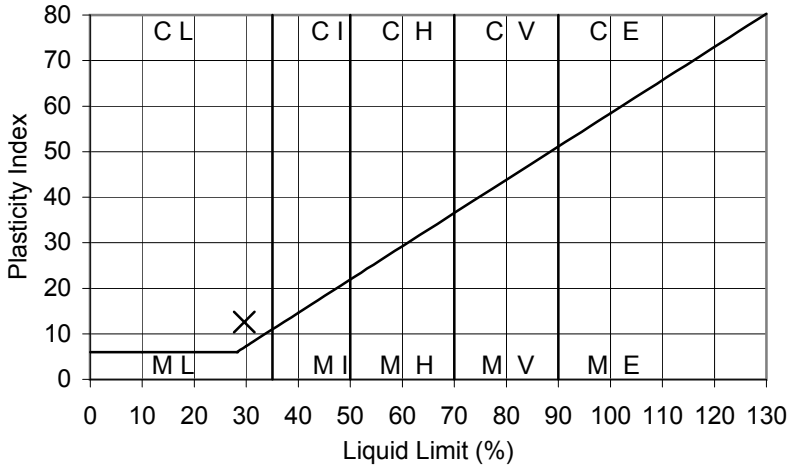
Originator	Checked & Approved	**Liquid Limit (Four Point Cone Penetrometer Method) Plastic Limit, Plasticity Index & Liquidity Index**	**Figure 3**
IG	Redacted	BS 1377:Part 2:Clause 4.3:1990 BS 1377:Part 2:Clause 5:1990	Sheet 1 of 1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES

Site	LONG LANE	**Contract No.**	**2986**
Client	Lithos Consulting Ltd	Hole ID	TP04
Engineer		Sample Ref	
		Depth (m)	1.90
		Sample Type	D

Non Engineering Description : Brown fine to coarse GRAVEL with some silty slightly clayey sand.

Preparation : Sample as received



Results :

As Received Moisture Content : (BS1377:Part 2:Clause 3:1990)	14	%
Percentage retained on 425µm sieve :	71	%
Liquid Limit :	30	%
Plastic Limit :	17	%
Plasticity Index :	13	
Equivalent moisture content of material passing 425µm sieve :	48	%
Liquidity Index :	2.38	

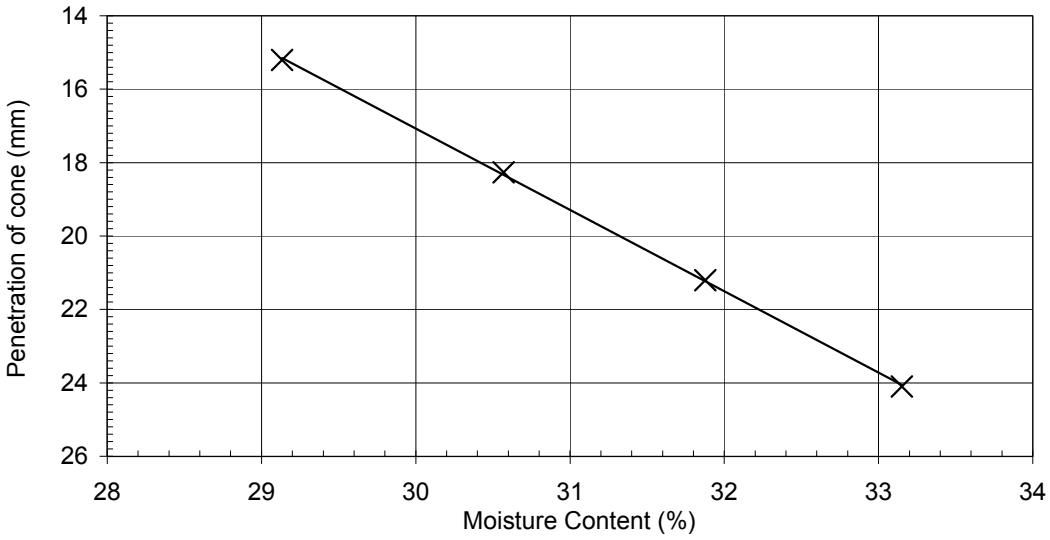
Originator	Checked & Approved	**Liquid Limit (One Point Cone Penetrometer Method)** **Plastic Limit, Plasticity Index & Liquidity Index** BS 1377:Part 2:Clause 4.4:1990 BS 1377:Part 2:Clause 5:1990	**Figure 4**
AT	Redacted		Sheet 1 of 1

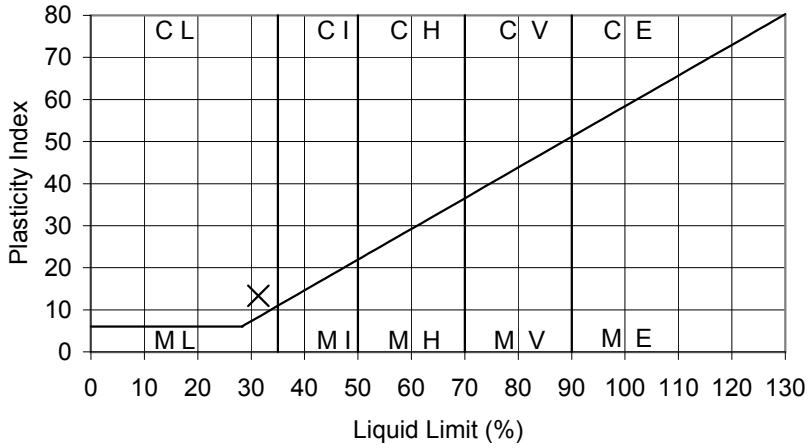
TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES

Site	LONG LANE	**Contract No.**	**2986**
Client	Lithos Consulting Ltd	Hole ID	TP05
Engineer		Sample Ref	
		Depth (m)	2.30
		Sample Type	D

Non Engineering Description : Brown silty slightly clayey SAND with some gravel. Gravel is fine to coarse.

Preparation : Sample washed and air dried





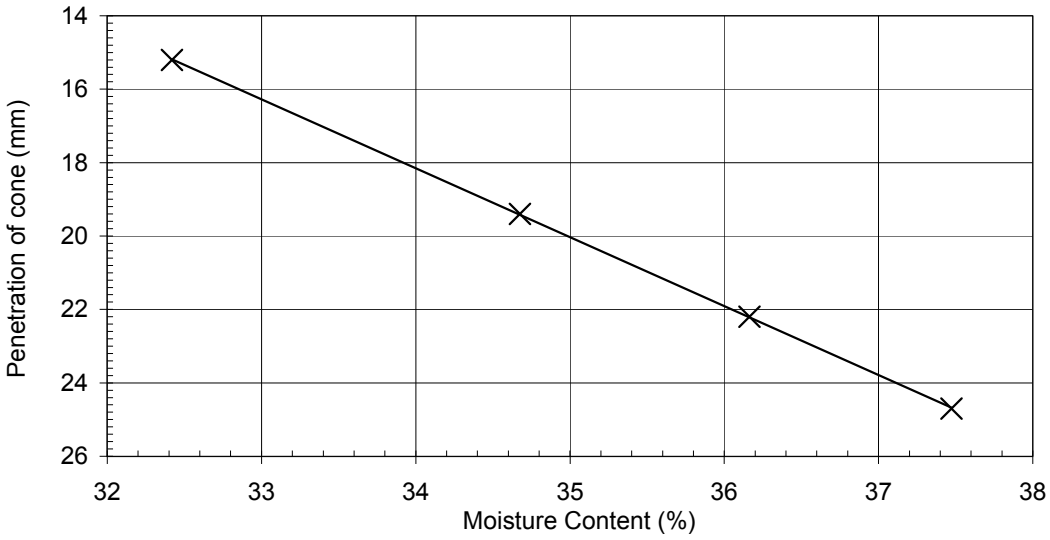
Results :

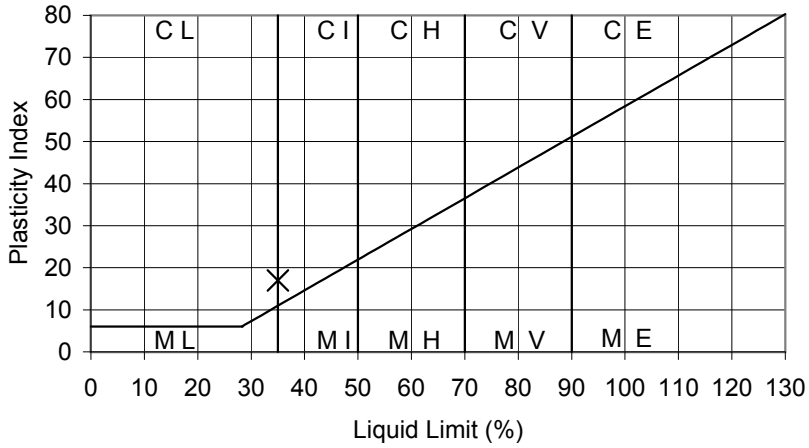
As Received Moisture Content : (BS1377:Part 2:Clause 3:1990)	11	%
Percentage retained on 425µm sieve :	37	%
Liquid Limit :	31	%
Plastic Limit :	18	%
Plasticity Index :	13	
Equivalent moisture content of material passing 425µm sieve :	17	%
Liquidity Index :	-0.08	

Originator	Checked & Approved	**Liquid Limit (Four Point Cone Penetrometer Method)** **Plastic Limit, Plasticity Index & Liquidity Index** BS 1377:Part 2:Clause 4.3:1990 BS 1377:Part 2:Clause 5:1990	**Figure 5**
AT/ME	Redacted		Sheet 1 of 1

Non Engineering Description : Brown fine to coarse GRAVEL with much slightly silty slightly clayey sand.

Preparation : Sample washed and air dried





Results :

As Received Moisture Content : (BS1377:Part 2:Clause 3:1990)	9.3	%
Percentage retained on 425µm sieve :	86	%
Liquid Limit :	35	%
Plastic Limit :	18	%
Plasticity Index :	17	
Equivalent moisture content of material passing 425µm sieve :	64	%
Liquidity Index :	2.71	

Originator	Checked & Approved
AT	Redacted

Liquid Limit (Four Point Cone Penetrometer Method)
Plastic Limit, Plasticity Index & Liquidity Index
BS 1377:Part 2:Clause 4.3:1990
BS 1377:Part 2:Clause 5:1990

Figure 6

TERRA TEK
SITE INVESTIGATION AND LABORATORY SERVICES

Site	LONG LANE	**Contract No**	**2986**
Client	Lithos Consulting Ltd	Hole	TP03
Engineer		Sample Ref	
		Depth (m)	1.30
		Sample Type	D

Particle Size	% Passing
125.0 mm	100
90.0 mm	100
75.0 mm	100
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	87
20.0 mm	84
14.0 mm	81
10.0 mm	78
6.30 mm	74
5.00 mm	72
3.35 mm	70
2.00 mm	67
1.18 mm	65
600 µm	60
425 µm	55
300 µm	48
212 µm	41
150 µm	34
63 µm	20

Non Engineering Description

Brown silty clayey SAND with much gravel. Gravel is fine to coarse.

Sample Proportions - %

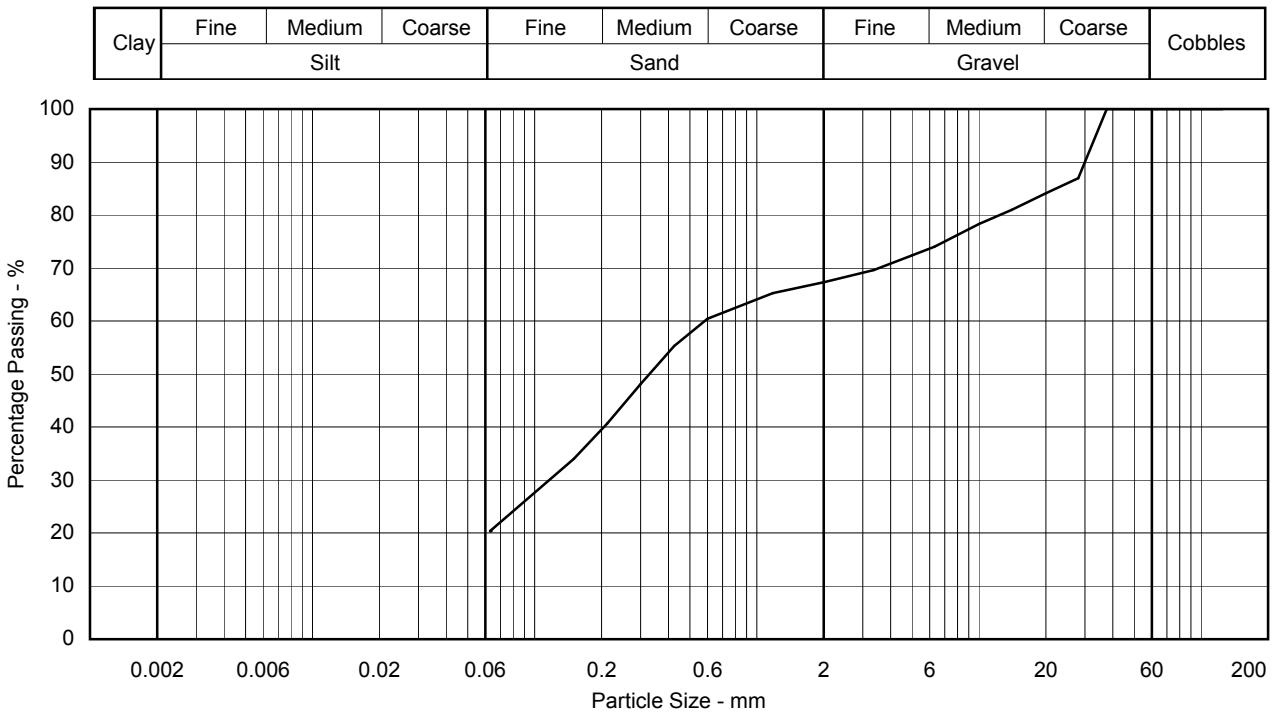
Cobbles	0.0
Gravel	32.7
Sand	47.0
Silt & Clay	20.4

Particle Diameter - mm

D100	38
D60	0.58
D10	
Uniformity Coefficient	N/A

Notes

Sample does not comply with BS1377 minimum mass requirements



Originator	Checked & Approved
LF/ME	Redacted

PARTICLE SIZE DISTRIBUTION
BS1377:Part 2:1990 Clause 9.2 - Wet Sieving

Figure 7

TERRA TEK
SITE INVESTIGATION AND LABORATORY SERVICES

Site	LONG LANE	**Contract No**	**2986**
Client	Lithos Consulting Ltd	Hole	TP04
Engineer		Sample Ref	
		Depth (m)	1.90
		Sample Type	D

Particle Size	% Passing
125.0 mm	100
90.0 mm	100
75.0 mm	100
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	63
20.0 mm	52
14.0 mm	52
10.0 mm	51
6.30 mm	51
5.00 mm	50
3.35 mm	48
2.00 mm	46
1.18 mm	42
600 µm	34
425 µm	29
300 µm	25
212 µm	21
150 µm	17
63 µm	9

Non Engineering Description

Brown fine to coarse GRAVEL with some silty slightly clayey sand.

Sample Proportions - %

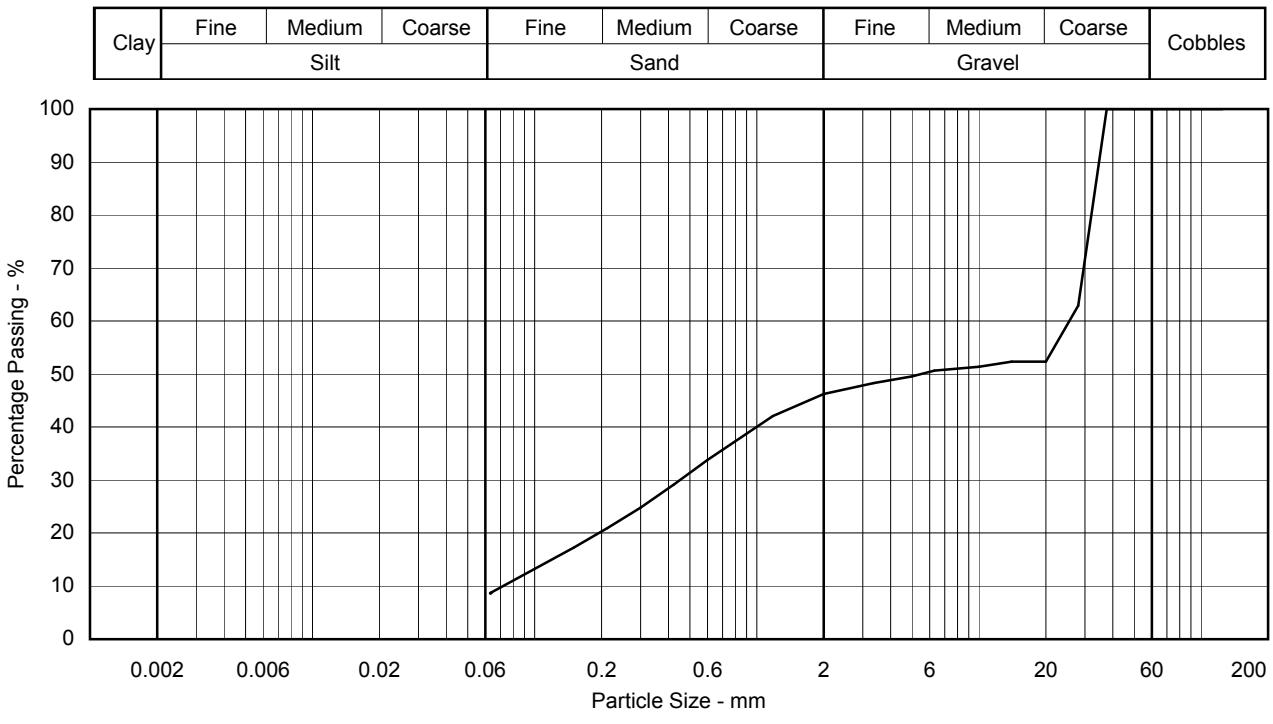
Cobbles	0.0
Gravel	53.8
Sand	37.6
Silt & Clay	8.6

Particle Diameter - mm

D100	38
D60	26
D10	0.072
Uniformity Coefficient	361.1

Notes

Sample does not comply with BS1377 minimum mass requirements



Originator	Checked & Approved
LF/ME	Redacted

PARTICLE SIZE DISTRIBUTION
BS1377:Part 2:1990 Clause 9.2 - Wet Sieving

Figure 8

TERRA TEK
SITE INVESTIGATION AND LABORATORY SERVICES

Site	LONG LANE	**Contract No**	**2986**
Client	Lithos Consulting Ltd	Hole	TP05
Engineer		Sample Ref	
		Depth (m)	2.30
		Sample Type	D

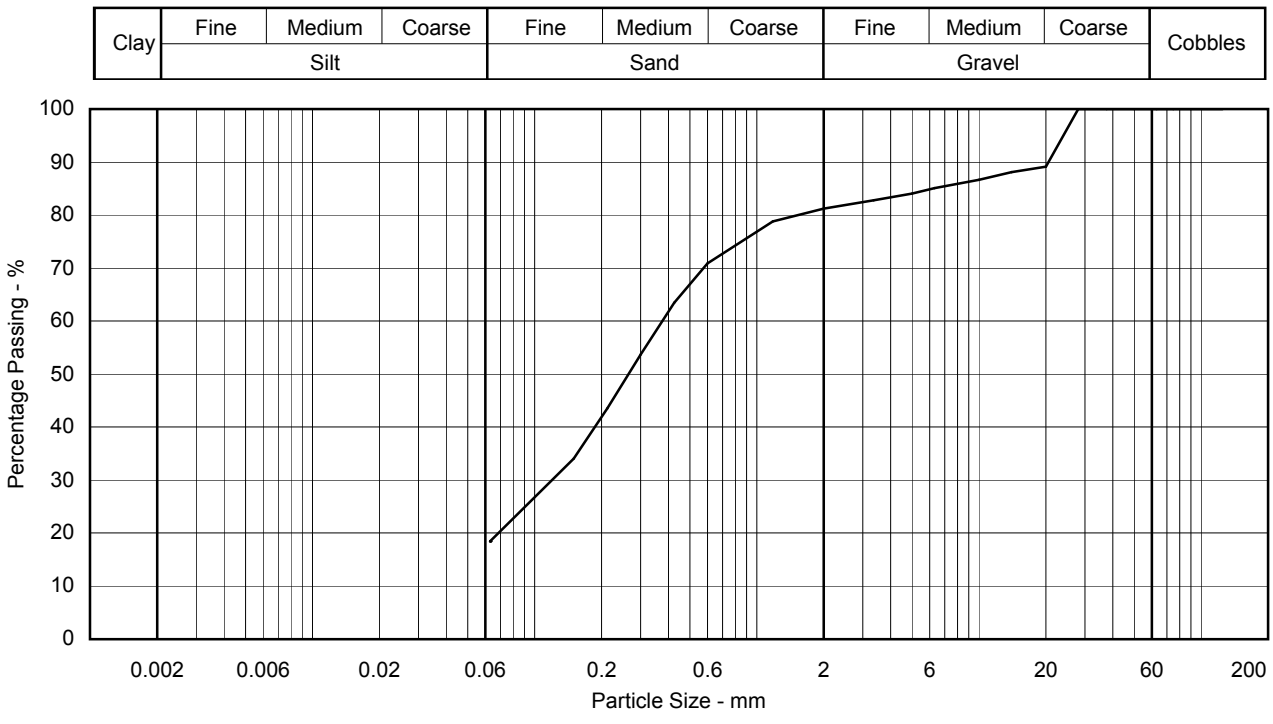
Particle Size	% Passing
125.0 mm	100
90.0 mm	100
75.0 mm	100
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	100
20.0 mm	89
14.0 mm	88
10.0 mm	87
6.30 mm	85
5.00 mm	84
3.35 mm	83
2.00 mm	81
1.18 mm	79
600 µm	71
425 µm	63
300 µm	54
212 µm	44
150 µm	34
63 µm	18

Non Engineering Description
Brown silty slightly clayey SAND with some gravel. Gravel is fine to coarse.

Sample Proportions - %	
Cobbles	0.0
Gravel	18.8
Sand	62.8
Silt & Clay	18.4

Particle Diameter - mm	
D100	28
D60	0.38
D10	
Uniformity Coefficient	N/A

Notes
Sample does not comply with BS1377 minimum mass requirements



Originator	Checked & Approved
LF/ME	Redacted

PARTICLE SIZE DISTRIBUTION
BS1377:Part 2:1990 Clause 9.2 - Wet Sieving

Figure 9

TERRA TEK
SITE INVESTIGATION AND LABORATORY SERVICES

Site	LONG LANE	**Contract No**	**2986**
Client	Lithos Consulting Ltd	Hole	TP09
Engineer		Sample Ref	
		Depth (m)	2.00
		Sample Type	D

Particle Size	% Passing
125.0 mm	100
90.0 mm	100
75.0 mm	100
63.0 mm	100
50.0 mm	100
37.5 mm	100
28.0 mm	90
20.0 mm	82
14.0 mm	66
10.0 mm	52
6.30 mm	40
5.00 mm	36
3.35 mm	31
2.00 mm	27
1.18 mm	24
600 µm	20
425 µm	18
300 µm	16
212 µm	14
150 µm	12
63 µm	7

Non Engineering Description

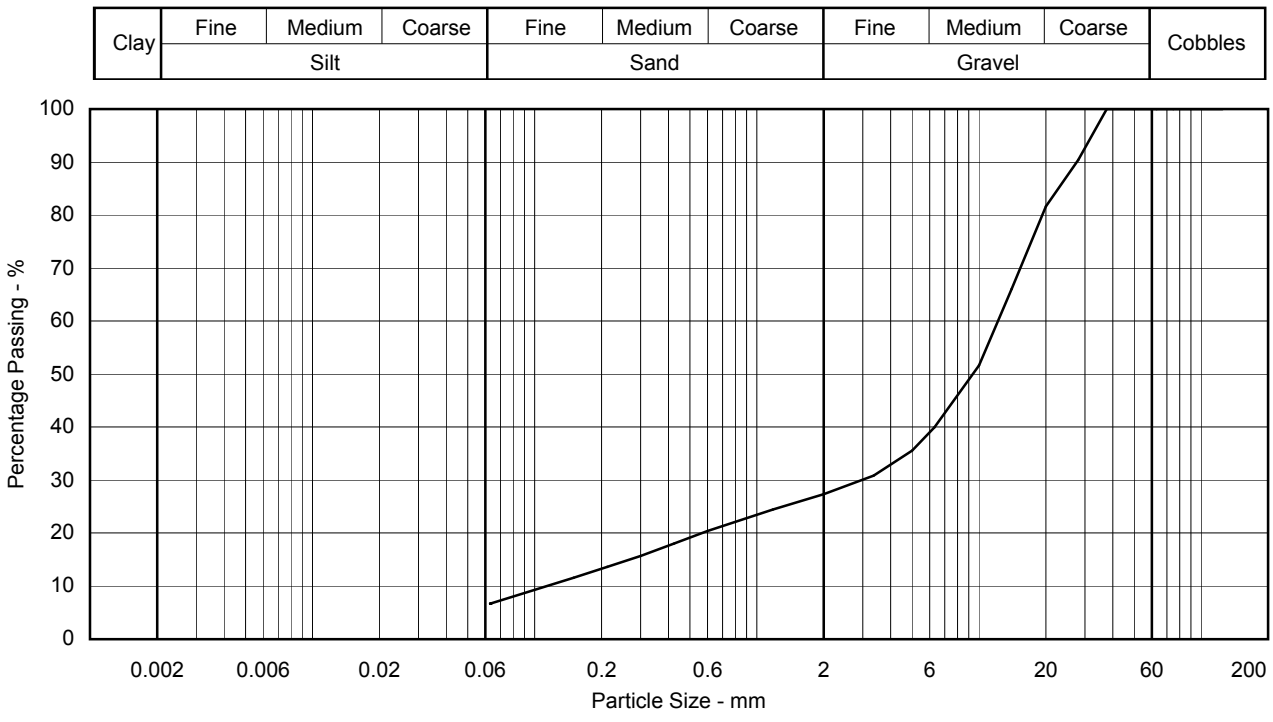
Brown fine to coarse GRAVEL with much slightly silty slightly clayey sand.

Sample Proportions - %	
Cobbles	0.0
Gravel	72.7
Sand	20.7
Silt & Clay	6.7

Particle Diameter - mm	
D100	38
D60	12
D10	0.11
Uniformity Coefficient	109.1

Notes

Sample does not comply with BS1377 minimum mass requirements



Originator	Checked & Approved
LF/ME	Redacted

PARTICLE SIZE DISTRIBUTION
BS1377:Part 2:1990 Clause 9.2 - Wet Sieving

Figure 10

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES

Site LONG LANE

Client Lithos Consulting Ltd

Engineer

Contract No E13009/1

Sample Identification				Lab Sample ID	Date Sampled	Temperature on receipt °C	PRIMARY MATRIX	Secondary Matrix	Additional matrix	% Loss at 30C	% Retained 2mm
Exploratory Hole	Depth m	Sample Ref	Sample Type								
TP04	2.90		D	453759	31/08/18		SANDSTONE	Fine to medium gravel		6.1	13.7
TP03	1.30		D	453760	31/08/18		SAND	Fine to medium gravel		9.3	16.9
TP05	2.30		D	453762	31/08/18		Clayey SAND	Fine to medium gravel		14.8	15.7
TP01	0.60		D	453764	31/08/18		SANDSTONE	Fine to medium gravel		7.7	33.5
TP06	0.70		D	453766	31/08/18		SAND	Fine to medium gravel		6.0	12.8
TP07	0.60		D	453767	31/08/18		SAND	Fine to medium gravel		5.3	53.6
TP01	2.40		D	453768	31/08/18		SANDSTONE	Fine to medium gravel		5.2	51.8

Notes

Terra Tek are accredited for clay, sand and loam matrix types only, where they constitute the major component of the sample. Other coarse granular materials such as gravel, are not accredited where they comprise the major component of the sample.

Results are expressed on a dry-weight basis (samples dried at 30°C ± 5°C) except where stated.

The laboratory removes any material > 2mm prior to analysis. The quantity and nature of the material is shown as the secondary and additional matrix types in the above table.

Where a parameter cannot be determined in house it is our policy to use a UKAS/MCERTS accredited laboratory wherever possible. Terra Tek will assume responsibility for the quality of subcontracted tests and the performance of the subcontractor chosen. Where there is no known UKAS/MCERTS laboratory for a particular parameter, a laboratory listed within the Terra Tek Approved Subcontractors List, which is subject to performance assessment, will be selected.

Originator	Checked & Approved
TH	Redacted

SAMPLE DESCRIPTIONS

Appendix S1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES

Site LONG LANE

Client Lithos Consulting Ltd

Engineer

Contract No 2986

Sample Identification				Lab Sample ID	Date Sampled	Deviating conditions						Preservatives used
Exploratory Hole	Depth m	Sample Ref	Sample Type			Sampling date has not been provided	Exceeded maximium holding time for selected test(s)	Presence of headspace in sample vial	Poorly fitting cap or lid	Damaged container		
TP04	2.90		D	453759	31/08/18							
TP03	1.30		D	453760	31/08/18							
TP05	2.30		D	453762	31/08/18							
TP01	0.60		D	453764	31/08/18							
TP06	0.70		D	453766	31/08/18							
TP07	0.60		D	453767	31/08/18							
TP01	2.40		D	453768	31/08/18							

NOTES

1 Results reported for samples classified as deviating may be compromised. Deviation types are shown as "X" or "Yes" in the table above.
2 The absence of "X" or "Yes" in the table above indicates no reported deviations.
3 Deviations due to use of incorrect sample container are shown on result tables.
4 Deviating results are indicated within result tables.

Originator	Checked & Approved	DEVIATING SAMPLES - SOIL	Appendix S2
TGH	Redacted 11/09/2018		Sheet 1 of 1

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES

Site LONG LANE

Client Lithos Consulting Ltd

Engineer

Contract No 2986

Method Code	Reference	Description of Method	ISO17025 Accredited	MCERTS Accredited	Wet/Dry Sample Tested
GP001	BS1377, Part 3, 1990: Soils for Civil Engineering Purposes.	Preparation of soil samples for chemical analysis	Yes	Yes	N/A
GP012	BS EN 12457-3: Characterisation of Waste - Compliance test for leaching of granular waste materials and sludges (two-stage batch test)	Preparation of soil samples for two-stage leachate test			Dry
TP019	BS1377, Part 3, 1990: Soils for Civil Engineering Purposes.	Determination of pH in 2.5:1 water/soil extract using pH meter.	Yes	Yes	Dry
TP029	BS1377, Part 3, 1990: Soils for Civil Engineering Purposes.	Determination of acid soluble sulfate by gravimetry.	Yes	Yes	Dry
TP032	MAFF Book 427: The Analysis of Agricultural Materials: Method 8	Determination of water soluble boron by colorimetry	Yes		Dry
TP033	APHA/AWWA, 19th edition: Method 5520E	Determination of Toluene Extractable Matter by soxhlet extraction.	Yes		Dry
TP040	APHA/AWWA, 19th edition: Method 3500Cr-D	Determination of hexavalent chromium by colorimetry.	Yes		Dry
TP041	BS1377, Part 3, 1990: Soils for Civil Engineering Purposes.	Determination of organic matter by titrimetry.	Yes		Dry
TP042	BS1377, Part 3, 1990: Soils for Civil Engineering Purposes.	Determination of loss on ignition at 50-440°C by gravimetry	Yes	Yes	Dry
TP043	BS1377, Part 3, 1990: Soils for Civil Engineering Purposes.	Determination of water soluble sulfate in 2:1 water/soil extract	Yes	Yes	Dry
TP045	GACHAMJA A.M. Chromatography and Analysis: 1992 9-11 (modified)	Determination of polyaromatic hydrocarbons extractable in dichloromethane, by GC/MS	Yes	Yes	Dry
TP046	MEWAM method: Phenols in water and Effluents: 4-aminoantipyrine method	Determination of monohydric phenols by steam distillation/colorimetry	Yes	Yes	Dry
TP047	MEWAM method: Cyanide in Waters etc	Determination of Free Cyanide by steam distillation/colorimetry	Yes		Dry
TP048	MEWAM method: Cyanide in Waters etc	Determination of total cyanide by steam distillation/colorimetry.	Yes	Yes	Wet
TP049	MEWAM method: Cyanide in Waters etc	Determination of complex cyanide by calculation	Yes		Dry
TP050	MEWAM method: Determination of Thiocyanate ,1985	Determination of thiocyanate by colorimetry	Yes	Yes	Dry
TP051	USEPA Method 9030B	Determination of acid soluble sulfides by steam distillation/colorimetry.	Yes	Yes	Dry
TP052	BS1881: Part 324, 1988: Testing Concrete	Determination of elemental sulfur by soxhlet extraction and titrimetry.	Yes		Dry
TP067	TNRCC Method 1005: 2001 (modified)	Determination of pentane/acetone extractable petroleum hydrocarbons (C8 - C40) by GC/FID	Yes	Yes	Wet
TP072	In-house documented method	Determination of ammoniacal nitrogen by colorimetry.			Dry

Notes

1. Terra Tek (Birmingham) are MCERTS accredited for clay, sand & loam matrix types only, where they constitute the major component of the sample. Other coarse granular materials, ie gravel, are not accredited where they comprise the major component of the sample.
2. Results are expressed on a dry-weight basis (samples dried at 30°C ± 5°C) except where stated.
3. The laboratory removes any material >2mm prior to analysis. The quantity and nature of any material removed from samples is recorded and the information is available on request.
4. The laboratory records the date of analysis of each parameter. This information is available on request.
5. Where a parameter cannot be determined in house it is our policy to use a UKAS/MCERTS accredited laboratory wherever possible. Terra Tek will assume responsibility for the quality of subcontracted tests and the performance of the subcontractor chosen. Where there is no known UKAS/MCERTS laboratory for a particular parameter, a laboratory listed within the Terra Tek Approved Subcontractors list, which is subject to performance assessment, will be selected.

Originator	Checked & Approved	SUMMARY OF IN-HOUSE ANALYTICAL TEST METHODS (SOIL)	Appendix S3
N/A	N/A		Sheet 1 of 2

TERRA TEK SITE INVESTIGATION AND LABORATORY SERVICES

Site LONG LANE

Client Lithos Consulting Ltd

Engineer

Contract No 2986

Method Code	Reference	Description of Method	ISO17025 Accredited	MCERTS Accredited	Wet/Dry Sample Tested
TP073	In-house documented method	Determination of anionic detergent (MBAS) by colorimetry			Dry
TP074	In-house documented method	Determination of water soluble fluoride by ion selective electrode			Dry
TP098	BS1377, Part 3, 1990: Soils for Civil Engineering Purposes.	Determination of acid soluble chloride by titrimetry			Dry
TP099	BS1377, Part 3, 1990: Soils for Civil Engineering Purposes.	Determination of water soluble chloride by titrimetry	Yes	Yes	Dry
TP100	Wisconsin DNR Modified GRO method, Method for Determining Gasoline Range Organics	Determination of Volatile Petroleum Hydrocarbons/GRO.	Yes	Yes	Wet
TP110	USEPA Methods 8082A & 3665A	Determination of Total & Speciated 7 PCB Congeners by GC/MS SIM	Yes	Yes	Wet
TP114	BS1377, Part 3, 1990: Soils for Civil Engineering Purposes.	Determination of carbonate in soil (rapid titration method)			Dry
TP126	TNRCC Method 1006 (modified)	Extracted petroleum hydrocarbons from TP067 split into aromatic and aliphatic fractions. Analysed by GC/FID.	Yes		Wet
TP134	In-house documented method	Determination of water soluble chloride by titrimetry	Yes	Yes	Dry
TP135	USEPA Methods 8100 & 8270D. In-house method TP045	Determination of polyaromatic hydrocarbons extractable in dichloromethane, by GC/MS (with concentration stage)			Dry
TP137	BS7755: Section 3.9: 1995/ISO 11466:1995	Determination of acid extractable metals in soil by ICP-OES	Selected	Selected	Dry
TP145	USEPA Methods 3550C & 8270D	Determination of Semi-Volatile Organic Compounds by GC/MS	Yes	Yes	Wet
TP147	USEPA Methods 8082A & 3665A	Determination of total & speciated WHO 12 PCB Congeners by GC/MS SIM.			Wet
TP150	USEPA Methods 8081B & 8141B	Determination of pesticides and herbicides in soil by GC/MS SIM			Wet
TP152	USEPA Method 556	Determination of carbonyls by GC/MS.			Wet
TP154	USEPA Method 5021. Wisconsin DNR modified GRO method	Determination of volatiles in by GC/MS headspace	Yes	Selected	Wet
TP158	USEPA Method 1671	Determination of glycols by GC/FID DI			Wet

Notes

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2. Results are expressed on a dry-weight basis (samples dried at 30°C ± 5°C) except where stated.
3. The laboratory removes any material >2mm prior to analysis. The quantity and nature of any material removed from samples is recorded and the information is available on request.
4. The laboratory records the date of analysis of each parameter. This information is available on request.
5. Where a parameter cannot be determined in house it is our policy to use a UKAS/MCERTS accredited laboratory wherever possible. Terra Tek will assume responsibility for the quality of subcontracted tests and the performance of the subcontractor chosen. Where there is no known UKAS/MCERTS laboratory for a particular parameter, a laboratory listed within the Terra Tek Approved Subcontractors list, which is subject to performance assessment, will be selected.

Originator	Checked & Approved
N/A	N/A

SUMMARY OF IN-HOUSE ANALYTICAL TEST METHODS (SOIL)

Appendix S3

Appendix I
Soakaway Test Results

SOIL INFILTRATION RATE IN ACCORDANCE WITH BRE DIGEST 365: 1991

Client:	Britology Limited
Engineer	Ashley Taylor
Job Name:	Long Lane, Earlsheaton
Job No.:	2986

Date:	31/08/2018
Trial Pit No.	TP01
Test No.	1

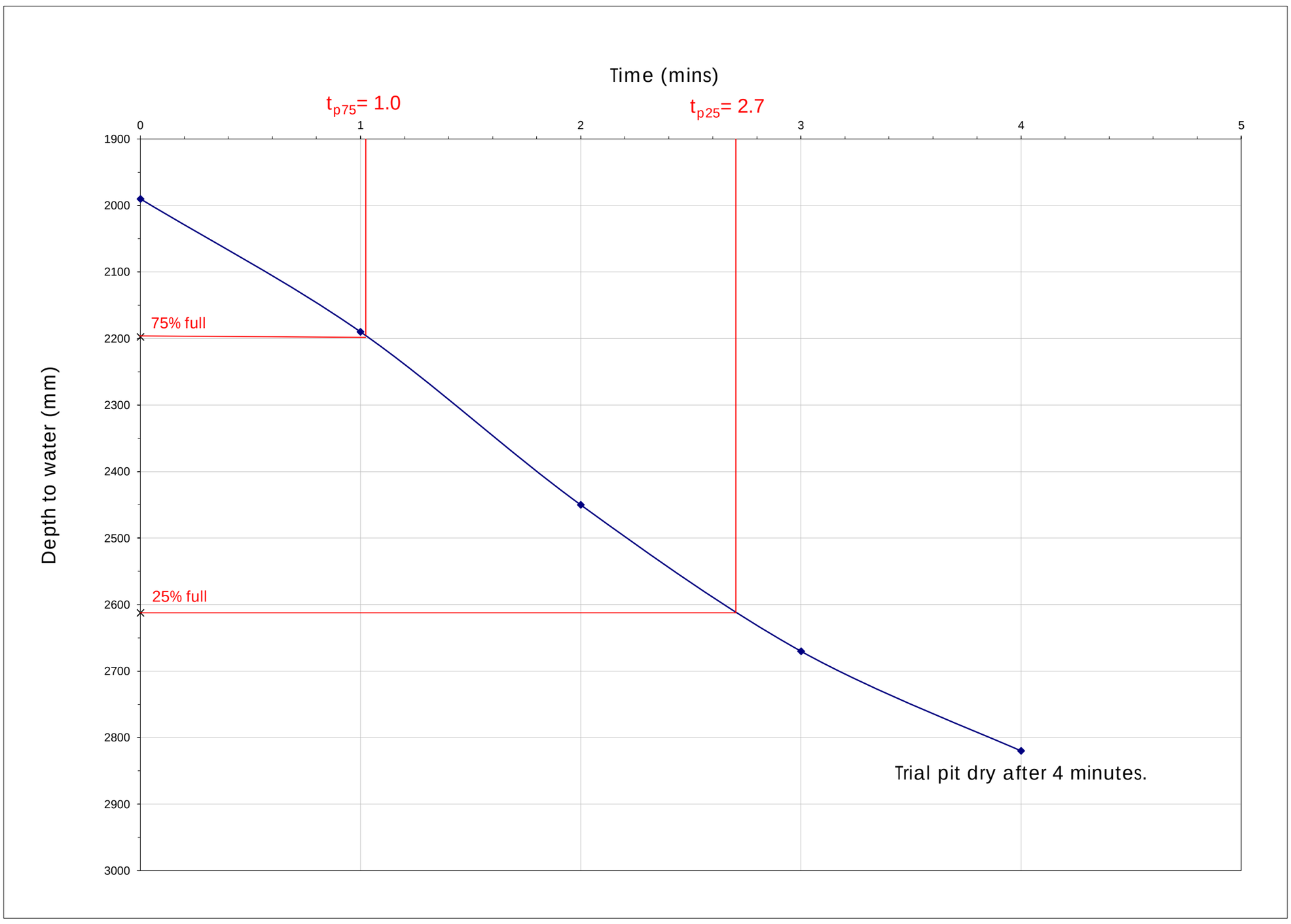
Time	Elapsed Time	Depth to water from ground level	
	(min)	(m)	(mm)
09:17	0	1.99	1990
09:18	1	2.19	2190
09:19	2	2.45	2450
09:20	3	2.67	2670
09:21	4	2.82	2820

SOAKAWAY TRIAL PIT			
Dimensions		(m)	(mm)
Length	=	2.80	2800
Width	=	0.90	900
Depth	=	2.82	2820

Effective Depth (% full)		(mm)	(m)
0.25	=	2612.5	2.61
0.50	=	2405	2.41
0.75	=	2197.5	2.20

Depth at start of test (mm)	=	1990
Depth at end of test (mm)	=	2820
Base area of pit	=	2.52
a_{p50} - 50% internal surface area inc. base	=	5.591
V_{p75-25} - Volume 75 - 25%	=	1.0458

Read from the graph:		
$t_{p\ 75}$ (min)	=	1.00
$t_{p\ 25}$ (min)	=	2.70



Soil infiltration rate, f, (m/s) = 1.83E-03

SOIL INFILTRATION RATE IN ACCORDANCE WITH BRE DIGEST 365: 1991

Client:	Britology Limited
Job Name:	Long Lane, Earlsheaton
Job No.:	2986

Trial Pit No.	TP01
Test No.	2

Time	Elpsed Time	Depth to water from ground level	
	(min)	(m)	(mm)
11:07	0	2.17	2170
11:08	1	2.44	2440
11:09	2	2.65	2650
11:10	3	2.82	2820

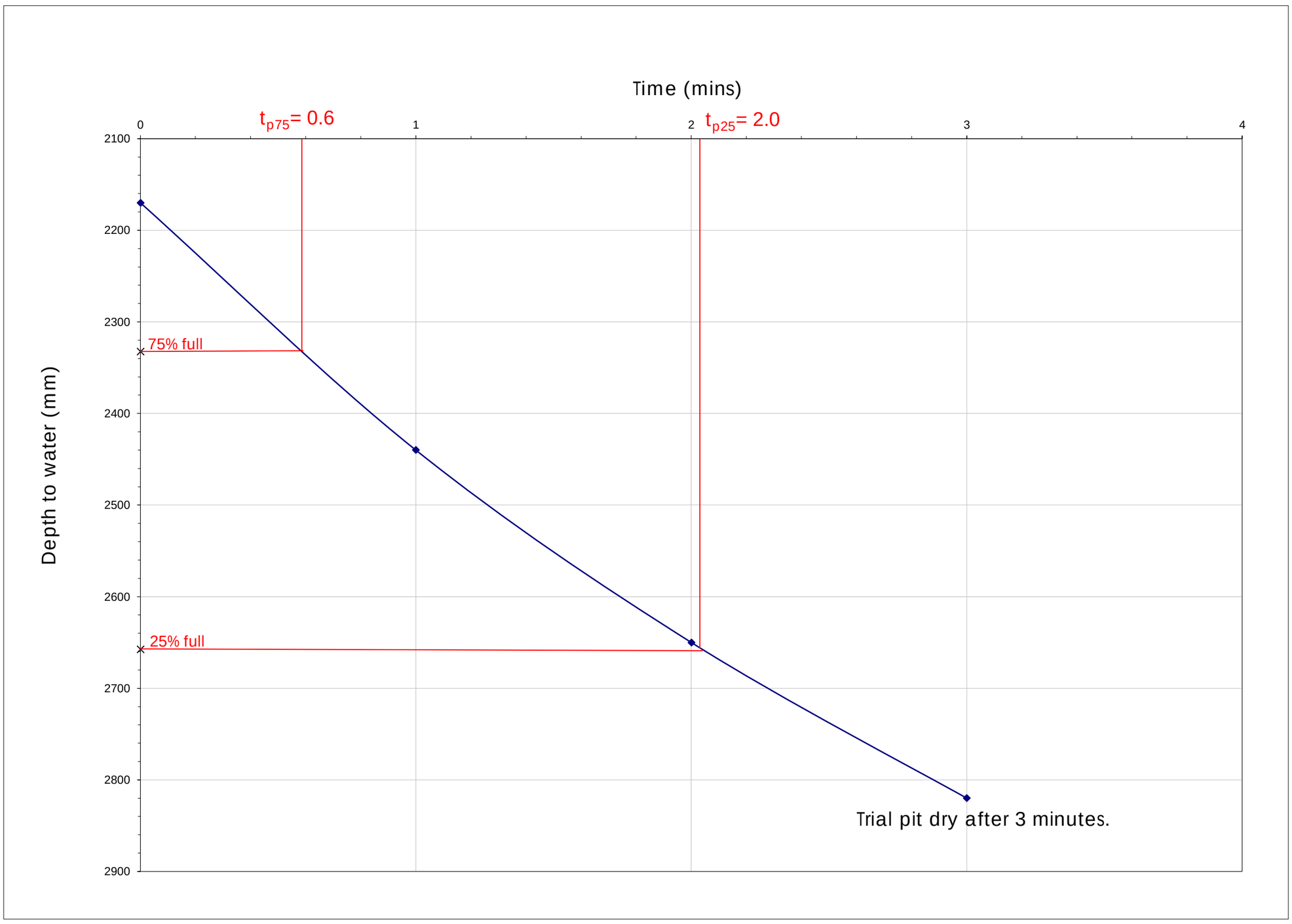
SOAKAWAY TRIAL PIT			
Dimensions		(m)	(mm)
Length	=	2.80	2800
Width	=	0.90	900
Depth	=	2.82	2820

Effective Depth (% full)		(mm)	(m)
0.25	=	2657.5	2.66
0.50	=	2495	2.50
0.75	=	2332.5	2.33

Depth at start of test (mm)	=	2170
Depth at end of test (mm)	=	2820

Base area of pit	=	2.52
a_{p50} - 50% internal surface area inc. base	=	4.925
V_{p75-25} - Volume 75 - 25%	=	0.819

Read from the graph:		
$t_{p\ 75}$ (min)	=	0.60
$t_{p\ 25}$ (min)	=	2.00



Soil infiltration rate, f, (m/s) = 1.98E-03

SOIL INFILTRATION RATE IN ACCORDANCE WITH BRE DIGEST 365: 1991

Client:	Britology Limited
Job Name:	Long Lane, Earlsheaton
Job No.:	2986

Trial Pit No.	TP01
Test No.	3

Time	Elpsed Time	Depth to water from ground level	
	(min)	(m)	(mm)
11:46	0	2.08	2080
11:47	1	2.21	2210
11:48	2	2.42	2420
11:49	3	2.59	2590
11:50	4	2.82	2820

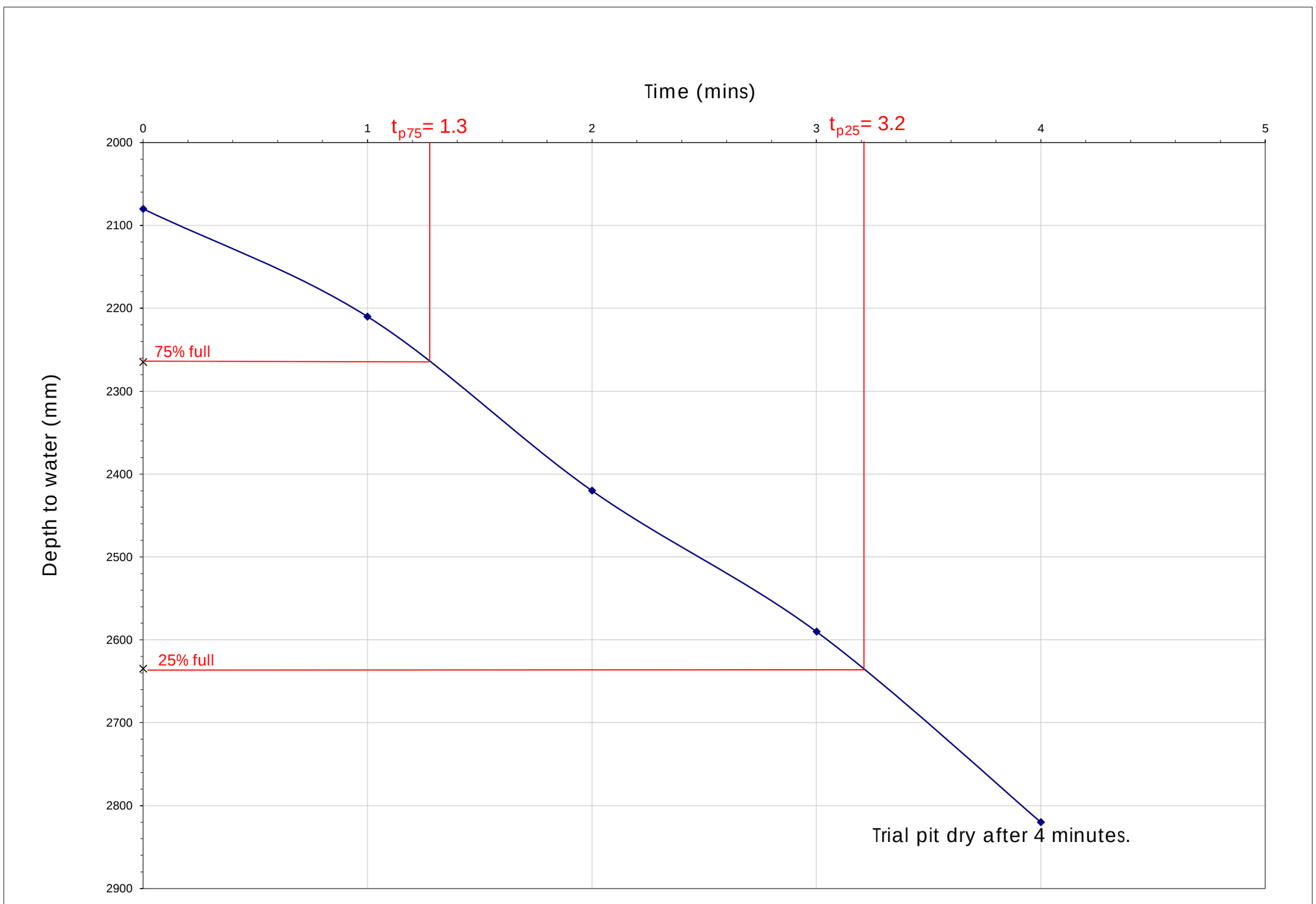
SOAKAWAY TRIAL PIT			
Dimensions		(m)	(mm)
Length	=	2.80	2800
Width	=	0.90	900
Depth	=	2.82	2820

Effective Depth (% full)		(mm)	(m)
0.25	=	2635	2.64
0.50	=	2450	2.45
0.75	=	2265	2.27

Depth at start of test (mm)	=	2080
Depth at end of test (mm)	=	2820

Base area of pit	=	2.52
a_{p50} - 50% internal surface area inc. base	=	5.258
V_{p75-25} - Volume 75 - 25%	=	0.9324

Read from the graph:		
$t_{p\ 75}$ (min)	=	1.30
$t_{p\ 25}$ (min)	=	3.20



Soil infiltration rate, f, (m/s) = 1.56E-03

SOIL INFILTRATION RATE IN ACCORDANCE WITH BRE DIGEST 365: 1991

Client:	Britology Limited
Job Name:	Long Lane, Earlsheaton
Job No.:	2986

Trial Pit No.	TP02
Test No.	1

Time	Elpsed Time	Depth to water from ground level	
	(min)	(m)	(mm)
09:28	0	2.41	2410
09:29	1	2.58	2580

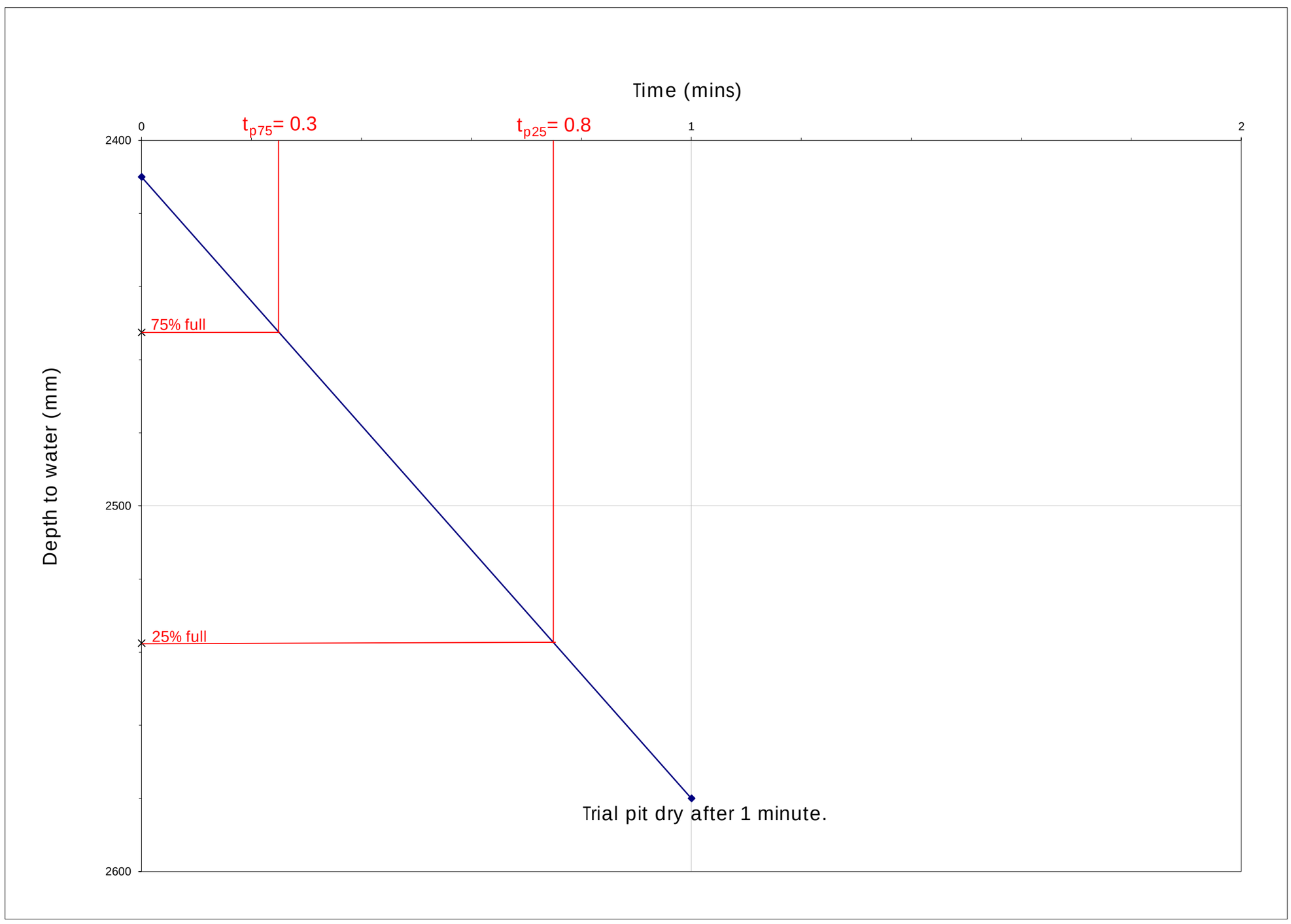
SOAKAWAY TRIAL PIT			
Dimensions		(m)	(mm)
Length	=	2.30	2300
Width	=	0.90	900
Depth	=	2.58	2580

Effective Depth (% full)		(mm)	(m)
0.25	=	2537.5	2.54
0.50	=	2495	2.50
0.75	=	2452.5	2.45

Depth at start of test (mm)	=	2410
Depth at end of test (mm)	=	2580

Base area of pit	=	2.07
a_{p50} - 50% internal surface area inc. base	=	2.614
V_{p75-25} - Volume 75 - 25%	=	0.17595

Read from the graph:		
$t_{p\ 75}$ (min)	=	0.30
$t_{p\ 25}$ (min)	=	0.80



Soil infiltration rate, f, (m/s) = 2.24E-03

SOIL INFILTRATION RATE IN ACCORDANCE WITH BRE DIGEST 365: 1991

Client:	Britology Limited
Job Name:	Long Lane, Earlsheaton
Job No.:	2986

Trial Pit No.	TP02
Test No.	2

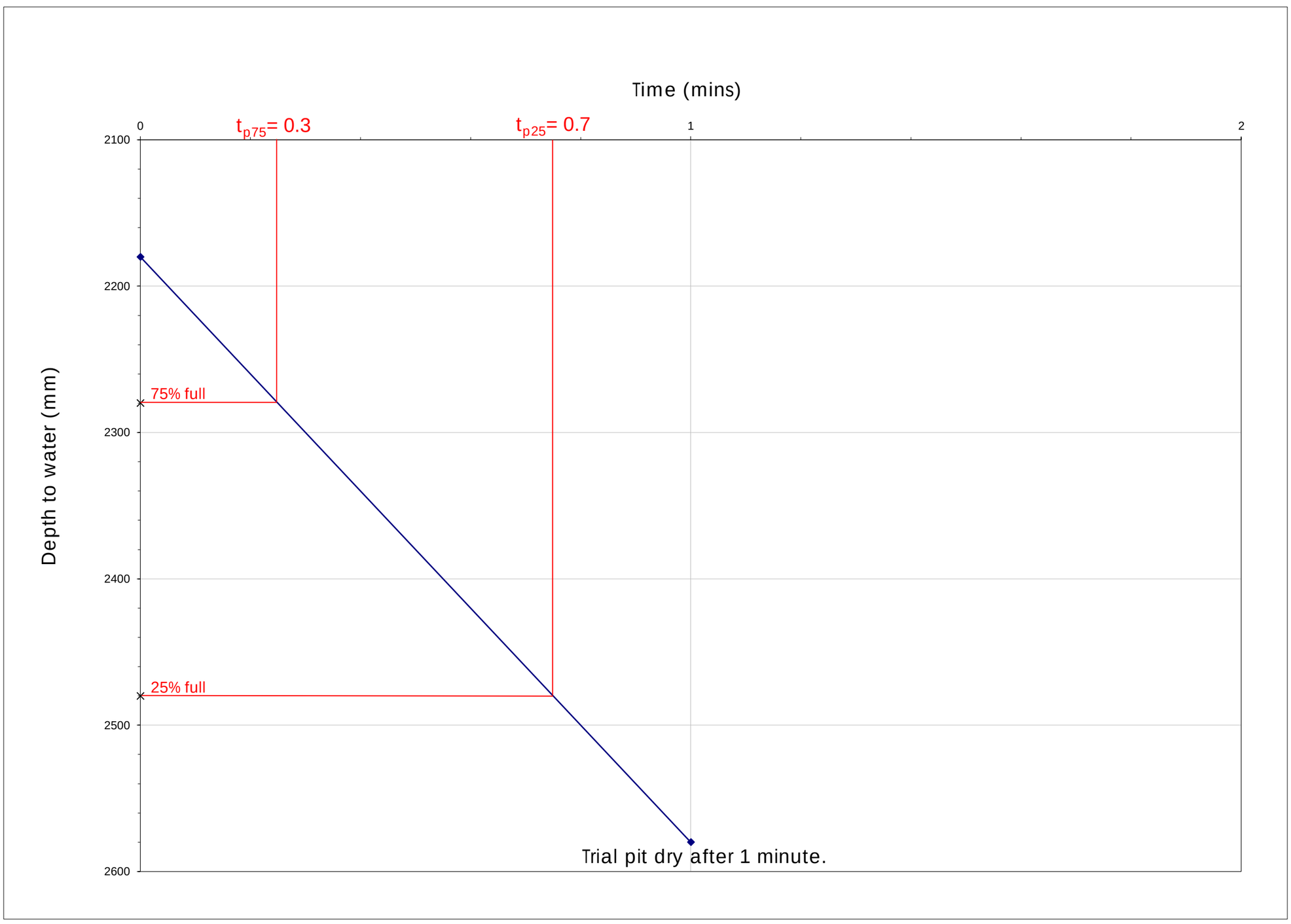
Time	Elpsed Time	Depth to water from ground level	
	(min)	(m)	(mm)
11:17	0	2.18	2180
11:18	1	2.58	2580

SOAKAWAY TRIAL PIT			
Dimensions		(m)	(mm)
Length	=	2.30	2300
Width	=	0.90	900
Depth	=	2.58	2580

Effective Depth (% full)		(mm)	(m)
0.25	=	2480	2.48
0.50	=	2380	2.38
0.75	=	2280	2.28

Depth at start of test (mm)	=	2180
Depth at end of test (mm)	=	2580
Base area of pit	=	2.07
a_{p50} - 50% internal surface area inc. base	=	3.35
V_{p75-25} - Volume 75 - 25%	=	0.414

Read from the graph:		
$t_{p\ 75}$ (min)	=	0.30
$t_{p\ 25}$ (min)	=	0.70



Soil infiltration rate, f, (m/s) = 5.15E-03

SOIL INFILTRATION RATE IN ACCORDANCE WITH BRE DIGEST 365: 1991

Client:	Britology Limited
Job Name:	Long Lane, Earlsheaton
Job No.:	2986

Trial Pit No.	TP02
Test No.	3

Time	Elpsed Time	Depth to water from ground level	
	(min)	(m)	(mm)
11:55	0	2.25	2250
11:56	1	2.58	2580

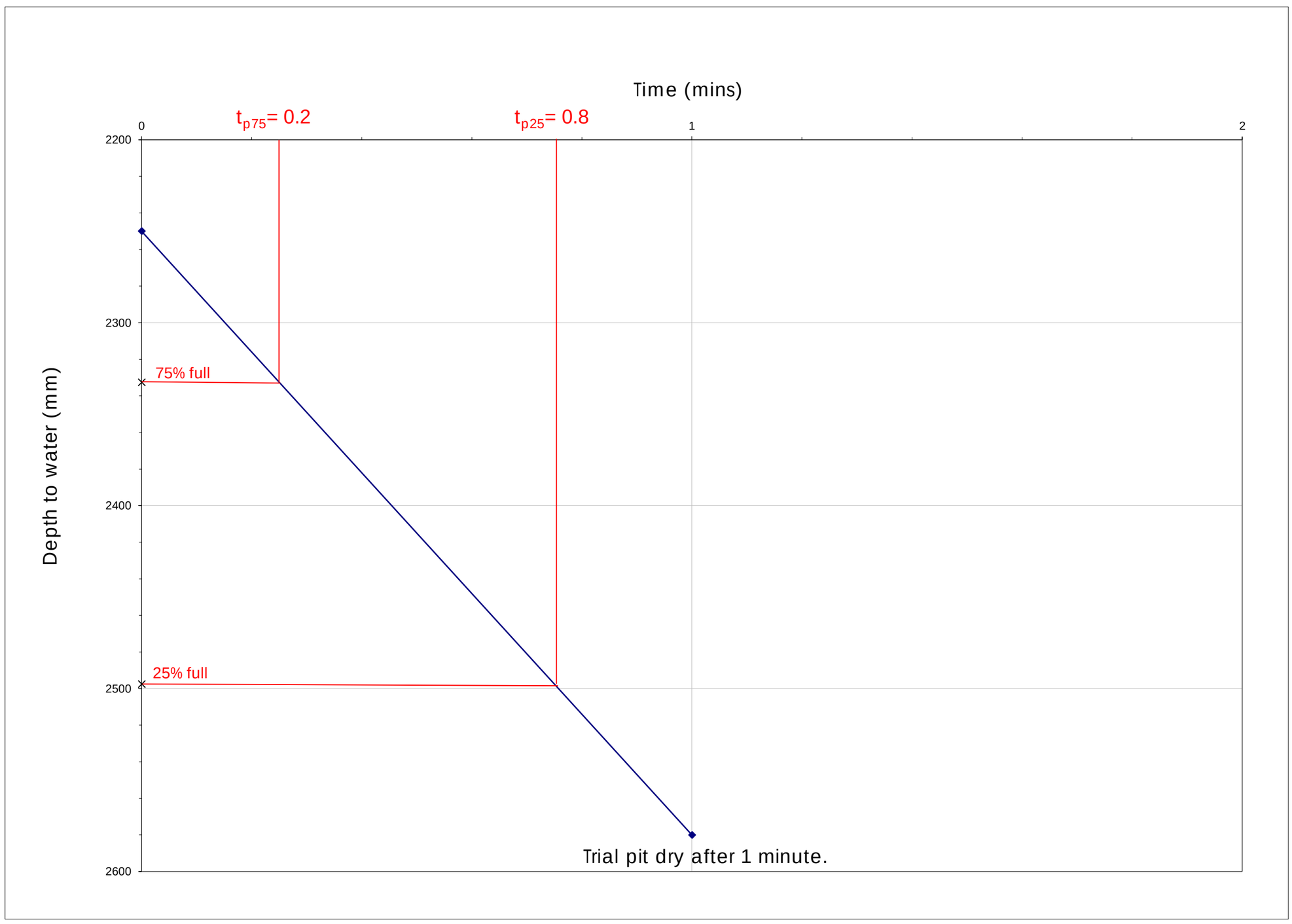
SOAKAWAY TRIAL PIT			
Dimensions		(m)	(mm)
Length	=	2.30	2300
Width	=	0.90	900
Depth	=	2.58	2580

Effective Depth (% full)		(mm)	(m)
0.25	=	2497.5	2.50
0.50	=	2415	2.42
0.75	=	2332.5	2.33

Depth at start of test (mm)	=	2250
Depth at end of test (mm)	=	2580

Base area of pit	=	2.07
a_{p50} - 50% internal surface area inc. base	=	3.126
V_{p75-25} - Volume 75 - 25%	=	0.34155

Read from the graph:		
$t_{p\ 75}$ (min)	=	0.20
$t_{p\ 25}$ (min)	=	0.80



Soil infiltration rate, f, (m/s) = 3.04E-03

SOIL INFILTRATION RATE IN ACCORDANCE WITH BRE DIGEST 365: 1991

Client:	Britology Limited
Job Name:	Long Lane, Earlsheaton
Job No.:	2986

Trial Pit No.	TP03
Test No.	1

Time	Elpsed Time	Depth to water from ground level	
	(min)	(m)	(mm)
10:04	0	2.36	2360
10:05	1	2.61	2610
10:06	2	2.72	2720
10:07	3	2.82	2820
10:08	4	2.89	2890
10:09	5	2.95	2950
10:10	6	2.97	2970

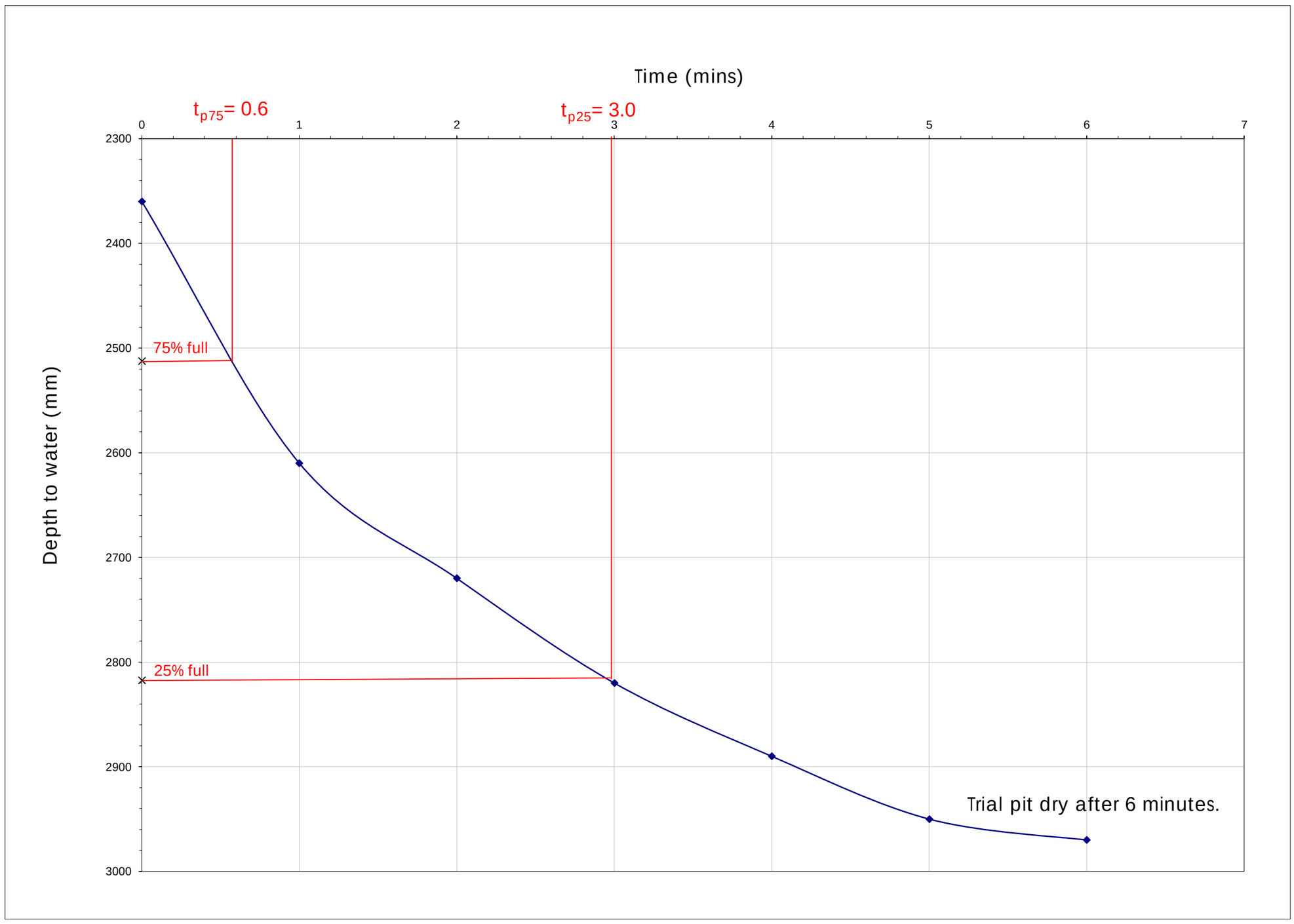
SOAKAWAY TRIAL PIT			
Dimensions		(m)	(mm)
Length	=	2.22	2220
Width	=	0.85	850
Depth	=	2.97	2970

Effective Depth (% full)		(mm)	(m)
0.25	=	2817.5	2.82
0.50	=	2665	2.67
0.75	=	2512.5	2.51

Depth at start of test (mm)	=	2360
Depth at end of test (mm)	=	2970

Base area of pit	=	1.887
a_{p50} - 50% internal surface area inc. base	=	3.7597
V_{p75-25} - Volume 75 - 25%	=	0.575535

Read from the graph:		
$t_{p\ 75}$ (min)	=	0.60
$t_{p\ 25}$ (min)	=	3.00



Soil infiltration rate, f, (m/s) = 1.06E-03

SOIL INFILTRATION RATE IN ACCORDANCE WITH BRE DIGEST 365: 1991

Client:	Britology Limited
Job Name:	Long Lane, Earlsheaton
Job No.:	2986

Trial Pit No.	TP03
Test No.	2

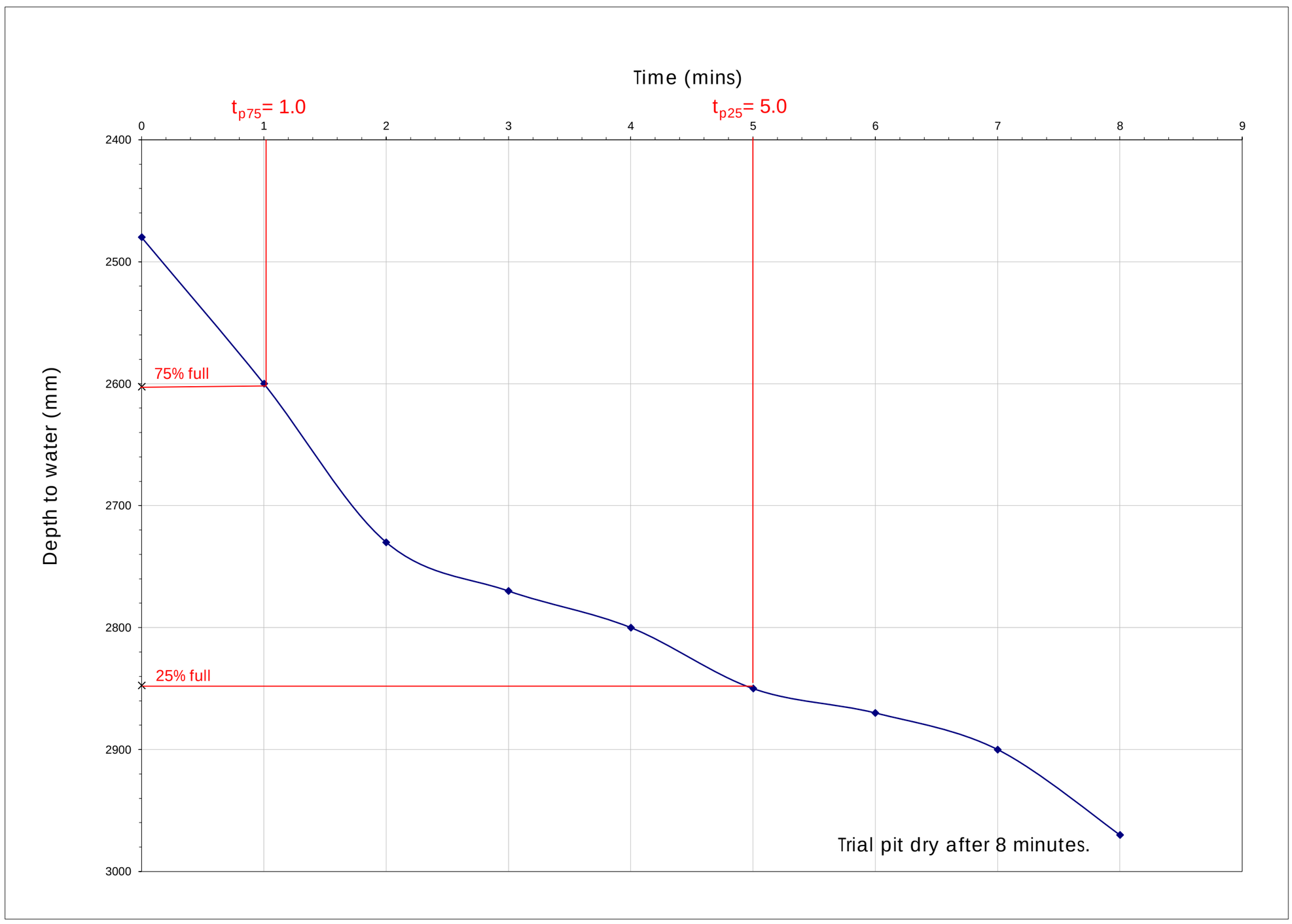
Time	Elpsed Time	Depth to water from ground level	
	(min)	(m)	(mm)
11:23	0	2.48	2480
11:24	1	2.60	2600
11:25	2	2.73	2730
11;26	3	2.77	2770
11:27	4	2.80	2800
11:28	5	2.85	2850
11:29	6	2.87	2870
11:30	7	2.90	2900
11:31	8	2.97	2970

SOAKAWAY TRIAL PIT			
Dimensions		(m)	(mm)
Length	=	2.22	2220
Width	=	0.85	850
Depth	=	2.97	2970

Effective Depth (% full)		(mm)	(m)
0.25	=	2847.5	2.85
0.50	=	2725	2.73
0.75	=	2602.5	2.60

Depth at start of test (mm)	=	2480
Depth at end of test (mm)	=	2970
Base area of pit	=	1.887
a_{p50} - 50% internal surface area inc. base	=	3.3913
V_{p75-25} - Volume 75 - 25%	=	0.462315

Read from the graph:		
$t_{p\ 75}$ (min)	=	1.00
$t_{p\ 25}$ (min)	=	5.00



Soil infiltration rate, f, (m/s) = 5.68E-04

SOIL INFILTRATION RATE IN ACCORDANCE WITH BRE DIGEST 365: 1991

Client:	Britology Limited
Job Name:	Long Lane, Earlsheaton
Job No.:	2986

Trial Pit No.	TP03
Test No.	3

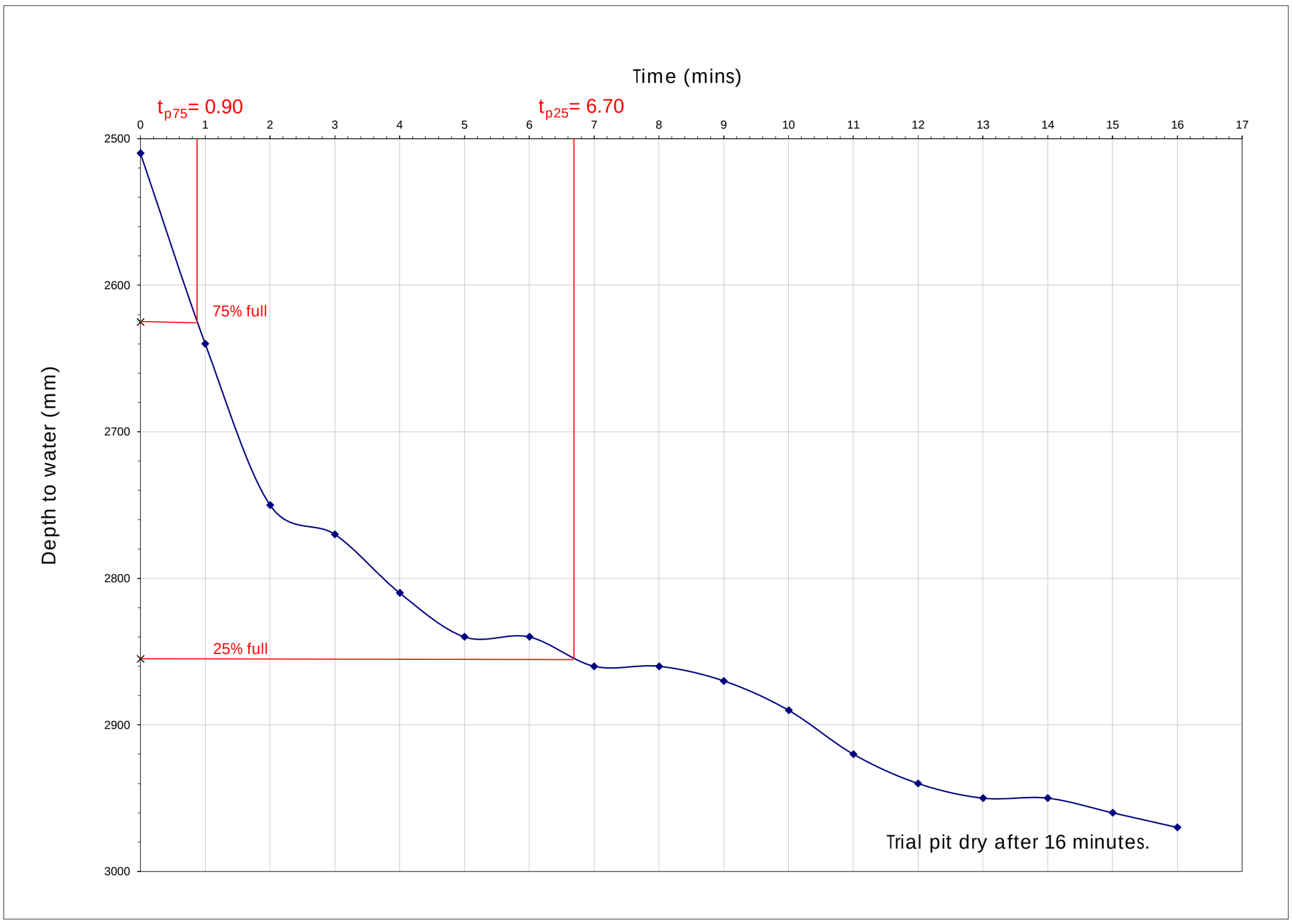
Time	Elpsed Time	Depth to water from ground level	
	(min)	(m)	(mm)
12:10	0	2.51	2510
12;11	1	2.64	2640
12:12	2	2.75	2750
12:13	3	2.77	2770
12:14	4	2.81	2810
12:15	5	2.84	2840
12:16	6	2.84	2840
12:17	7	2.86	2860
12:18	8	2.86	2860
12:19	9	2.87	2870
12:20	10	2.89	2890
12:21	11	2.92	2920
12:22	12	2.94	2940
12:23	13	2.95	2950
12:24	14	2.95	2950
12:25	15	2.96	2960
12:26	16	2.97	2970

SOAKAWAY TRIAL PIT			
Dimensions		(m)	(mm)
Length	=	2.22	2220
Width	=	0.85	850
Depth	=	2.97	2970

Effective Depth (% full)		(mm)	(m)
0.25	=	2855	2.86
0.50	=	2740	2.74
0.75	=	2625	2.63

Depth at start of test (mm)	=	2510
Depth at end of test (mm)	=	2970
Base area of pit	=	1.887
a_{p50} - 50% internal surface area inc. base	=	3.2992
V_{p75-25} - Volume 75 - 25%	=	0.43401

Read from the graph:		
$t_{p\ 75}$ (min)	=	0.90
$t_{p\ 25}$ (min)	=	6.70



Soil infiltration rate, f, (m/s) = 3.78E-04

SOIL INFILTRATION RATE IN ACCORDANCE WITH BRE DIGEST 365: 1991

Client:	Britology Limited
Job Name:	Long Lane, Earlsheaton
Job No.:	2986

Trial Pit No.	TP04
Test No.	1

Time	Elpsed Time	Depth to water from ground level	
	(min)	(m)	(mm)
10:31	0	2.04	2040
10:32	1	2.12	2120
10:33	2	2.12	2120
10:34	3	2.14	2140
10:35	4	2.14	2140
10:36	5	2.15	2150
10:41	10	2.15	2150
10:46	15	2.17	2170
10:51	20	2.18	2180
10:56	25	2.18	2180
11:01	30	2.20	2200
11:35	64	2.27	2270
12:01	90	2.30	2300
12:31	120	2.35	2350
13:01	150	2.37	2370
13:31	180	2.39	2390

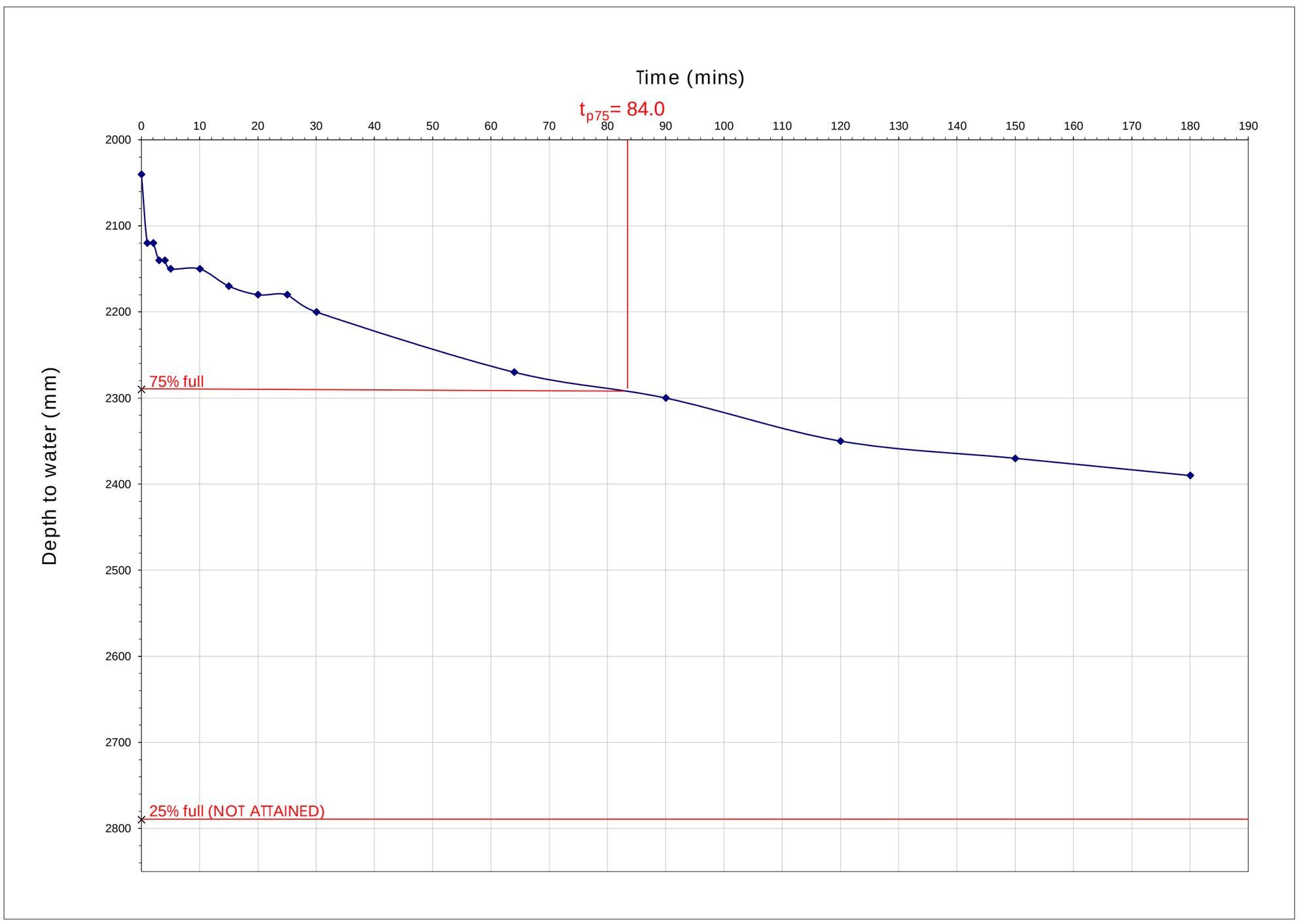
SOAKAWAY TRIAL PIT			
Dimensions		(m)	(mm)
Length	=	2.64	2640
Width	=	0.89	890
Depth	=	3.04	3040

Effective Depth (% full)		(mm)	(m)
0.25	=	2790	2.79
0.50	=	2540	2.54
0.75	=	2290	2.29

Depth at start of test (mm)	=	2040
Depth at end of test (mm)	=	2390

Base area of pit	=	2.3496
a_{p50} - 50% internal surface area inc. base	=	5.8796
V_{p75-25} - Volume 75 - 25%	=	1.1748

Read from the graph:		
$t_{p\ 75}$ (min)	=	84.00
$t_{p\ 25}$ (min)	=	N/A



Test did not attain 25% Effective depth. Unable to calculate soil infiltration rate