ST Consult
Environmental & Geotechnical

Desk Study and Site Investigation Report

Desk Studies | Risk Assessments | Site Investigations | Geotechnical | Contamination Investigations | Remediation Design and Validation

Site: Underpass at Bicester

Client: A2 Dominion

Report Date: 24th April 2014

Project Reference: JN0591

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SUMMARY

The subject site mainly comprises a small meadow field behind a Police Transport Depot, in Bicester, Oxfordshire. The area of interest also includes strips of land marginal to a railway embankment further to the east. Development proposals comprise a new spine road along the northern edge of the meadow, extending eastward toward the railway, where road underpasses will be required.

Geological records indicate the site and area to be underlain by Cornbrash (a Secondary A Aquifer), over the Forest Marble Formation, over White Limestone (Principal Aquifers). The site lies outside a Source Protection Zone (SPZ) for public drinking water.

A desk study was carried out, which showed the site and surrounding areas have mainly been open fields since the earliest mapping. Some quarrying and a lime kiln were, however, located in the northern portion of the meadow site from about the 1920's until the mid 1960's. Similarly, quarrying has been carried out in the near vicinity and a landfill is recorded on and adjacent to the meadow site.

A single phase of intrusive investigation was carried out, comprising trial pits, windowless sampler trial holes and rotary cored boreholes. A gas monitoring survey was included.

The soils encountered generally comprised TOPSOIL, over SUBSOIL, over weathered LIMESTONE, over firm to stiff CLAY and SILT, over stronger LIMESTONE.

Groundwater was recorded at levels of between 1.5-2m for most of the site, although to the east of the railway it was monitored at about 1m, with artesian surface water discharge in the north-east (BH3).

The sulphate content of both the made ground and shallow natural soil tested was found to be relatively low, although for the dataset as a whole Class DS-2 conditions prevail. The ACEC classification for the site is AC–2. Deeper construction might prudently consider more robust design classification (eg.DS-3, AC-3) for new concrete, due to the higher sulphate concentrations recorded.

For new roads, subject to preparation and proof rolling of an undisturbed natural formation, it is likely that the immediate clay/silt sub-grade will offer a CBR of 3%, improving to 5% towards the interface with the shallow rock rubbles below, but this should be confirmed, in-situ, on the prepared formation. The immediate sub-grade should also be considered frost susceptible. Natural formations are anticipated but may, alongside TP12, encounter fills, which should be grubbed out accordingly.

General comments are provided on the likely bearing afforded by the natural ground encountered and should be the subject of structural engineers review upon finalising design proposals.

In terms of the proposed development, the soils analysed were generally free from significant contamination, although some impact was reported which may have implications for the waste classification and the health and safety procedures on site. The topsoil analysed was free from significant contamination and should be stripped and stockpiled for any future residential phases proposed.

Due to the backfilled quarries in the area, which included part of the subject site, gas monitoring wells were installed to allow some preliminary gas monitoring. Although we understand that new buildings are not proposed for this part of the site, the monitoring to date has not indicated a significant gas risk, with only fairly minor levels of carbon dioxide reported.

A discovery strategy is recommended to deal with any significant contamination that comes to light during the construction works.

The site investigation was conducted and this report has been prepared for the sole internal use and reliance of A2 Dominion and their appointed engineers. This report shall not be relied upon or transferred to

SUMMARY

any other parties without the express written authorization of Southern Testing Laboratories Limited. If an 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 findings and opinions conveyed via this Site Investigation Report are based on information obtained from a variety of sources as detailed within this report, and which Southern Testing Laboratories Ltd believes are reliable. Nevertheless, Southern Testing Laboratories Ltd cannot and does not guarantee the authenticity or reliability of the information it has obtained from others.

J. Kelly PhD		C. Nolan BSc MSc FGS
(Countersigned)		(Signed)

For and on behalf of Southern Testing Laboratories Limited

STL: JN0591
24 April 2014

TABLE OF CONTENTS

A INTRODUCTION

1 Authority

Our authority for carrying out this work was given in writing by Stephen Jury, Technical Director (South East) of A2Dominion New Homes dated 6th March 2014.

2 Location

The subject site mainly comprises a small meadow field behind a Police Transport Depot, in Bicester, Oxfordshire. The area of interest also includes strips of land marginal to a railway embankment further to the east. Development proposals comprise a new spine road along the northern edge of the meadow, extending eastward toward the railway, where road underpasses will be required.

The site is located on the north-western edge of Bicester, at the junction of Bucknell Road and Howes Lane (the A4095). The subject site mainly comprises a small meadow field behind a Police Transport Depot, and upon which Environmental Database searches have been centred. The National Grid Reference for the centre of the meadow is SP 570 239. The investigation also included some limited work in neighbouring fields either side of an embanked railway line – to the east of the railway line is Farmer Tim's field, whilst to the west is Farmer Derek's field

3 Proposed Construction

It is proposed to construct a new road, with current layouts suggesting that the line of this skirts the northern boundary of the meadow and beyond, extending under a railway line to the east. A pedestrian underpass is proposed under the railway line to the north, and a vehicular underpass is proposed directly to the east.

For the purposes of the contamination risk assessment, the proposed development land use is classified as commercial with plant uptake (CLEA model[1]). The gas sensitivity of the site is therefore rated as low (CIRIA C665[2]).

4 Object

This is a Phase 1 Desk Study and Walkover and Phase II geotechnical and contamination (risk estimation and evaluation) investigation (Tier 1).

The object of the investigation was to assess foundation bearing conditions and other soil parameters relevant to the proposed development, and to assess the likely nature and extent of soil, groundwater and soil gas contamination on the site.

5 Scope

This report presents our desk study findings, exploratory hole logs and test results and our interpretation of these data. As with any site there may be differences in soil conditions between exploratory hole positions. Fieldworks scope is in general accordance with that suggested by the clients Engineer.

This report is not an engineering design and the figures and calculations contained in the report should be used by the Engineer, taking note that variations will apply, according to variations in design loading, in techniques used, and in site conditions. Our figures therefore should not supersede the Engineer's design.

The findings and opinions conveyed via this Site Investigation Report are based on information obtained

[1] Environment Agency Publication SC050021/SR3 'Updated technical background to the CLEA Model' (2009).
[2] CIRIA C665 (2006) Assessing risks posed by hazardous ground gases to buildings.

from a variety of sources as detailed within this report, and which Southern Testing Laboratories Limited believes are reliable. Nevertheless, Southern Testing Laboratories Limited cannot and does not guarantee the authenticity or reliability of the information it has obtained from others.

The site investigation was conducted and this report has been prepared for the sole internal use and reliance of A2 Dominion and their appointed engineers Hyder Consulting. This report shall not be relied upon or transferred to any other parties without the express written authorization of Southern Testing Laboratories Limited. If an 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 recommendations contained in this report may not be appropriate to alternative development schemes.

B DESK STUDY & WALKOVER SURVEY

6 Desk Study

A desk study has been carried out. Reference has been made to the following information sources.

- Geological Maps
- Hydrogeological/Groundwater Vulnerability maps
- Aerial Photographs
- Historical Ordnance Survey Maps
- Environmental Databases
- Environment Agency website
- BRE Radon Atlas[3]

The environmental databases search report compiled for this desk study contains site-specific environmental data drawn from datasets that comprise publicly available information together, with data from third parties, some of which is under review. Accordingly, Southern Testing Laboratories Limited does not warrant its accuracy, reliability or completeness.

The full report is included in Appendix D, a summary of the salient features is included in the following sections of this report.

6.1 Geology

The British Geological Survey Mapping (1:50,000 map No. 219 Buckingham) indicates that the site geology comprises Cornbrash, over Forest Marble Formation, over White Limestone. There are no superficial deposits mapped.

6.1.1 Solid Geology

Cornbrash	**Cornbrash** is so called as it gives rise to a stony or 'brashy' soil that is favourable for growing corn, with the formation consisting of strong shelly limestone. As it is thin, the outcrop is narrow, although extensive areas are found near Peterborough, where it is highly weathered and relatively easy to excavate near the surface. Below a depth of about 2m, hard massive bluish grey limestone is common and hard rock excavation techniques are required. The bearing capacity is usually controlled by the strength of the underlying Blisworth Clay.

[3] BR 211 (2007) 'Radon: guidance on protective measures for new buildings'

Forest Marble Formation	**The Forest Marble Formation** comprises silicate-mudstone, greenish grey, variably calcareous and, in the south, notably sandy, with lenticular typically cross-bedded limestone units that form banks and channel-fills, especially in lower part. A variety of limestone types occur, of which grey, weathering brown and flaggy, variably sandy medium to coarsely bioclastic grainstone or less commonly packstone predominates, especially at the base, which is increasingly ooidal north from Bath (termed the Acton Turville Beds from Biddestone to Didmarton). Other types include fissile sandy limestone, grading to calcareous sandstone, and oyster-limestone. South of the Mendip Hills, a silici-muddy, fossiliferous lime-mudstone (Boueti Bed) lies at the base. Bivalves and brachiopods dominate the fauna, and lignite debris and fish scales and teeth are common, but infauna and signs of bioturbation are rare. The formation consists of interbedded mudstone and limestone in the Weald and English Channel basins, but in St George's Channel Basin it comprises rhythmically bedded mudstone, siltstone and fine sandstone.
White Limestone	**White Limestone** comprises a pale grey to off-white or yellowish limestone, peloidal wackestone and packstone with subordinate ooidal and shell fragmental grainstones, recrystallised limestone and/or hardgrounds at some levels with rare sandy limestone, argillaceous limestone, marl and mudstone or clay.

6.2 Hydrology and Hydrogeology

The groundwater within the chalk is thought to lie at around 25m bgl on the basis of hydro-geological mapping. Data from the Environment Agency and other information relating to controlled waters is summarised below.

Data		Remarks	Possible Hazard to/from Site Y/N
Groundwater Vulnerability	Bedrock	Cornbrash – Secondary (A) Aquifer Forest Marble/White Limestone – Principal Aquifer	Yes
Abstractions (groundwater)		None reported within 500m of site.	N/A
Source Protection Zones		The site does not lie within a Source Protection Zone.	No
Surface Water Features		The nearest surface water course listed is a field drain located 101m to the south.	No
Flood Risk		According to the Environment Agency website (April 2014), the site lies outside a flood risk area. EA surface water flood maps infer a low risk alongside the western extremities of the railway embankment, near BH1 & 2.	Yes
Discharge Consents		593m to the north-east – for a domestic property discharging trade effluent into a freshwater stream.	No

6.3 Historical Map Search

Copies of historical Ordnance Survey maps dating back to 1881 are appended, with a summary of the salient features given below.

The first map of the area showed the site as part of a larger agricultural field associated with Gowell Farm. The site was bound to the north by a road heading north-west and along the southern boundary was the present day Howes Lane (A4095). Approximately 100m to the north-east of site, a quarry was mapped. The surrounding area was generally rural.

There were no changes mapped on site or in the close vicinity until 1922, although, at the turn of the century, there were further quarries mapped 1km away to the south-east.

In 1922, in the northern portion of the subject site, a quarry was mapped, along with a lime kiln. Along the north eastern boundary was another quarry and associated workings. The site was still located within the larger field; approximately 100m to the east, there was a water pumping station and tower shown. Approximately100m to the north and north-east was a railway, whilst the previously mentioned small quarry had moved slightly.

The quarrying, both on and off-site, and the limekiln were shown until 1966. By 1967 the quarrying was no longer shown and site is was open land again. Housing developments originally dating from the 1930's, located over 500m away to the south-east, expanded rapidly in the 1960s.

In the 1970s, the site itself was unchanged although Bicester had expanded rapidly and extensively. The pumping station, 100m to the east of site, also had a depot at this time.

There was no change to the site or the local area until 1995, when the large police headquarters was constructed on the eastern boundary. This construction gave the site its distinctive shape.

6.4 Environmental Databases

	Distance (m)	Direction	Details	Possible Hazard to site
Contaminated Land Register Entries and Notices	--	--	None recorded within 1km of the site.	N/A
Contemporary Trade Entries (4 within 250m)	45	SE	Active – medical instruments manufactures.	Yes
	80	NE	Active – Window frame manufacturers	No
	134	E	Inactive – Pharmaceutical manufacturers.	No
	140	E	Active – Toys and sporting good manufacturers.	No
Current and Historical Landfills	0	--	Listed on site – Gowell Farm depositing inert, commercial and household waste, with reference also made to ash, glass, brick and pottery.	Yes
Waste management, treatment	--	--	None recorded within 1.0km of site.	N/A

	Distance (m)	Direction	Details	Possible Hazard to site
or disposal site				
Fuel Sites	--	--	None recorded within 1km of the site.	N/A
Pollution Incidents to controlled waters	--	--	None recorded within 650m of the site.	N/A
IPPC Authorisations	--	--	None recorded within 1.0km of site.	N/A
LA PPC's	--	--	None recorded within 1.0km of site.	N/A
Hazardous Substances Consents	--	--	None recorded within 1km of the site.	N/A

6.5 Geological Hazards and Mining Activities

Data from various sources relating to potential geological hazards at the site are summarized below. The Hazard Potentials listed for the BGS data are as presented in the Envirocheck report, derived from various generic BGS sources, which are not considered site-specific. It is important that this information is considered in context of the actual site topography, ground conditions encountered during this and any future investigation, and the development proposals.

Data Source	Hazard	Hazard Potential to Site	Remarks
BGS	Potential for Collapsible Ground Stability Hazard	Yes	Very Low
	Potential for Compressible Ground Stability Hazard	No	--
	Potential for Ground Dissolution Stability Hazard	Yes	Very Low*
	Potential for Landslide Ground Stability Hazard	Yes	Very Low
	Potential for Running Sand Ground Stability Hazard	No	--
	Potential for Swelling or Shrinking Clay Ground Stability Hazard	No	--
	Coal Mining Affected Area	No	--
	Natural Cavities	No	--
	Man-made Mining Cavities	No	--
	Radon Risk	No – a lower probability area.	--
	Mineral Sites	Opencast limestone mine 26m to the	High Risk

Data Source	Hazard	Hazard Potential to Site	Remarks
		north-east of the site on Gowell Farm.	
ARUP	Mining Instability	No	--
CSS/KURG*8	Underground openings	No	--

**Chalk and limestone terrains will always maintain a potential residual risk of stability related to ground dissolution.*

***Chelsea Spelaeological Society/ Kent Underground Research Group*

7 Walkover Survey

A walkover survey was carried out on 4th March 2014, at which time the weather was warm and dry. The rainfall in the Midlands for January, February and March was variable with 209, 198 & 77% of the normal for that time of year, respectively. The farmers that own the land were in attendance, advising on the location and routes of known services, access issues etc. General photos showing the site condition at the time of the fieldwork are included below.

7.1 General Description

The Police meadow is relatively flat with a very slight fall down to the north. Palisade fencing bounds the police compound in which a fuel dispensing pump (and presumably an UFST) was noted; the remaining boundaries are post and wire fencing in very poor condition. Farmer Derek's field, located between the police compound and the west of the rail embankment, is a horse paddock; again, this is relatively flat but with low points at the north-east and south-east corners. Farmer Tim's field is under brassica crop and also has low points to the north-west and south-west. The low points in the south of each field are believed to have been created by former shallow quarrying.

Plate 1: The north-west corner of Farmer Derek's field from TP2.

Plate 2: The view to the north from TP5 in Farmer Tim's field.

The site boundaries include sporadic and poorly maintained hedgerows, with some self seeded deciduous tree saplings.

7.2 Buildings and Land Use on Site and Nearby

There are no structures in the police meadow nor in the other two fields, except for two telecom masts (and compounds) to the east and the rail embankment, estimated to be approximately 2-4m high, electrified with 45 degree side batters. The embankment has scrub vegetation and animal burrows.

As discussed, the adjacent police compound includes a small fuel dispensing canopy and the main building appears to be a steel clad portal frame-type structure of approximately 8m eaves height. An electricity substation is incorporated within the police workshop structure.

Plate 3: The meadow sub-grade arisings from TP16.

Plate 4: The Police Meadow.

C PRELIMINARY CONCEPTUAL MODEL

8 Introduction

In the context of this report, the conceptual model summarises the potential pollutant linkages identified for the site and forms the basis of the risk assessment. The preliminary model comprises the potential sources of contamination, receptors that could be harmed and exposure pathways identified from the desk study and walkover survey. These potential linkages form the basis upon which the investigation is designed and reported.

9 Potential Sources of Contamination

The potential sources can therefore be summarised as below.

9.1 On Site Sources

Source	Potential Contaminants
Lime Kiln	Heavy metals, PAHs, asbestos, petroleum hydrocarbons.
Registered Landfill	Land gas, heavy metals, PAH's, petroleum hydrocarbons, land gas.

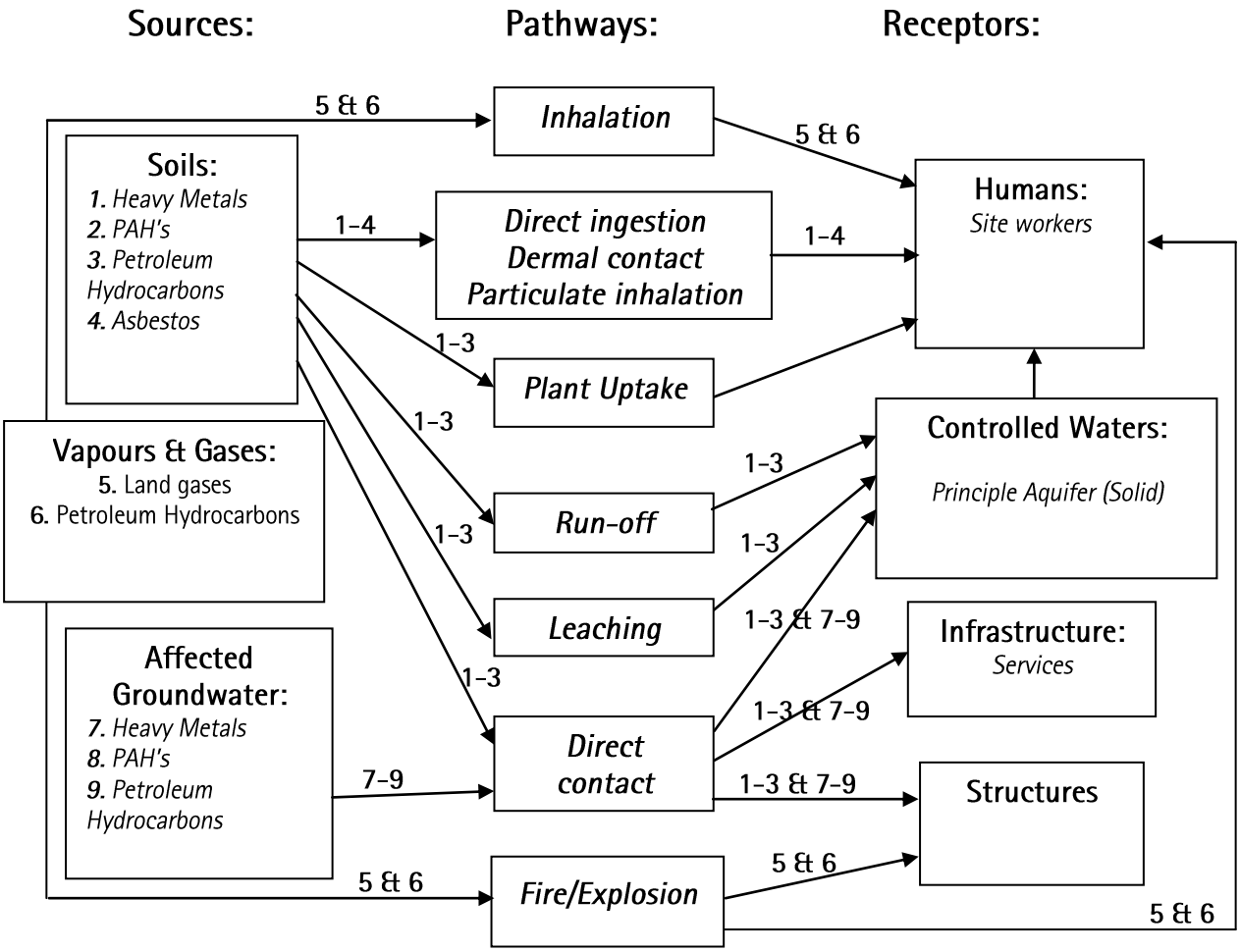
9.2 Off Site Sources

Source	Potential Contaminants
Historic Quarry/Landfill	Land gas, heavy metals, PAH's, petroleum hydrocarbons, land gas.
Police Compound, substation & Fuel Dispensing	Heavy metals, PAHs, asbestos, petroleum hydrocarbons, PCB's.

Historically, quarrying is inferred, from the historic maps, in the south of both of the farmer's fields and in the east of the police meadow. There is very little information provided for the registered landfill, which occupies the whole meadow site, within the data entries and historic mapping infers a more likely association with the backfilling of the Limekiln pit, limited to the eastern part of the meadow.

9.3 Pollutant Linkages and Model Summary

The following diagram shows the potential pollutant linkages identified for the site and summarises the preliminary conceptual model:



// denotes potential pollutant linkage not complete

10 Conclusions and Recommendations

The conceptual model is based upon both the historic and current uses of the site. Each of the pathways reviewed above is possibly significant and should be assessed by an intrusive investigation, although at this stage, the overall risk of contamination is likely to below low, certainly in the context of the proposed development (a road and underpass are to be constructed so, other than the site workers, there is no long-term potential receptor).

D SITE INVESTIGATION

11 Method

The outline scope for the investigation was devised by the client's engineer, and the strategy adopted for the intrusive investigation comprised a series a trial pits, boreholes, windowless sampler holes and CBR's. Gas and groundwater monitoring standpipes were installed in the majority of boreholes and windowless sampler holes, with subsequent monitoring undertaken.

12 Weather Conditions

The fieldwork was carried out on the 17th-25th March 2014, at which time the weather was generally bright and dry.

13 Soils as Found

The soils encountered are described in detail on the attached exploratory hole logs (Appendix A). For convenience, the general natural substrate sequence is summarised below.

Depth	Soil Type	Description
g.l-0.12/0.35m	Topsoil	Brown friable silty fine to medium sand with occasional sub-angular limestone gravel.
-0.3/0.47m	Subsoil	Loose to medium dense clayey silty fine to medium SAND with occasional limestone gravel; occasionally a clay / sand.
-0.4/1.25m	Flaggy Cobbles	Weathered LIMESTONE as bedded flaggy cobbles with buff sandy partings. Becoming stronger / intact rock. Occasionally absent.
-1.0/2.3m	Clays & Silts	Firm to stiff beige orange brown silty CLAYS with fine white calcareous gravels. Becoming buff silty sands with sandstone lithorelicts.
-6.7/9.4m	Limestone	Moderately strong thin to medium bedded shelly LIMESTONE with beds of beds of calcareous stiff silts / lithorelict siltstone. Occasional pyritic charcoal inclusions to base.
15m+	Limestone	Moderately strong medium and thin bedded paler grey shelly LIMESTONE with rare thin calcareous siltstone beds.

13.1 Made Ground

Of the 29 trial holes undertaken, six included made ground sequences.TP16 appeared to be an over-deepened topsoil subsoil sequence, whilst TP14 had the appearance of an isolated pocket of recent construction fill (likely associated with the adjacent police compound).

Trial holes TP12, TP15, WLS3 & 4 were located within the backfilled limekiln pit and included clinker/ash based materials. The clinker based fill included black and brown mottling and abundant glass sharps, but no other visual or olfactory evidence of significant contamination. The historic quarrying activity in the vicinity of TP4 & 5 does not appear to have been backfilled, rather simply left as lower lying ground.

E DISCUSSION OF GEOTECHNICAL TEST RESULTS AND RECOMMENDATIONS

14 Swelling and Shrinkage

The immediate sub-grades, being a mixed clay / silt / sand, were subject to laboratory analysis for both plasticity indices (2 samples) and gradings (4 samples). The modified Plasticity Indices (PI), after removing the granular fraction, ranged from 16-33%. The particle size distributions tests confirmed fine to medium sand sub-grades with some coarse gravel and a significant fines fraction, ranging from 28-48%.

Deeper sequences included, at times, calcareous clay and a then a silty sand before 'rockhead' was encountered. The calcareous clays analysed returned PI's of 33 & 45% - medium to high shrinkability, and the deeper sands were more uniformly graded, but still had a significant fines fraction (16-37%).

15 Groundwater Levels and Soakaways

The site lies outside any Source Protection Zone (SPZ)for public drinking water. The groundwater within the natural and fill material generally stabilises at around 1.5-2.0m (as monitored in the standpipes). The exception is in the eastern field, where a standing water level of around 1.0m was recorded in the south-east (in BH4) and, following a fissure strike at 4.65m, sustained artesian flow was observed in BH3. This borehole was abandoned and back grouted with a bentonite seal.

An assessment of the soakage potential did not form part of the requested scope of works. Whilst higher level weathered limestone bands infer some potential for fracture flow dissipation of waters, storage capacity will always be limited by the high groundwater table. Soakaway schemes should be the subject of Environment Agency review and agreement, particularly in light of the sensitivity of the aquifer at depth.

16 Sulphates and Acidity

Water soluble sulphate and soil pH have been analysed in 23 samples of the sub-soils from across site, at various depths, with material including topsoil, made ground and natural soil. The samples recorded pH values in the range of 6.8-8.2, near neutral to slightly alkaline. All near surface water soluble sulphate results were <500mg/l, although the deeper samples included concentrations of up to 2300mg/l. The rounded mean of the highest 20% of results is 800mg/l.

Groundwater samples were recovered from each of the seven groundwater monitoring wells, and recorded levels of soluble sulphate of <400mg/g.

Statistical review infers that the appropriate design sulphate class is therefore DS-2 and, given the presence of groundwater, the ACEC site classification is AC-2. At times, however, higher sulphate concentrations were recorded in some of the deeper samples analysed and, on several occasions, the rotary boreholes recorded the presence of pyrite within charcoal fragments at around 7m depth. Deeper construction might therefore prudently consider more robust design classification (eg.DS-3, AC-3) for new concrete.

17 Foundations and Bearing Capacity

Structural information and foundation design requirements have not been made available. On the basis of the investigation to date, however, higher level reinforced pad, strip or trench fill foundations are likely to be feasible, where firm to stiff clays or rubbley limestone is encountered close to the surface. High level foundations, with formations on competent natural materials, may consider an allowable bearing capacity of 125kPa. No structures appear to have been detailed over the Limekiln Pit fill mass, although the spine road skirting to the north may just clip position TP12. At this specific location, 1.3m of loose fill was encountered and local grub out / foundation extra-dig would be required.

From around 2.5m depth, stronger and less weathered limestone bands are encountered which may afford an increased allowable bearing capacity. As discussed, the inverts of the proposed underpasses are not known at this time, although it is conceivable that heavily loaded railway bridge abutment foundations may need to be extended down to the more 'massive' limestone (with fewer and thinner mudstone bands) encountered from about 7m depth.

Groundwater control may play a significant part in any substructure construction, and rapid inflows should be anticipated. There may also be a 'tanking' requirement for any structure below 1m invert.

Whilst the details of the proposed construction procedure are not available, the creation of the underpasses is likely to involve an element of earth retaining. Whilst direct investigation of the rail embankment did not form part of these works, a brief inspection from outside the fence line infers it to be about 3.5m high, with a simple earth batter at around 45 degrees. Although there were no outwardly obvious signs of slope face instability, rabbit burrows suggest that it is formed of local buff silts sands and limestone gravels. Natural formations are likely to outcrop along the bottom of any underpass excavation. The following parameters may be considered for the existing soils on site, and bearing conditions may be assumed as above. It should also be noted that the construction work proposed is likely to alter the groundwater regime.

Soil Type	Angle of Friction (ϕ')	Bulk Density (γ_b)	Cohesion (c')
Embankment Fill	35°	19kN/m^3	0
Clays & Gravels	25°	20kN/m^3	0
Banded Rock	42°	27kN/m^3	0

18 Excavation and Trenching

We understand that there are two underpasses proposed, and it is also conceivable that spine roads may include some relatively deep sewer infrastructure runs. The likely depth of any excavation is not known, but may require deep open excavation techniques. Both the boreholes and trial pits infer relatively shallow limestone.

Three Uniaxial Compression Tests (UCS) were undertaken on the limestone and calcareous mudstone from BH1 at 5.0m, BH2 at 14.0-14.30m & BH4 at 8.50-8.80m. The reported strengths were 24.1MPa, 14.2 MPa and 16.0MPa, respectively. Point load tests were also undertaken on four samples of the limestone and mudstone from BH3 at 4.30-4.50m, BH2 at 9.20-9.40m, BH1 at 13.50m and BH4 at 15.0m. The two limestone samples tested from BH2 &t3 reported a strength of 5.01 & 6.09MPa, while the two mudstone samples tested had a strength of 0.48 and 0.68MPa, respectively.

Stronger bands of limestone /calcareous mudstone rock may well be encountered during construction. These results, together with the borehole logs, should be forwarded to potential contractors to allow determination of the best method of excavation.

Significant near surface groundwater was encountered and control measures will be required. In made ground sequences, or in silt sands and mudstones between the limestone rock bands, more significant instability should be anticipated, with closed side support necessary and shuttering a possibility. Accordingly, close attention should be paid to the design of lateral support to the excavations, with consideration given to dewatering techniques, if the deep sewer is perused. Additionally, side support will be required in all excavations where access is required, in accordance with HSE regulations. Given the presence of the limestone rock bands, allowances will be required for rock excavation / breaking methods, and material quantities factored for side spalling and overbreak.

19 Estate Road Construction

On the basis of the plasticity indices of the clay sub-grades tested, CBR values in the region of 3% could be estimated assuming average to good construction conditions. Sporadically absent, the subsoil was usually underlain by limestone rock rubble. Five Landrover mounted CBR's and nine DCP CBR probe tests were undertaken at the location of each of the trial pits, from ground level down to 1m. Towards the lower half of the probes, below the topsoil, subsoil CBR results ranged from about 2.9%+, generally increasing to 5%+ towards the base of the probes on the rock rubble. Landrover CBR's targeted the subsoil at around 400mm and inferred CBR's of 8-9%.

The CBR test undertaken in TP12 was on made ground and, accordingly, reported poorer results.

Subject to preparation and proof rolling of an undisturbed natural formation, it is likely that the immediate clay/silt sub-grade will offer a CBR of 3%, improving to 5% towards the interface with the shallow rock rubbles below, but this should be confirmed, in-situ, on the prepared formation. On the basis of the plasticity indices and particle size distributions reported, the sub-grades should be considered potentially frost susceptible, and with siltier units also noted on site, likely to be prone to deterioration on exposure to the elements and when tracked.

The desk study and fieldwork have identified the following potentially significant features:-

- Springs
- Strong banded rock substrate
- Railway infrastructure
- Trees and hedge lines
- Existing services
- Landfill materials in TP12

Each of the above features could have design/construction implications for the carriageway on a localised scale. Springs remain a potential in the east of the site.

The variable geological sequence and service runs might each result in a rapid change of sub-grade character and condition. Such features will obviously be addressed by close scrutiny of the prepared formations and through proof rolling, but might prudently also be mitigated by inclusion of geo-grid reinforcement in the carriageway.

The mature hedge line crossing the carriageway, at the eastern edge of the police meadow, will have desiccated the sub-grades locally, potentially significantly. Consideration could again be given to a nominal amount of extra-dig of the sub-grades in this location, both to mitigate heave potential and allow more robust carriageway construction.

F LAND QUALITY

20 Analytical Framework

There is no single methodology that covers all the various aspects of the assessment of potentially contaminated land and groundwater. Therefore, the analytical framework adopted for this investigation is made up of a number of procedures, which are outlined below. All of these are based on a Risk Assessment methodology centred on the identification and analysis of Source–Pathway–Receptor linkages.

The CLEA model[4] provides a methodology for quantitative assessment of the long term risks posed to human health by exposure to contaminated soils. Toxicological data is used to calculate a Soil Guideline Value (SGV) for an individual contaminant, based on the proposed site use; these represent minimal risk concentrations and may be used as screening values.

The CLEA model and associated guidance was updated through 2009. A new model has been released and new TOX and SGV reports are to be published. New SGVs are used where appropriate.

In the absence of any published SGVs for certain substances, Southern Testing have derived Tier 1 screening values for initial assessment of the soil, based on available current UK guidance including the LQM/CIEH[5] and CL: AIRE[6] generic assessment criteria. Site-specific assessments are undertaken wherever possible and/or applicable.

CLEA requires a statistical treatment of the test results to take into account the normal variations in concentration of potential contaminants in the soil and allow comparisons to be made with published guidance.

21 Site Investigation – Soil

The number of trial holes was based on the original scoping brief, and included the police meadow which is designated as a landfill on regulator databases. The proposed road line is, however, just outside this area for the most part, running along the meadow's northern boundary.

The potential for contamination by heavy metals, PAHs, asbestos, TPH, VOC's and hydrocarbons was identified in the preliminary conceptual model and, therefore, the following tests were selected.

Test Suite	Number of Samples	Soil Tested
STL Key Contaminant Suite (heavy metals, PAH's and asbestos)	7 4 2 2	Topsoil Made Ground Capping Natural
Petroleum Hydrocarbons	3	Made Ground/Natural

Although PCB's were discussed as a potential contaminant in earlier sections, in association with the off-site sub-station, the structure is remote from the subject site boundary and not included in the conceptual model. Although the fuel dispensing area is also remote from the subject area, petroleum hydrocarbons are more mobile contaminants than PCB's, so some TPH analysis formed part of the analytical strategy.

[4] Environment Agency Publication SC050021/SR3 'Updated technical background to the CLEA Model' (2009).
[5] The LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment 2nd Edn. (2009).
[6] The EIC/AGS/CL:AIRE Soil Generic Assessment Criteria for Human Health Risk Assessment (2009).

The test results are presented in full in Appendix C. A summary and discussion of the significance of the results and identified contamination sources is given below.

21.1 General Contaminants

The results of the key contaminant tests have been analysed in accordance with the CLEA methodology. The samples have been grouped into four populations comprising topsoil, made ground, capping (to the landfill) and natural soil. Given the finite amount of analysis undertaken statistics were only applicable to the topsoil and made ground populations. For each parameter in each population, the sample mean is calculated and compared to a Tier 1 screening value (in this case, for a commercial land-use). If the sample mean exceeds the screening value, the soil may be regarded as contaminated and further assessment may be required. If neither the sample mean nor any single value exceeds the screening value, the soil may be regarded as not contaminated, though further confirmatory assessment may still be required. Where any single parameter value exceeds the screening value but the sample mean does not, further statistical analysis may be applied to that parameter if the available data is suitable. Such analysis would include an assessment of the normality of the distribution of the data, consideration of the presence of outliers, and the calculation of a UCL estimate of the mean.

Summary data is presented in the tables below and the laboratory analysis is included in Appendix C.

Soil Type: TOPSOIL

Contaminants	Units	No of Samples Tested	Range	Sample Mean	Tier 1 Screening Value
Arsenic (As)	mg/kg	7	15-21	18	640
Cadmium (Cd)	mg/kg	7	<0.2-0.3	0.21	230
Total Chromium (Cr)	mg/kg	7	16-33	24	8840
Hexavalent Chromium (CrVI)	mg/kg	7			35
Lead (Pb)	mg/kg	7	36-66	47	750
Mercury (Hg)	mg/kg	7	<0.3	0.30	73
Selenium (Se)	mg/kg	7	<1	1.0	13000
Nickel (Ni)	mg/kg	7	18-26	23	1800
Copper (Cu)	mg/kg	7	23-39	30	71500
Zinc (Zn)	mg/kg	7	51-89	69	665000
Phenol	mg/kg	7	<2	2.0	775
Benzo[a]pyrene	mg/kg	7	<0.1-0.26	0.12	14
Total Cyanide (CN)	mg/kg	7	<1	1.0	/
Acidity (pH value)	Units	7	6.8-7.8	7.5	/
Soil Organic Matter	%	7	6.9-12.0	9.1	/

Relative to the Tier 1 assessment criteria, the topsoil samples tested were generally free from significant contamination. Given that, in general, only road/underpass construction is proposed for this part of the site, commercial screening values have been applied.

However, the results do not exceed the stringent Tier 1 screening values for residential soils, are generally indicative of background concentrations and concur with the observations made and the site history. As part of the construction works, it would be prudent to strip and stockpile the topsoil at an early stage, to prevent damage, for potential use in gardens and soft landscaping of the residential phases.

Soil Type: Made Ground

Contaminants	Units	No of Samples Tested	Range	Sample Mean	Tier 1 Screening Value
Arsenic (As)	mg/kg	4	9.5-68	32	640
Cadmium (Cd)	mg/kg	4	<0.2-3.4	1.3	230
Total Chromium (Cr)	mg/kg	4	8.7-42	25	8840
Hexavalent Chromium (CrVI)	mg/kg	4			35
Lead (Pb)	mg/kg	4	23-**780**	339	750
Mercury (Hg)	mg/kg	4	<0.3	1.2	73
Selenium (Se)	mg/kg	4	<1	1.0	13000
Nickel (Ni)	mg/kg	4	13-97	49	1800
Copper (Cu)	mg/kg	4	33-1700	512	71500
Zinc (Zn)	mg/kg	4	46-2400	874	665000
Phenol	mg/kg	4	<2	2.0	775
Benzo[a]pyrene	mg/kg	4	<0.1-7	2.0	14
Total Cyanide (CN)	mg/kg	4	<1-1	1.0	/
Acidity (pH value)	Units	4	7.4-7.6	7.5	/
Soil Organic Matter	%	4	4.7-27	20	/

Relative to the Tier 1 assessment criteria, the made samples tested were generally free from significant contamination. Although not elevated relative to the Tier 1 screening values, occasional elevated concentrations of benzo[a]pyrene, lead, zinc and copper were reported in some of the fill samples tested (relative to background concentrations and screening values for residential soils, for example), which concurs with the observations made during the investigation; material such as ash and clinker were recorded, which are commonly impacted with a range of heavy metals and PAH's. Although not considered significant in terms of the development works proposed, the results may have implications for the waste classification should this material be excavated and removed from site during the construction.

Soil Type: CAPPING

Contaminants	Units	No of Samples Tested	Range	Sample Mean	Tier 1 Screening Value
Arsenic (As)	mg/kg	2	17-23	20	640
Cadmium (Cd)	mg/kg	2	<0.2-<0.2	0.2	230
Total Chromium (Cr)	mg/kg	2	15-20	18	8840

Hexavalent Chromium (CrVI)	mg/kg	2			35
Lead (Pb)	mg/kg	2	19-34	27	750
Mercury (Hg)	mg/kg	2	<0.3-<0.3	0.3	73
Selenium (Se)	mg/kg	2	<1.0-<1.0	1.0	13000
Nickel (Ni)	mg/kg	2	18-29	24	1800
Copper (Cu)	mg/kg	2	18-25	22	71500
Zinc (Zn)	mg/kg	2	43-61	52	665000
Phenol	mg/kg	2	<2.0	2.0	775
Benzo[a]pyrene	mg/kg	2	<0.1	0.1	14
Total Cyanide (CN)	mg/kg	2	<1	1.0	/
Acidity (pH value)	Units	2	7.9-8.2	8.1	/
Soil Organic Matter	%	2	5.9-8.0	7.0	/

For the trial holes excavated over the old lime kiln pit, a variable depth of cover or 'capping was observed in each case. This either comprised a shallow depth of topsoil or a more significant covering of topsoil and subsoil. Two samples of the subsoil 'capping' were analysed from WS3 and 4, both of which were free from significant contamination. This concurs with the visual and olfactory evidence.

Soil Type: Natural Soil

Contaminants	Units	No of Samples Tested	Range	Sample Mean	Tier 1 Screening Value
Arsenic (As)	mg/kg	2	7.2-23	15	640
Cadmium (Cd)	mg/kg	2	<0.2-<0.2	0.2	230
Total Chromium (Cr)	mg/kg	2	8.6-12	10.3	8840
Hexavalent Chromium (CrVI)	mg/kg	2			35
Lead (Pb)	mg/kg	2	4.9-12	8	750
Mercury (Hg)	mg/kg	2	<0.3-<0.3	0.3	73
Selenium (Se)	mg/kg	2	<1.0-<1.0	1.0	13000
Nickel (Ni)	mg/kg	2	15-27	21	1800
Copper (Cu)	mg/kg	2	12-12	12	71500
Zinc (Zn)	mg/kg	2	18-37	28	665000
Phenol	mg/kg	2	<2.0-<2.0	2.0	775
Benzo[a]pyrene	mg/kg	2	<0.1	0.1	14
Total Cyanide (CN)	mg/kg	2	<1	1	/
Acidity (pH value)	Units	2	7.7-7.9	7.8	/
Soil Organic Matter	%	2	2.4-3.3	2.9	/

Both of the natural soils analysed were free from significant contamination, which concurs with the visual and olfactory evidence. The sample analysed from TP12 was overlain by fill material in which some minor lead impact was reported (780 mg/kg). A background concentration was reported at 1.5m, which suggests that negligible vertical migration has taken place in this trial hole.

21.2 Asbestos

All the samples analysed were also screened for asbestos as part of the general contaminant testing. None of the samples reported positive results for asbestos fibres or asbestos containing materials. This concurs with the observations made on site, although it is acknowledged that material used as backfill is often variable and there is the potential for ACM's to be present elsewhere in the fill material.

21.3 Petroleum Hydrocarbons

Although there was no visual or olfactory evidence of fuel contamination noted in any of the trial holes, deep fill was noted in places, in association with backfilled lime kiln pit, the source of which is unknown; as such, this material had the potential to be impacted with petroleum hydrocarbons so, as a precaution, two representative samples were analysed, as was a sample of natural soil from WLS4. Two of the three samples analysed reported concentrations, for all the aliphatic and aromatic bands, below the detection limit. For the deeper sample from TP15, fairly minor impact was reported, mainly for the 'heavier' aliphatic bands, although the concentrations were significantly lower than the LQM guidelines for even residential soils. The likely source is the ash/clinker material noted, rather than fuel impact.

21.4 Waste Acceptance Criteria

The chemical analysis appended will provide information to assist in classifying any soils to be removed from site to landfill as part of the ground works. It appears, from the analysis obtained to date, that site arisings are likely to largely constitute an inert or non-hazardous waste classification. This should, however, be confirmed with the receiving landfill site and may change if more significant contamination is encountered.

The developer, as the waste producer, will ultimately be responsible for the material removed from site. The contents of this report should be forwarded to tip operators for their own assessment, to confirm classification of the soils for off-site disposal, and whether they can accept the material. Waste Acceptance Criteria (WAC) testing may be requested for confirmation of the materials classification.

22 Site Investigation – Groundwater

As part of this investigation, ten gas and groundwater monitoring wells were installed in a mixture of the rotary boreholes and windowless sampler trial holes, providing good general coverage.

During one of the monitoring visits, groundwater was recovered from 7 of these wells. All samples were screened for general contaminants (STL Key Contaminant Suite) and TPH CGWs, in line with the analytical strategy for the soils and the conceptual model. The results are included in Appendix C.

In general, the results were very good, concurring with the analytical results for the soils. None of the waters analysed were impacted with PAH's or petroleum hydrocarbons. Relative to drinking water standards, however, two of the samples tested were impacted with lead (26 ug/l and 17 ug/l, relative to a drinking water guideline of 10 ug/l), whilst some minor arsenic impact was also reported (14 ug/l, relative to a drinking water standard of 10 ug/l) and selenium (52 ug/l, relative to a drinking water guideline of 10 ug/l). The source of the impact is not always clear, as none of the soils analysed were significantly impacted with either selenium or arsenic.

For BH's 4 and 5, for example, where only a natural soil sequence was encountered, the slightly elevated concentrations of lead and selenium reported in the groundwater samples analysed are not likely to have originated from the soil in thta specific area. However, it is acknowledged that some lead impact has been reported in some of the samples of fill tested from the site.

23 Site Investigation – Ground Gases

23.1 Gas Sources

The desk study and conceptual model identified potential on-site and off-site source of land gas in the form of the backfilled lime kiln pit and quarrying/landfill, respectively. The Phase II investigation confirmed areas of deep fill on site, although little of the material appeared likely to be significant in terms of potential land gas generation.

Generally these types of sources are characterised as being of low generation potential, after Wilson and Haines (2005)[7].

23.2 Sampling Strategy

The number and spacing of the gas monitoring wells was based on providing good general coverage of the site, given the access restrictions, and five monitoring wells were installed around the site boundary.

23.3 Monitoring Programme and Results

The sensitivity of the proposed development is rated as high and three initial rounds of monitoring have been undertaken to date. The full results of the monitoring are given in full in Appendix D and are summarised below.

Borehole Gas Monitoring Results Summary

Well	WLS1	WLS3	WLS4	WLS5	BH1	BH2	BH4	BH5	BH6	BH7
Response Zone / Stratum	0.3-0.8 natural	1-3 fill	1-3 fill	1-2 fill	1-15 natural	1-15 natural	1-7 natural	9-10 natural	1-8 natural	1-9 natural
No. of visits (to date)	3	3	3	3	3	3	3	3	3	3
Methane % range	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Carbon Dioxide %	1.4-2.3	4.7-5.7	5.1-5.9	1.2-2.8	0.4-1.6	1-2	<0.1	0-0.5	1.2-2.8	0.3-1
Oxygen % range	18.9-20.1	14.2-14.8	12.9-14.8	17.6-19.8	10.4-19.2	16.3-18.7	20.6-20.9	20.2-20.9	17.6-19.4	18.5-19.4
Flow rate l/hr range	-0.2 to <0.1	<0.1 to 1.8	<01 to 0.2	-0.8 to <0.1	<0.1 to 0.3	-1.5t o <0.1	<0.1	-0.1to 0.1	-0.7 to 0.3	-0.1to 1
Borehole Pressure range mb	-0.3to 0.4	-0.8 to -0.1	-0.9 to -0.2	-0.3 to -0.1	-0.3 to <0.1	-0.5 to <0.1	-0.4 to <0.1	-0.3 to -0.1	-0.5 to 0.1	-0.4 to -0.1
Water level mbgl	Dry	1.45-1.68	1.45-1.62	1.65-1.9	1.5-1.8	1.8-1.9	0.9-1	2.2-2.31	1.5-1.55	1.9-1.98

[7] Wilson, S and Haines, S. 2005. Site investigation and monitoring for ground gas assessment – back to basics. Land Contamination & Reclamation 13, 3, 211-222.

Borehole Gas Monitoring Results Summary										
Atmos pressure mb	996-1003	996-1003	996-1003	996-1003	996-1003	996-1003	996-1003	996-1012	996-1012	996-1012

23.4 Identified Gas Regime

On the basis of the monitoring to date, using a peak carbon dioxide reading of 6% and a flow of 2 l/hr (both rounded up), a worst-case gas screening value of 0.12 l/hr is calculated which therefore places the site in characteristic situation 2 (CS2), CIRIA C665. The monitoring was undertaken over a reasonable range of atmospheric pressures and the highest carbon dioxide levels were recorded in WLS3 and WLS4, both of which had a significant depth of fill material, the likely source of this gas.

On this basis, were any new buildings being proposed some basic gas protection measures would be necessary although, in the absence of any such structures, the gas risk is considered very low (the underpass is assumed to be of an open nature and therefore well vented).

Should the proposals change, however, as a guide, due to the significant depth of made ground on parts of the site, and likely in some of the surrounding area, any buildings should have a suspended floor slab, with well ventilated sub-floor voids and a 2000 gauge membrane, lapped across the cavity and sealed at the service entries. This will help to mitigate any minor risk from land gas. Additional monitoring would be required, however, to better assess the gas regime and confirm the gas protection measures.

24 Revised Conceptual Model

The preliminary site model has been refined in light of the findings of this investigation and is summarised below.

Metals	Land Gas	*Petroleum Hydrocarbons*	*Asbestos*	PAH's	PATHWAYS	RECEPTORS
P	n/a	N	N	P	Ingestion and inhalation of contaminated soil and dust	Human Health
N	P	N	n/a	N	Inhalation of vapours or gases	
N	n/a	N	n/a	N	Uptake into edible fruit and vegetables	
N	n/a	N	n/a	N	Surface water run-off into surface water features	Water Environment
N	n/a	N	n/a	N	Migration through ground into surface water or groundwater	
N	n/a	N	n/a	N	Off-site migration of contaminated groundwater	
N	n/a	N	n/a	N	Vegetation on site growing in contaminated soil	Flora and Fauna
N	n/a	N	n/a	N	Aquatic life in affected waters	
P	n/a	N	n/a	P	Contact with contaminated soil	Building materials/ buried services
n/a	N	N	n/a	n/a	Fire or explosion	

Key:

Y	Pollutant linkage likely
N	Pollutant linkage not likely
P	Pollutant linkage possible
n/a	Pathway not applicable to contaminant

On the basis of the test results to date, and the development proposals (a road and underpass) there is a very low or negligible risk to the end-user, with a low risk to both the site-workers (assuming good site practices are employed) and the underlying aquifer from the contamination on site; given the history of the site, however, more significant contamination should be anticipated, in places. A discovery strategy is recommended to deal with any significant contamination that may come to light during the development work.

25 Recommendations

1. The topsoil analysed was free from significant contamination and should be stripped and stockpiled, as part of a topsoil management plan, to prevent damage of this valuable resource. This appears suitable for re-use in areas of soft landscaping and private gardens elsewhere on the wider development.
2. The made ground analysed to date, which was deep in places, was generally free from significant contamination, in terms of the new road and underpasses proposed. It is also not considered a significant risk to the aquifer (see below). However, it is impacted, in places with various heavy metals and PAH's, which may have implications for the waste classification and site health and safety practices.
3. As discussed, the soils tested from the site were generally free from significant levels of contamination, in terms of the construction proposed. However, the analysis has confirmed some PAH and heavy metal impact of the general fill, which may constitute a non-hazardous waste classification. The natural soil on site is likely to be classified as inert and therefore should be separately stockpiled. The chemical analysis appended will provide information to assist in classifying any soils to be removed from site to landfill as part of the ground works; this should be confirmed with the receiving landfill site. See the discovery strategy below for the possible influence of any more significant contamination being encountered on site.
4. Part of the site was associated with historic quarrying, as was much of the surrounding area, with a lime kiln once located in the northern portion of the site. An historic landfill is registered on or adjacent to the site, for Gowell Farm and, as such, preliminary gas monitoring was undertaken to assess the gas regime, although no new structures are proposed for the site. The gas monitoring to date has not indicated a significant gas risk, with only slightly elevated levels of carbon dioxide recorded. Should any new structures be proposed, subject to further monitoring to confirm the gas regime, basic measures should be sufficient to mitigate any risk.
5. The groundwater quality, although slightly impacted in places with some heavy metals, is generally good.
6. Given the site history and contamination reported to date, high specification water pipes are likely to be requested by the suppliers.

7. A discovery strategy should be put in place to deal with any significant contamination that comes to light during the ground works. Encountering more significant contamination may change the remediation strategy and the waste classification, and possibly the health and safety measures employed on site, should be subject to a contaminated land engineer's assessment.

These recommendations are subject to the approval of the regulatory authorities, particularly the local environmental health officer, but also the Environment Agency.

G CONSIDERATIONS FOR IMPLEMENTATION AND VALIDATION OF REMEDIATION

26 General Guidance

Allowance should be made for experienced verification of the site works, should any contamination be identified.

It may be that specific local requirements apply to this site, of which we are not aware at this time.

Some contamination has been identified by this investigation, in the form of PAH and heavy metal impact of the fill, and there remains the potential for as yet undiscovered contamination elsewhere on site (particularly given the filling that has taken place on part of the site).

In general terms, the workforce and general public should be protected from contact with contaminated material. There is a range of relevant documents published by the Health and Safety Executive, and organisations such as CIRIA, and the BRE.

Some soils will require removal from site and disposal to suitably licensed landfills. Different guidelines and charges will apply to different waste classification. As waste producers, the Developer holds responsibilities under the various governing regulations, the key elements of which are:-

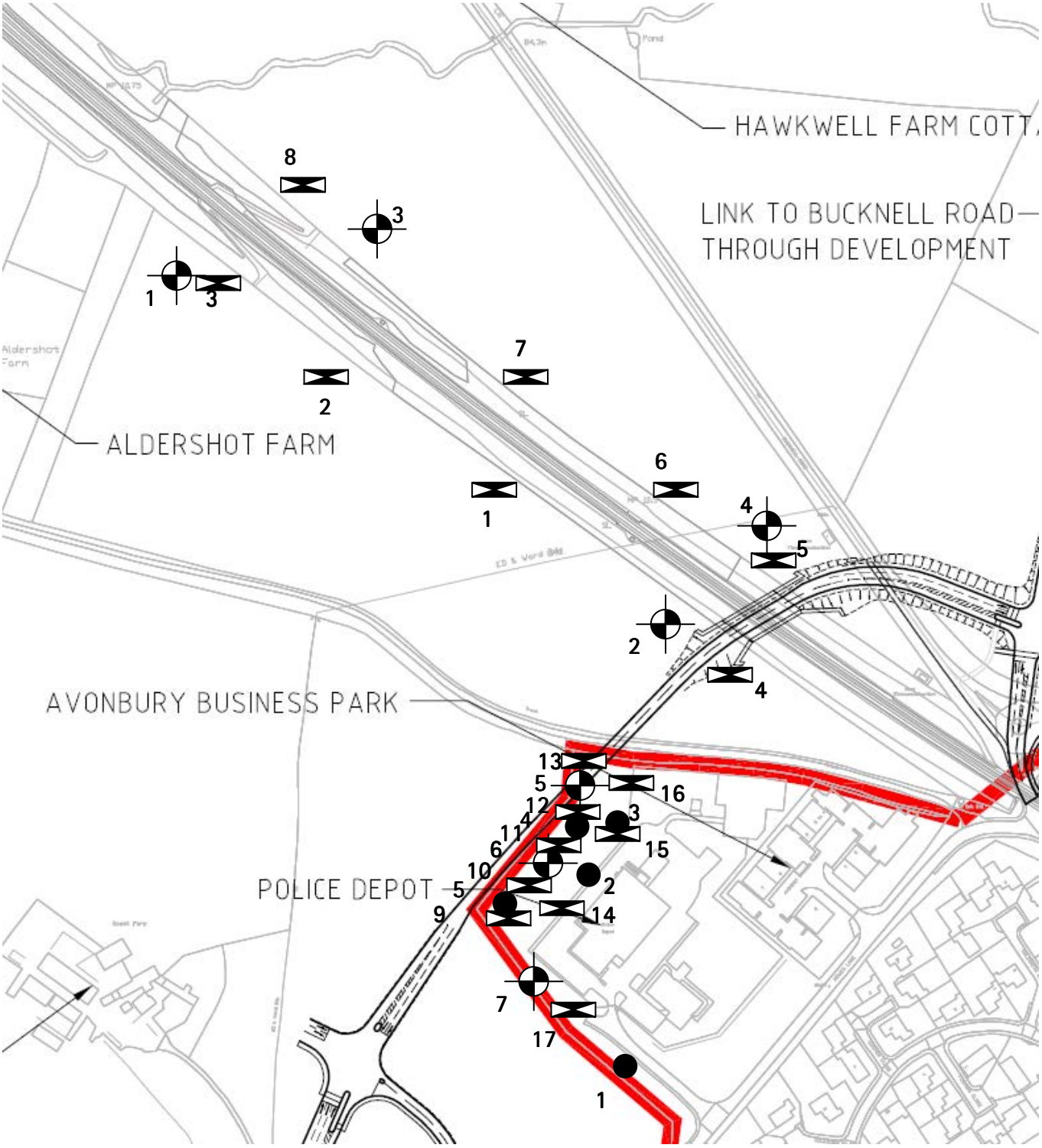
- Ensuring that waste is characterised in accordance with Technical Guidance WM2.
- Ensuring that waste is disposed of at a facility appropriately licensed to receive the waste as classified.
- Keeping accurate records of all waste classification, transfer and a disposal log including information such as:
    - Date, Waste Classification, Carrier's Registration Number, Transfer Note Number, Ultimate Destination.
- Submitting full copies of those records for inclusion in validation/closure reports.
- Maintaining those records for potential future regulatory inspection.

All hazardous and non-hazardous soils leaving site will need to be pre-treated.

It should be noted that organic contaminants present in the soils could affect plastic underground service pipes (such as the types used by water and gas supply companies). Guidance should be sought from the relevant companies regarding any proposed plant in the affected area.

Many water supply companies now require higher specification pipe on contaminated sites, even following remediation.

APPENDIX A – SITE PLANS AND EXPLORATORY HOLE LOGS



NB: Positions of Boreholes and/or Trial Pits are only indicative

Site: Bicester	STL: JN0591	Fig No: 1
Date:	Fieldwork Locations	

Southern Testing

Southern Testing: Keeble House, Stuart Way, East Grinstead, West Sussex RH19 4QA
ST Consult: Twigden Barns, Brixworth Road, Creaton, Northampton NN6 8NN

ST Consult

Southern Testing Environmental & Geotechnical | ST Consult Environmental & Geotechnical
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Project No.	Borehole No	
JN0591	**BH1** Sheet 1 of 1	AGS

Project Name: Underpass	NGR: -	Hole Type Rotary
Location: Bicester	Level: -	
Client: A2	Dates: 18/03/2014	Logged By CN

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Thickness	Legend	Stratum Description
		0.50		UCS = 170	0.30		0.30		Firm, grey-brown, silty, sandy clay TOPSOIL with rootlets.
		0.75-1.50	50	5 0 80	0.75		0.45		Firm (medium strength), orange-brown, grey, slightly silty, sandy CLAY.
		1.50-3.10	100	95 60 10	1.50		0.75		Very weak, grey, flaggy LIMESTONE. recovered as gravels and cobbles with orange-brown silty sand matrix in fractures.
		3.20		UCS = 600	3.10		1.60		Weak to moderately strong, grey , thin to medium bedded LIMESTONE with shell fragments. 2.10m - 2.50m: Orange, brown and arencious.
		3.60		UCS = 600					Hard (extremely high strength), initially buff, becoming grey, lithified CLAY.
		4.00		UCS = 600	4.20		1.10		
		4.20-6.30	100	95 60 4			2.10		Moderately strong, grey, thin to medium bedded, shelly, LIMESTONE. Sandy on fracture faces with calcareous veining. 5.30m: Subvertical fracture
		6.30-6.50	100	100 100	6.30		0.20		Weak, light grey, calcareous SILTSTONE.
	▽	6.70		UCS = 600	6.50		0.40		Hard (extremely high strength), dark grey-green, weakly lithified, silty, calcareous CLAY. Initially friable with occasional shells.
		7.40-8.10	100	100 100 0	6.90		0.50		Weak, light grey, calcareous SILTSTONE.
					7.40		0.70		Moderately strong, medium bedded, grey LIMESTONE.
					8.10		1.30		Very stiff (very high strength), dark grey, mottled light grey, silty CLAY with shelly fragments, weak lithorelict structure, organic material, pyrite and charcoal.
		9.40-10.70	90	50 50 3	9.40		1.30		Moderately strong, thin to medium bedded, light grey to off white, shelly LIMESTONE. 10.10m: Subvertical fracture.
		10.70-15.20	95	65 65 3	10.70		4.50		Moderately strong, grey, thinly bedded, shelly LIMESTONE. 10.90m: 45 degree fracture and vug. 11.40m: 45 degree fracture. 13.00m: 45 degree fracture.
					15.20				End of Borehole at 15.20 m

TCR | SCR | RQD | FI

Borehole Details

Casing Depth m bgl	Hole Depth m bgl	Casing Diameter mm

Water Strikes

Date	Water (m)	Casing (m)	Time (mins)	Rose to (m)	Sealed (m)
18/03/2014	7.10	-	-	-	-

General Remarks:

50mm standpipe, slotted 1-15m

Southern Testing Environmental & Geotechnical | ST Consult Environmental & Geotechnical
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Project No.	Borehole No	
JN0591	BH2 Sheet 1 of 1	AGS

Project Name: Underpass	NGR: -	Hole Type Rotary
Location: Bicester	Level: -	
Client: A2	Dates: 19/03/2014	Logged By CN

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Thickness	Legend	Stratum Description
					0.10		0.10		Brown, sandy clay TOPSOIL with frequent rootlets.
		0.10-1.30	30	0 0 0			1.20		Moderately strong, light grey, off white, thinly bedded, shelly LIMESTONE. Orange, brown, clay on fracture surfaces. Buff, silty sandy clay at base.
					1.30				Moderately strong, light grey, thinly bedded, shelly LIMESTONE.
		1.30-3.10	80	30 25 10			1.80		
					3.10				Weak to moderately strong, thin to medium bedded, grey, shelly LIMESTONE with ferruginous weathering on fractures.
							1.40		3.20m - 3.30m: Stiff (high strength), dark grey, slightly fine sandy CLAY with charcoal smuts and rare shells.
		4.50-4.90	80	30 30 10	4.50		0.40		3.90m - 4.20m: Dark grey, calcareous, fine sandy CLAY with abundant shell fragments.
		5.10		UCS = 500	4.90				Weak, light grey, clacareous SILTSTONE.
	▽	6.20		UCS = 500			1.90		Very stiff (very high strength), initially green-grey, becoming dark grey, calcareous, silty, shelly CLAY with lithorelic structure, charcoal smuts and pyrite.
		6.70		UCS = 600					
		6.90		UCS = 400	6.80				
		7.40		UCS = 500			0.80		Stiff, green-grey-turquoise, mottled orange, silty CLAY with lithorelic structure becoming siltstone gravels. Occasional shells and charcoal at base.
		7.60-8.40	90	65 60 6	7.60		0.80		Moderately strong, grey, thin to medium bedded LIMESTONE with shell fragments.
									8.10m - 8.20m: Sub vertical fractures and vug.
					8.40				Moderately strong, medium bedded, dark-light grey LIMESTONE with occasional shells and rare vugs.
									9.60m - 9.70m: Stiff (high strength), dark grey CLAY.
		8.40-15.00	100	95 90 3			6.60		11.60m: 45 degree fracture.
		13.00		UCS = 600					12.90m - 13.10m: Stiff (high strength), grey, slightly silty CLAY with lithorelict structure.
									13.70m - 14.00m: 45 degree fracture.
		14.95		UCS = 600	15.00				14.90m - 15.00m: Stiff (high strength), grey, slightly silty CLAY with lithorelict strucutre.
									End of Borehole at 15.00 m

TCR | SCR | RQD | FI

Borehole Details

Casing Depth m bgl	Hole Depth m bgl	Casing Diameter mm

Water Strikes

Date	Water (m)	Casing (m)	Time (mins)	Rose to (m)	Sealed (m)
18/03/2014	6.40	-	-	-	-

General Remarks:

50mm stanpipe, slotted 1-15m

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Project No.	Borehole No	
JN0591	BH3 Sheet 1 of 1	AGS

Project Name: Underpass	NGR: -	Hole Type Rotary
Location: Bicester	Level: -	
Client: A2	Dates: 20/03/2014	Logged By CN

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Thickness	Legend	Stratum Description
		0.30		UCS = 150	0.20		0.20		No recovery - presumed topsoil.
					0.40		0.20		Firm (medium strength), brown-orange, silty CLAY.
		0.40-1.60	95	50 0 400			1.20		Moderately strong, very thinly bedded, flaggy LIMESTONE with orange, silty fine sand within fractures.
					1.60				
		1.60-2.80	95	90 10 200			1.20		Moderately strong to strong, very thinly bedded, grey LIMESTONE with frequent calcite veining and grey-orange silty, fine sand within fractures.
					2.80				
		3.00		UCS = 200			0.80		Firm to stiff (medium to high strength), grey, green, occasionally mottled orange, silty CLAY with weak lithorelict structure and rare silty partings.
		3.50		UCS = 215	3.60				3.30m - 3.40m: Moderately strong, grey, thinly bedded, calcareous MUDSTONE.
		3.60-5.50	95	60 60 80			1.90		Strong, grey mottled orange, medium bedded LIMESTONE with frequent calcite veining and shell fragments. 4.30m - 4.40m: 45 degree fracture. 4.50m - 4.60m: Stiff (high strength), grey CLAY. 4.65m - 5.10m: Sub vertical fracture with ferreginous crystaline faces.
					5.50				
		5.70		UCS = 550	5.80		0.30		Hard (extremely high strength), grey, fine sandy CLAY with lithorelic structures and occasional shell fragments.
									End of Borehole at 5.80 m

TCR | SCR | RQD | FI

Borehole Details

Casing Depth m bgl	Hole Depth m bgl	Casing Diameter mm

Water Strikes

Date	Water (m)	Casing (m)	Time (mins)	Rose to (m)	Sealed (m)
20/03/2014	4.65	-	3	0.00	5.80

General Remarks:

Hole terminated at 5.8m due to artesian water strike.
Hole fully grouted.

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Project No.	Borehole No	
JN0591	**BH4** Sheet 1 of 1	AGS

Project Name: Underpass	NGR: -	Hole Type Rotary
Location: Bicester	Level: -	
Client: A2	Dates: 20/03/2014-21/03/2014	Logged By CN

Well	Water Strikes	Samples & In Situ Testing Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Thickness	Legend	Stratum Description
		0.50		UCS = 180	0.60		0.60		Firm (medium strength), orange-brown, slightly silty, sandy CLAY becoming very sandy at base.
					0.90		0.30		Medium dense, orange-brown, weakly lithified, silty, fine to medium SAND with shell fragments.
		0.90-2.90	95	90 60 8			2.00		Moderately strong, light-dark grey, thin to medium bedded, shelly LIMESTONE with orange-brown weathering on fracture surfaces. Silty, clay in fracture matrix.
		3.00		UCS = 400	2.90		0.30		Stiff to hard (medium to high strength), dark grey, sandy calcareous CLAY with lithorelic structure.
		3.20-3.50	90	70 50 5	3.20 3.50		0.30		Moderate strong becoming very weak, dark grey, shelly LIMESTONE becoming weak limestone gravels in clayey sand matrix.
		3.50-5.40	95	60 60 10			1.90		Weak, light grey, clacareous MUDSTONE. 3.90m - 4.70m: Recovered as weak lithorelict structures.
					5.40		0.60		Moderately strong, light grey LIMESTONE with calcareous veining and abundant shells.
		6.20		UCS = 360	6.00				
		6.00-6.70	95	80 0 0			0.70		Very weak, light-dark grey, calcareous SILTSTONE. Recovered as lithorelict gravels.
		6.60		UCS = 330	6.70				
		6.70-8.40	100	100 50 12			1.70		Weak to moderately strong, light grey, thin to medium bedded, LIMESTONE with calceous veining and sub horizontal fractures present.
		8.50		UCS = 320	8.40 8.60		0.20		Stiff (high strength), light grey, silty, gravelly CLAY with friable lithorelicts.
									Moderately strong, dark grey, shelly LIMESTONE with grey, medium sand on fractures. 9.60m: 45 degree fracture.
		8.60-15.20	95	85 70 8			6.60		11.60m - 11.70m: Stiff to hard (high to extremely high strength) , grey, calcareous lithorelict CLAY.
					15.20				End of Borehole at 15.20 m

TCR | SCR | RQD | FI

Borehole Details

Casing Depth m bgl	Hole Depth m bgl	Casing Diameter mm

Water Strikes

Date	Water (m)	Casing (m)	Time (mins)	Rose to (m)	Sealed (m)
20/03/2014	5.40	-	-	-	-

General Remarks:

50mm standpipe, slotted 1-7m. Grouted 7-15m.

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Project No.	Borehole No	
JN0591	**BH5** Sheet 1 of 1	AGS

Project Name: Underpass	NGR: -	Hole Type RO
Location: Bicester	Level: -	
Client: A2	Dates: 24/03/2014	Logged By Driller

Well	Water Strikes	Samples & In Situ Testing: Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Thickness	Legend	Stratum Description
					0.00		3.00		Pale orange, sandy CLAY with abundant limestone bands.
					3.00		7.00		Dark, grey LIMESTONE. 4.00m - 4.30m: Band of MUDSTONE. 7.00m - 8.00m: Band of MUDSTONE.
					10.00				End of Borehole at 10.00 m

Type	Results

Borehole Details

Casing Depth (m bgl)	Hole Depth (m bgl)	Casing Diameter (mm)

Water Strikes

Date	Water (m)	Casing (m)	Time (mins)	Rose to (m)	Sealed (m)
24/03/2014	6.00	-	-	-	-

General Remarks:

50mm standpipe, slotted 9-10m.

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Project No.	Borehole No	
JN0591	**BH6** Sheet 1 of 1	AGS

Project Name: Underpass	NGR: -	Hole Type RO
Location: Bicester	Level: -	
Client: A2	Dates: 24/03/2014-25/03/2014	Logged By Driller

Well	Water Strikes	Samples & In Situ Testing: Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Thickness	Legend	Stratum Description
							1.00		Dark, orange-brown sandy CLAY.
					1.00				
							1.50		Dark orange LIMESTONE
					2.50				Moderately strong, pale grey LIMESTONE.
	▽						6.00		
					8.50				End of Borehole at 8.50 m

1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0

Type | Results

Borehole Details

Casing Depth (m bgl)	Hole Depth (m bgl)	Casing Diameter (mm)

Water Strikes

Date	Water (m)	Casing (m)	Time (mins)	Rose to (m)	Sealed (m)
24/03/2014	5.50	-	-	-	-

General Remarks:

50mm standpipe, slotted 1-8m.

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Project No.	Borehole No	
JN0591	**BH7** Sheet 1 of 1	AGS

Project Name: Underpass	NGR: -	Hole Type RO
Location: Bicester	Level: -	
Client: A2	Dates: 25/03/2014	Logged By Driller

Well	Water Strikes	Samples & In Situ Testing: Depth (m)	Type	Results	Depth (m)	Level (m AOD)	Thickness	Legend	Stratum Description
							1.00		Banded, pale orange clay and limestone.
					1.00				
							1.50		Pale yellow LIMESTONE.
					2.50				Moderately strong, pale grey LIMESTONE.
	▽								5.40m - 5.50m: Mudstone band.
							6.50		
					9.00				End of Borehole at 9.00 m

Type | Results

Borehole Details

Casing Depth (m bgl)	Hole Depth (m bgl)	Casing Diameter (mm)

Water Strikes

Date	Water (m)	Casing (m)	Time (mins)	Rose to (m)	Sealed (m)
25/03/2014	6.50	-	-	-	-

General Remarks:

50mm standpipe, slotted 1-9m

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Project No.	Hole Type	Borehole No
JN0591	WLS	**WLS1** Sheet 1 of 1

Project Name: Underpass

Dates: 19/03/2014

Location: Bicester

NGR: -

Client: A2

Level: -

Logged By: CN

Well	Water Strikes	Samples & In Situ Testing: Depth (m)	Type	Results	Level (m AOD)	Thickness	Legend	Depth (m)	Stratum Description
		0.15	ES			0.25		0.25	TOPSOIL - grey friable silty fine tomedium sand with rootlets.
		0.70	D			0.50		0.75	Medium dense buff orange brown slightly clayey fine to coarse SAND with abundant limestone gravel.
						0.05		0.80	Moderately strong grey LIMESTONE recovered as flaggy cobbles.
									End of Borehole at 0.80 m

1.0

2.0

Type | Results

Borehole Details

Casing Depth (m bgl)	Hole Depth (m bgl)	Casing Diameter (mm)

Water Strikes

Date	Water (m)	Casing (m)	Time (mins)	Rose to (m)	Sealed (m)

General Remarks:

38mm gas pipe slotted 0.5-0.8m.

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Project No.	Hole Type	Borehole No
JN0591	WLS	**WLS2** Sheet 1 of 1

Project Name: Underpass

Dates: 19/03/2014

Location: Bicester

NGR: -

Client: A2

Level: -

Logged By: CN

Well	Water Strikes	Samples & In Situ Testing: Depth (m)	Type	Results	Level (m AOD)	Thickness	Legend	Depth (m)	Stratum Description
						0.20			TOPSOIL - grey silty sands with rootlets.
						0.10		0.20	Moderately strong grey flaggy LIMESTONE with buff orange brown surfaces.
								0.30	End of Borehole at 0.30 m

1.0

2.0

Type	Results

Borehole Details

Casing Depth (m bgl)	Hole Depth (m bgl)	Casing Diameter (mm)

Water Strikes

Date	Water (m)	Casing (m)	Time (mins)	Rose to (m)	Sealed (m)

General Remarks:

Hole terminated on limestone rock below topsoil.

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Project No.	Hole Type	Borehole No
JN0591	WLS	**WLS3** Sheet 1 of 1

Project Name: Underpass

Dates: 19/03/2014

Location: Bicester

NGR: -

Client: A2

Level: -

Logged By: CN

Well	Water Strikes	Samples & In Situ Testing: Depth (m)	Samples & In Situ Testing: Type	Samples & In Situ Testing: Results	Level (m AOD)	Thickness	Legend	Depth (m)	Stratum Description
						0.20		0.20	TOPSOIL - grey brown silty sands with roots.
		0.60	ES			0.75		0.95	MADE GROUND - Reworked natrual buff brown silty sandy gravelly clays including limestone.
						2.05		3.00	MADE GROUND - Loose dark grey balck sands and gravels of clinker ash, slate, pottery. Poor recovery. Browner (more'ashy') at base.
									End of Borehole at 3.00 m

1.0

2.0

Type | Results

Borehole Details

Casing Depth (m bgl)	Hole Depth (m bgl)	Casing Diameter (mm)

Water Strikes

Date	Water (m)	Casing (m)	Time (mins)	Rose to (m)	Sealed (m)
19/03/2014	0.15	-	20	1.50	-

General Remarks:

38mm gas pipe slotted 0.9-2.9m.

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Project No.	Hole Type	Borehole No
JN0591	WLS	**WLS4** Sheet 1 of 1

Project Name: Underpass

Dates: 19/03/2014

Location: Bicester

NGR: -

Client: A2

Level: -

Logged By: CN

Well	Water Strikes	Samples & In Situ Testing: Depth (m)	Type	Results	Level (m AOD)	Thickness	Legend	Depth (m)	Stratum Description
						0.20		0.20	TOPSOIL - brown silty sands
		0.30	ES			0.35		0.55	MADE GROUND - Reworked natural buff brown mottled silty very sandy very gravelly clay.
						1.85		2.40	MADE GROUND - Loose black sandsand gravels of cinder, clinker, asha nd pottery. Poor recovery.
		3.00	ES			0.60		3.00	Probable natural - Firm moist buff green grey silty slightly sandy CLAY.
									End of Borehole at 3.00 m

1.0

2.0

	Type	Results

Borehole Details

Casing Depth m bgl	Hole Depth m bgl	Casing Diameter mm

Water Strikes

Date	Water (m)	Casing (m)	Time (mins)	Rose to (m)	Sealed (m)

General Remarks:

38mm gas pipe slotted 1-3m.

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Project No.	Hole Type	Borehole No
JN0591	WLS	**WLS5** Sheet 1 of 1

Project Name: Underpass

Dates: 19/03/2014

Location: Bicester

NGR: -

Client: A2

Level: -

Logged By: CN

Well	Water Strikes	Samples & In Situ Testing: Depth (m)	Samples & In Situ Testing: Type	Samples & In Situ Testing: Results	Level (m AOD)	Thickness	Legend	Depth (m)	Stratum Description
						2.15		2.15	MADE GROUND - TP9 backfill (see TP9 for log) End of Borehole at 2.15 m

1.0

2.0

Borehole Details

Casing Depth (m bgl)	Hole Depth (m bgl)	Casing Diameter (mm)

Water Strikes

Date	Water (m)	Casing (m)	Time (mins)	Rose to (m)	Sealed (m)
19/03/2014	2.15	-	20	2.15	-

General Remarks:

38mm gas pipe slotted 1-2.0m.
Driven through TP9 backfill.