P3Eco Ltd

P3Eco (Bicester) Ltd and A2Dominion Group

NW Bicester Eco Development

Geotechnical Interpretative Report - Exemplar Site

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Geotechnical Interpretative Report - Exemplar Site

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1 INTRODUCTION

Hyder Consulting (UK) Limited (HCL) has been instructed by P3Eco (Bicester) Ltd. (P3Eco) and A2Dominion Group Ltd. (A2Dominion) to undertake a Geotechnical and Geo-Environmental intrusive investigation with subsequent factual and interpretative reports for a proposed new eco development on the north-western periphery of the town of Bicester, Oxfordshire.

This geotechnical interpretative report presents a summary of data collected during an initial preliminary ground investigation undertaken at the proposed Exemplar site in August 2010 and provides advice relating to the physical and chemical nature of the ground based on interpretation of this data. Prior to undertaking the ground investigation, a desk study report (Ref. 1) and following completion of the investigation a factual report (ref. 2) were produced by HCL, which should be read in conjunction with this document.

1.1 Background to the Proposed Development

Land at NW Bicester is identified in the Supplement to Planning Policy Statement 1 (PPS1) entitled ‘Eco Towns’ (July 2009) as a potential location for an Eco Town. PPS1 sets out the Government's overarching planning policies on the delivery of sustainable development through the planning system. The Supplement to PPS1 sets out a range of criteria against which Eco Town proposals should be assessed.

The development of land at NW Bicester as an Eco Town has been promoted by P3Eco. P3Eco have selected A2Dominion as its development partner for the promotion and implementation of the Exemplar scheme (see Figure 1 – site location plan for land proposed for the Exemplar Scheme) and also as its affordable housing partner in respect of the wider Masterplan scheme.

The proposed development is still in the preliminary design stage and as such, the ground investigation was designed based on the information provided within the desk study to provide the assessment of general ground conditions and parameters from a geotechnical, hydrogeological and geo-environmental perspective.

The purpose of this report therefore is to identify the geotechnical, environmental, geological, hydrogeological and hydrological conditions and constraints to the proposed eco development present at the Exemplar site. In additionally to use the information gathered during the investigation and desk study phases, including the historic land use knowledge, to develop an understanding of any potential contamination risks that might arise from current or potential future use of the site.

1.2 Objectives of the Report

The principal objective of the report is to provide an assessment of the current geotechnical and geo-environmental conditions of the proposed Exemplar site. To this end, this report aims to:

- Establish ground and groundwater conditions beneath the site;
- Identify the presence of contaminants within the soil;
- Identify health and safety issues arising as a result of the ground conditions; and
- Discuss materials management and waste disposal issues.

In order to meet these objectives, a preliminary site-specific intrusive ground investigation was undertaken by HCL’s in –house SI contracting division, using CJ Associates Ltd. (CJA) as the specialist drilling subcontractor, with all technical direction and supervised provided by HCL.

2 THE EXEMPLAR SITE SETTING

2.1 Site Location

The town of Bicester lies approximately 24km to the north east of Oxford and 28km to the south east of Banbury. The M40 motorway lies 2km to the south west, with ready access to the town from Junction 9. The proposed eco development site will comprise approximately 5,000 homes with supporting employment and education infrastructure, and will be situated on the north-western periphery of Bicester, beyond the A4095 (which forms part of the Bicester Ring Road), approximately 1.5km from the town centre.

The whole of the development site covers an area of approximately 416ha and at present, comprises Grade 3 agricultural land with a number of farmhouses and other buildings, as well as a small commercial area on the western side of Howes Lane (A4095). Immediately beyond the Site to the north-west is the village of Bucknell, with Caversfield located on the north-eastern Site boundary, beyond the B4100 highway.

This geotechnical interpretative report is restricted to the Exemplar site, which extends over an area of approximately 21.1ha, situated within the north eastern boundary of the whole development site, to the south of Caversfield. The sole landowner of the Exemplar development site is Mr Phipps.

The location of the site is presented in Figure 1 with the proposed site development plan included in Figure 3; and comprises of predominantly two storey houses, although this is subject to change and was current at the time of writing.

2.2 Site Description

The Exemplar site is predominantly flat, arable farmland and the agricultural land value is Grade 3 (good to moderate quality) which is currently being used as grazing land for livestock at the time of the ground investigation. Fields are bounded either by post and wire fences or by dense hedges with some large trees. Most fields were surrounded by drainage ditches approximately 0.5m to 0.75m deep, though all were dry at the time of the Site walkover and Ground Investigation.

The site is dissected from east to west by a low flow watercourse/stream, with ground level dropping at a low grade to the river. There is one stream on the Exemplar site (flowing in a NW to SE direction), which feed the N to S flowing River Bure.

Existing buildings within the Site boundary comprise those at Home Farm. The buildings here contain grade 2 listed buildings.

2.3 Public Register and Historical Information

Public register information relating to the Site and the surrounding area has been obtained mainly from the Landmark Information Group Ltd. A full review of public register and historical information can be seen in the desk study report (Ref. 1).

2.4 Geology and Hydrology

The following section contains extracts from the accompanying desk study report (Ref. 1) and supplemented by information gained from the recent ground investigation.

2.4.1 Superficial Deposits

Late Quaternary age superficial deposits of Alluvium flank the streams in narrow tracts, typically some 20m wide (locally up to 80m wide) and some 1m to 3m in thickness. The Alluvium typically comprises sandy, calcareous clay overlying gravelly clay with limestone clasts and may locally include highly compressible, organic-rich (peaty) layers.

Head deposits may be present near the streams where the erosive action of the water has carved small valleys. These deposits are formed by soil creep or hill wash and their composition reflects that of the local materials from which they were derived, either the bedrock or other types of superficial deposits (or both). They are typically poorly stratified and poorly sorted and are not expected to be present in thicknesses much greater than 1m.

Beneath the topsoil, the remainder of the Site has only a thin cover (approximately 1m) of superficial deposits, mainly derived from the partial to complete weathering of the underlying solid geology.

2.4.2 Solid Geology

The landscape of the Site follows the underlying geology, which dips in a south-easterly direction at a very gentle ~0.7°. The Site area is underlain at rock head by various formations and members of the Great Oolite Group, of Mid-Jurassic age, which are dominated by limestone's with subordinate mudstone beds.

There are no geological faults shown on Site; however some minor faults have been mapped to the north-east of Bucknell village, with ground displacements of up to 5m. Faults are planes of movement, along which, adjacent blocks of rock strata have moved relative to each other. They commonly consist of zones, perhaps up to several tens of metres wide, containing several to many fractures. The portrayal of such faults as a single line on the geological map is therefore a generalisation. The geological faults in the Bicester area are ancient in origin and are today mainly inactive, therefore are not thought to present a threat to the proposed development.

Sequence of Strata

The Cornbrash Formation (CB) is the youngest bedrock unit represented and dominates the outcrop within the Site area. It comprises approximately 5m of thick grey to brown, bioclastic, rubbly-bedded limestone with thin subordinate beds of grey mudstone.

The older, underlying Forest Marble Formation (FMB) is exposed as a narrow outcrop on the flanks of the three stream valleys in the area where the Cornbrash Formation has been eroded. The FMB comprises approximately 5m to 10m of grey calcareous mudstone with lenticular beds of bioclastic, ooidal limestone (particularly common at the base).

Although not represented in outcrop on Site, the FMB is underlain at an erosive contact by the White Limestone Formation (WHL), which crops approximately 2km to the north-west. The WHL comprises up to 25m of white to yellow, bedded, peloidal and bioclastic limestone (see Additional Geological Considerations below).

The White Limestone Formation is underlain by four further formations of the Great Oolite Group: in ascending order the Horsehay Sand, the mudstone-dominated Sharp's Hill, the Taynton Limestone and the mudstone-dominated Rutland formations, totalling approximately 20m in thickness. These are then underlain by 2m to 6m of the ferruginous sandstones of the Northampton Sand Formation before the 100m+ of the mudstone-dominated Lias Group is encountered.

2.5 Hydrogeology

With the exception of the Forest Marble Formation cropping out in the floors and sides of the valleys, the whole of the Site area is underlain by the Cornbrash Formation. This is a local aquifer and water strikes have been recorded in shallow boreholes drilled within the Site area. The standing water levels are generally between 0.5m and 4.0m below the ground surface.

The Forest Marble Formation may hold small quantities of water in any limestone bands present, but the upper part generally acts as an aquiclude, i.e. an essentially impermeable barrier between the Cornbrash Formation and the underlying White Limestone Formation. None of the boreholes drilled at the Exemplar Site reached the Forest Marble Formation.

The White Limestone Formation constitutes a major aquifer in the area, which provides some sources of public supply. There are several boreholes in the wider area, some within the Site area, that penetrate this formation:

- A 34m deep borehole at Gowell Farm (SP52/19 at SP 5709 2384), drilled pre-1909 to supply Bicester with water. This penetrated the complete 25m thickness of the White Limestone Formation, underlying about 7.2m of Forest Marble Formation and terminating in the underlying Rutland Formation. Water was struck at 28m and 32m below the ground level in the White Limestone Formation. The rest water level rose to the surface after the first strike, and was artesian, with a rest water level about 1m above ground level (about 88m AOD) after the second strike. The yield was over 7 l/s.

- An 80 m deep borehole at Lords Farm (SP52/18 at SP 5746 2424), drilled in 1941, was drilled through a similar sequence and terminated in the Lias. It struck water in the Cornbrash Formation, which was cased out, and at two levels below the White Limestone Formation. The rest water level was at 11m below ground level (about 68m AOD) and it yielded 1.7 l/s.

Other records of water levels at Lords Farm (SP52/17A, B and C at about SP 569 245) show that the water level was at approximately 3.6m below ground level (about 76m AOD).

In addition to the available geological information, the Environment Agency (EA) Groundwater Vulnerability Map on the EA website has been reviewed to determine the vulnerability of the groundwater underlying the Site with the following conclusions:

- The superficial deposits are not classified as an aquifer. The underlying Cornbrash Formation is classified as a Secondary ‘A’ Aquifer, which comprises “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.”

This designation corresponds with the geological interpretation given above.

There is insufficient data to determine a groundwater flow direction, but locally it will probably be towards the nearest stream and regionally, down-dip towards the south-east.

2.5.1 Groundwater Source Protection Zones

The Environment Agency (EA) has defined Source Protection Zones (SPZs) for groundwater sources such as wells, boreholes and springs used for public drinking water supply. The SPZs show the risk of contamination from any activities that might cause pollution in the area.

Source protection zones are defined as follows:

A Source Protection Zone III is the total area needed to support removal of water from a borehole, and to support any discharge from the protected borehole/well/spring used for public drinking water supply.

A Source Protection Zone II (outer protection zone) covers pollution that takes up to 400 days to travel to the abstraction point, or 25% of the total catchment area – whichever area is the biggest.

A Source Protection Zone I (inner protection zone) defines an area where pollution can travel from the source to the extraction point within 50 days. A Source Protection Zone I also has a minimum 50m protection radius around a public supply borehole.

According to the EA website, the Site does not lie within a SPZ.

2.6 Flooding

Information contained within the desk study report (Ref. 1) indicates that the site is not within the zone of potential flooding from fluvial watercourses. According to the Environment Agency Flood Maps included within the Envirocheck Report, the Site does not generally lie within a zone susceptible to flooding; however, the River Bure that flows to the south east of the site in a roughly north-easterly to south-westerly direction is shown to present a risk of flooding from Rivers or Sea without Defences (Zone 3)" to an area confined to the stream's valley (i.e. its natural floodplain).

Note that EA flood maps are based upon coarse DTM and JFLOW modelling and are not considered suitable to delineate the flood plain to support a planning application. The stream that flows across the site in a west to east direction has not been modelled by the EA, as it is too small. As such, a separate, Site-specific hydraulic model should be developed in order to confirm the flood plain extents across the Site.

2.7 Drainage Soakaways

As part of the development, the suitability of the ground for accepting soakaways for surface water drainage will need to be considered. Based on the available documented evidence on the geology and visual evidence from the Site walkover (where the superficial deposits were typically loamy and all field drainage ditches and the stream that feeds the River Bure were dry), it is considered at this stage that the ground will likely be suitable for some form of soakaway, this is discussed in more detail within the Hyder Exemplar Site Drainage Strategy Report (Ref.3).

3 GROUND INVESTIGATION

The preliminary ground investigation for the whole site was carried out between 2nd August and 16th August 2010 and included the investigation of the Exemplar site. The investigation was undertaken and supervised by HCL on behalf of A2Dominion and P3Eco.

The site specific ground investigation at the Exemplar site was designed to address the objectives identified within Section 1.2 of this report. The findings of the ground investigation, GI are summarised below and are detailed in the HCL Factual Report (Ref. 2)

3.1 Site Works

The completed scope of the ground investigation at the Exemplar site is as follows:

- 3 no. window sample boreholes with rotary follow on to maximum depth of 7m below ground level (bgl) with Standard Penetration test (SPTs) at 1m interval to 5m and at 1.5m intervals thereafter. Gas and groundwater monitoring standpipes were installed within two of the three boreholes;
- 2 no. in-situ permeability tests within selected boreholes;
- 6 no. machine excavated trial pits to depths of up to 2.9m bgl; and
- 3 no. in-situ soakaway tests within selected machine-excavated trial pits.

The depth, thickness and descriptions of the strata (including depths of sampling points) are given on the relevant exploratory logs, presented within the HCL Factual Report (Ref. 2).

Upon their completion, the trial pits were safely backfilled and compacted and the ground re-instated, as far as practicable. Selected rotary boreholes were completed with gas and groundwater monitoring installations for monitoring purposes with raised locking covers.

3.2 Sampling

A Geotechnical Engineer from HCL logged the boreholes and trial pits in accordance with the recommended procedures provided by document BS5930:1999 “Code of Practice for Site Investigations” (Ref. 4). Disturbed, undisturbed and environmental samples were collected from the exploratory holes, which were subsequently sent for geotechnical, chemical and contamination analysis with the testing scheduled by HCL.

Water was added to all boreholes to assist drilling so groundwater inflows were not apparent. Groundwater was recorded in TP1 at a depth of 2.9m, but there was insufficient inflow to allow sampling.

Furthermore boreholes BH1 and BH5 have been installed with groundwater and gas monitoring standpipes and an ongoing programme of monitoring is currently taking place over a three month period to allow the groundwater and gas levels to stabilise and to be recorded over a range of (short-term) climatic variations.

The full results of the gas and groundwater monitoring will be issued as a separate addendum to this interpretative report.

3.3 Laboratory Testing

Geotechnical and chemical laboratory testing was undertaken on selected samples taken from the boreholes and trial pits and are summarised in Table 3.1 below. Testing of all samples was scheduled by HCL and undertaken by an HCL appointed laboratory. The test results are discussed within Sections 5 to 8 of this report and are presented in full within the HCL Factual Report (Ref. 2). Asbestos presence was analysed as a precautionary health and safety measure due to the desk study identifying possible ACMs (Asbestos Containing Materials) as being present on site, and possibly residing in the ground following demolition of former buildings.

Table 3.1: Summary of Analysis Undertaken on Scheduled Samples

Type of Test	Standard	Number of Samples
Geotechnical Testing on Soil Samples		
Soil Moisture Content	BS1377:1990 Part 2:3	11
Atterberg tests	BS1377:1990 Part 2:4 & 5	11
Particle Size Distribution tests (PSDs)	BS1377:1990 Part 2:9	8
Consolidation Tests	BS1377:1990 Part 5	3
Point Load Tests	International Journal of Rock Mechanics, Science and Geomechanics, Abstract volume 22, No.2 pp 51 to 60, 1985	5
Unconfined Compressive Strength	ISRM Suggested Methods pp 111 to 116 1981	3
Compaction testing, 2.5kg rammer	BS1377:1990 Part 4	2
BRE Sulphate Suite	BRE Special Digest 1:2005	7
Type of Test	**Standard**	**Number of Samples**
Contamination Tests		
Soil		
arsenic, barium, beryllium, cadmium, chromium, nickel, lead, copper, zinc, mercury, lithium, magnesium, phosphorous, potassium, selenium, sodium, strontium, zinc	MCERTS Accredited	7
Total, complex and free cyanide, total phenols, sulphide and pH.	MCERTS Accredited	7
Speciated PAH (USEPA 16)	MCERTS Accredited	6
TPH GRO/DRO/MRO	MCERTS Accredited	6
TPH (Total Petroleum Hydrocarbons) 6 banded	MCERTS Accredited	6
Total pheols	MCERTS Accredited	6
PAH	MCERTS Accredited	6
Asbestos screen	MCERTS Accredited	1

4 GROUND CONDITIONS ENCOUNTERED

4.1 Summary of Strata Sequence

The typical strata sequence encountered across the proposed Exemplar Site has been summarised in Table 4.1, with the full exploratory hole logs presented within the HCL Factual Report (Ref 2). The material properties and engineering considerations of the strata encountered are discussed respectively in Section 5 of this report and the contamination testing is discussed in Section 6.

The strata sequence generally comprises of Topsoil overlying an orange-brown, superficial head deposits comprising of gravelly, sandy Clay with many cobbles and / or orange-brown, sandy, clayey Gravel and Cobbles. Below this superficial layer, yellow-grey, sandy Gravel, and in places yellow grey Clay was encountered. This layer is thought to be a completely weathered layer derived from the underlying limestone as it grades into a limestone rock with depth. Below this level, the stratum alternates between generally a moderately strong to strong limestone, interbedded with stiff Clay and Mudstone layers. The weathered and strong limestone rock with interbedded clay and mudstone layers combine to form part of the cornbrash formation.

The strata descriptions used in the factual report (Ref. 2) are in accordance with BS 5930:1999 (Ref. 4).

Table 4.1: General Sequence of Strata across Site

Stratum	General description of Stratum	Typical Depth Range (m bgl)
Topsoil	Topsoil	GL to 0.2m (Max. 0.3m)
Superficial/Head deposits	Red brown, clayey sandy gravel with cobbles, or in places gravelly sandy Clay with cobbles	To 0.6m (max 0.8m)
Completely Weathered Limestone	Recovered as yellow-grey, sandy Gravel and in places yellow grey Clay	To 1.9m, maximum 2.9m
Interbedded Limestone and Clays	Interbedded moderately strong to strong Limestone and stiff or hard Clay and mudstone	1.9 to >7m

4.2 Groundwater and Ground Gas

During the ground investigation at the Exemplar site, water was added to the boreholes to assist the rotary drilling process within the limestone rock to keep the drill bit cool and limit the rock dust generated. It was therefore not possible to carry out groundwater monitoring of the boreholes during the investigation. All of the six trial pits excavated were found to be dry apart from trial pit, TP 1 which struck water at a depth of 2.9m bgl, located immediately above what is thought to be the top of the interbedded Limestone/Clay. Water entered the TP1 pit as a slow trickle that was not sampled due to the low rate of inflow.

Gas and groundwater monitoring results following completion of the ground investigation at the Exemplar site are ongoing. A further two visits will be carried out as part of monitoring over the next three months of monitoring. Available results are presented within Table 4.2; the remaining monitoring results will be reported separately as an addendum report.

Table 4.2: Groundwater Levels from Monitoring Visit on 13/08/10

Borehole	Eastings	Northings	13/08/2010 (m bgl)
BH1	457493	225428	3.1
BH5	457618	224855	6.3

The results show that borehole, BH1 recorded a standing water level at 3.1m bgl and borehole, BH5 recorded a standing water level at 6.3m bgl. The 13th August monitoring visit suggests that excavations for foundations will not encounter groundwater as the excavation required for the proposed development will typically be limited to a depth of less than 2m bgl.

However, excavations during the ground investigation within the surrounding area were carried out following heavy rain and encountered shallower groundwater inflows above the limestone. Therefore, where foundations are based at shallow level on top of the limestone, some water inflow may be expected following heavy rain where the water is perched above the limestone.

During the ground water monitoring visit, gas measurements were taken from the boreholes, with the results showing that no methane was present and only a small concentration of carbon dioxide was present (max. 3.6% in BH5). The complete set of three month gas and ground water monitoring results will be issued as an Addendum report once the results have been obtained.

5 GEOTECHNICAL PROPERTIES

5.1 Introduction

A testing programme for soil samples recovered from the exploratory hole locations was scheduled by HCL and carried out by a designated laboratory, as specified by document BS1377:1990 "Methods of Tests for Soils for Civil Engineering Purposes" (Ref. 5). The results are summarised in this Section and included in full in the factual report (Ref. 2).

5.2 Superficial Deposits/Head

The superficial deposits/Head are generally consistent across the Exemplar site with a typical subsoil depth of 0.6m. The deposits predominantly comprise of a reddish/orange, brown clayey Gravel with cobbles, or in places a gravelly Clay with cobbles. Based on inspection of the trial and archaeological pits, the material composition varies with depth. When the ground level drops towards the streams or water courses, the granular content of the subsoil decreases and vice versa. Therefore at a higher elevation there is a much higher content of granular material, with increasing cobble content.

5.2.1 Laboratory Testing on Superficial Deposits/Head

One atterberg limits test and one moisture content test was carried out on a cohesive sample of the superficial deposits in trial pit, TP5. The material was found to be of intermediate plasticity with a plasticity index, PI value of 20%. The moisture content testing for the same material indicates a mc of 22%.

Five particle size distribution tests were carried out on the subsoil and indicate this material to comprise mainly silty/clayey, sandy gravel and some cobbles; although in places the cobble fraction is more dominant. Two compaction tests at 0.5m depth were carried out in the superficial deposits and the maximum dry density ranged from 1.65 mg/m^3 to 1.83mg/m^3 and optimum moisture content of between 13% and 16%.

In accordance with BRE Special Digest SD1 (Ref. 9), sulphate content and pH value testing was carried out on selected soil samples and the test results lie within the limit of Sulphate Design Class DS-1, as defined within the BRE guidelines. The minimum pH value is 6.4 and the maximum sulphate value is 100mg/l. The groundwater regime is considered as mobile, therefore an Aggressive Chemical Environment for Concrete (ACEC) classification of AC-1 is considered appropriate.

5.2.2 In Situ Testing in the Superficial Deposits

Two standard penetration tests, SPT's were carried out within the superficial deposits both giving SPT values in excess of 50 blows, suggesting that the superficial deposits are very dense (Ref. 6).

5.3 Completely Weathered Limestone

The completely weathered Limestone was generally recovered as a yellow-grey, sandy Gravel and yellow grey Clay. This material grades to a moderately weathered limestone with depth.

5.3.1 Laboratory testing on the completely weathered Limestone

Two atterberg Limit tests were carried out on the completely weathered limestone in trial pit, TP1 at 2.6m and in TP3 at 1.5m. Both tests indicate a high plasticity within this stratum, with PI values of 31% recorded for both samples. Moisture content testing carried out on these samples give mc values of 22% and 24%.

Three particle size distribution tests were carried out on the weathered limestone in TP1, TP4 and TP6. Tests indicate that the material is a silty /clayey, sandy Gravel with some cobbles.

5.3.2 In situ testing in the completely weathered Limestone

One SPT test was carried out within the completely weathered Limestone and gives an SPT value in excess of 50.

5.4 Interbedded Limestone

The Limestone was encountered in all exploratory holes, however due to the high strength of the material, excavation of the Limestone was not possible with the JCB 3CX. Rotary coring was used to investigate the limestone strata to depths of up to 7m.

The Limestone was generally moderately strong to strong, oolitic and frequently fossiliferous and grey, interbedded at medium spaced intervals with a stiff to very stiff or hard grey, silty Clay.

5.4.1 Laboratory testing on the interbedded Limestone

Eight atterberg limit tests were carried out on the Clays that are interbedded within the limestone at various depths in order to get a moisture content/Atterberg Limit profile. The tests indicate that the material is generally of intermediate plasticity, with PI values of between 23% and 26% recorded. One test result at depth gives a lower plasticity of 14%, chart 5.1 shows the mc/PI profile for Clays within the interbedded Limestone:

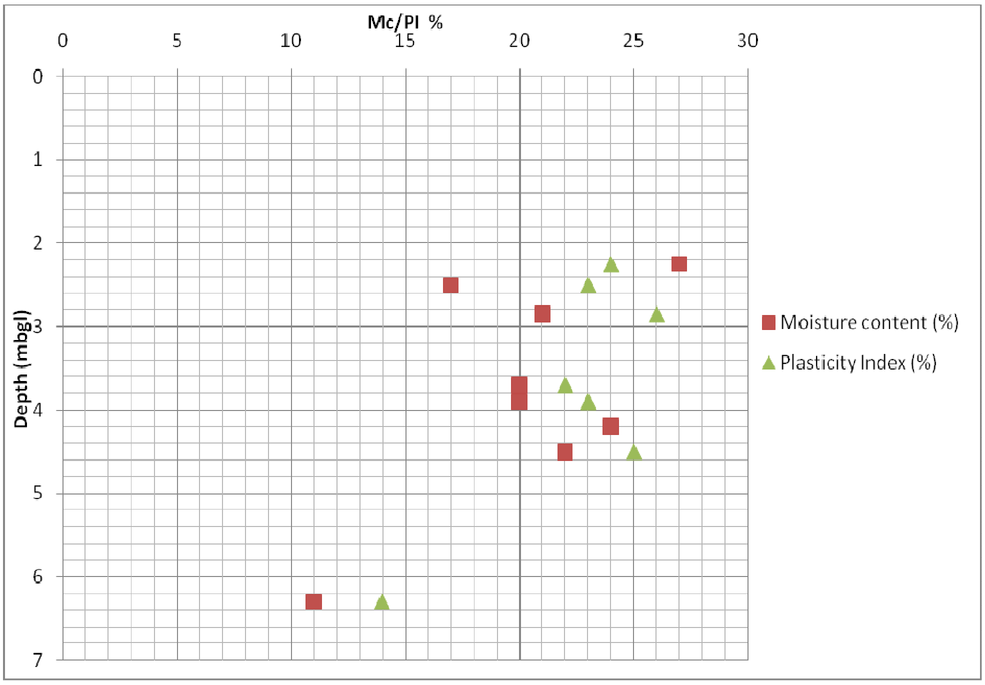

Chart 5.1 mc/PI profile for the interbedded Limestone

Moisture content testing was carried out on all of the samples tested for Atterberg Limits and give mc values of between 11% and 27%. One dimensional consolidation testing was carried out on three clay samples from the interbedded Limestone, from borehole BH1 at 4.5m, BH5 at 2.25m and from BH5 at 3.9m. Test results indicate a coefficient of volume compressibility (Mv) values ranging from 0.013 m^2/MN to 1.119 m^2/MN and coefficient of consolidation (Cv) values ranging from 0.678 m^2/yr to11.6 m^2/yr.

The minimum pH value in the interbedded Limestone is 6.4. and the maximum sulphate value is 240mg/l.

Point load tests indicate Point Load Indices ($I_{s(50)}$) of between 0.09MPa and 4.14MPa in a diametral direction and 0.22MPa and 3.98MPa in an axial direction.

Testing to determine the Unconfined Compressive Strength (UCS) of the limestone was carried out and indicates a UCS of between 19.3mpa and 39.8MPa.

5.4.2 In situ testing in the interbedded Limestone

Fourteen SPT tests have been carried out within the Limestone bands, thirteen of these giving results in excess of 50 blows. One anomalous result gives an SPT count of 28.

One SPT result is available within a Clay band within BH5 at a depth of 4.1m. This gives an SPT value of 38 which gives an undrained shear strength of 171kN/m^2 and indicates that this material is very stiff.

5.5 General

Geotechnical Parameters for each principal stratum type encountered within the boreholes are summarized in Table 5.1. These are based on available test results or published data. It is important that the accompanying notes and previous reports are read in detail when using this data for design and the construction process.

Table 5.1 – Summary of geotechnical properties

	Plasticity Indices			Natural Moisture Content	Undrained Cohesion	Effective angle of Shearing Resistance	Unconfined Compressive Strength	Standard Penetration Test	Concrete Class	Coefficient of volume compressibility /Coefficient of Consolidation
Strata	LL (%)	PL (%)	PI (%)	%	Cu (kPa)	Phi' (degrees)	UCS (MPa)	('N') value	DC/ACEC	(m²/MN)/(m²/year)
Superficial deposits cohesive	49	29	20	22	150 based on description	30 based on PI value	-	>50	AC-1	N/A
Superficial deposits Granular	-	-	-	-	-	40 (based on description SPT and BS 8002)	-	>50	AC-1	N/A
Weathered Limestone Granular	-	-	-	-	-	40 (based on description, SPT and BS 8002)	-	>50	AC-1	N/A
Weathered Limestone Cohesive	54-58	23-27	31	22-24	>150 based on description and SPT result	28	-	>50	AC-1	N/A
Interbedded Limestone Rock						40 (based on values published by Hoek and Bray)	19-40	>50	AC-1	
Interbedded Limestone Clay	29-46	15-23	14-26	11-24	>150 based on description and SPT result	28	-	38	AC-1	0.013 to 1.119 / 0.678 to11.6

5.6 Foundations

The exploratory hole logs indicate that shallow strip or pad foundations will be suitable for the proposed residential two storey site development shown in Figure 3.

Based on Atterberg testing, the cohesive strata on the Exemplar site are generally of between low and medium volume change potential. Foundation design should be carried out in conjunction with landscaping design and in accordance with the guidance provided in NHBC chapter 4.2 (Ref. 7) to ensure that no damage to foundations results from shrinkage/swelling of clays.

Due to the potential presence of medium volume change potential Clay beneath the Superficial Deposits, it is recommended based on NHBC chapter 4.2 that foundations are located at a minimum of 0.9m below ground level (where roots are noted / present then foundations should be extended below the level of the roots – see section 5.8.1), unless limestone is encountered at shallower depth.

There is some variability in the depth to the interbedded limestone across the site, so that when considering foundation types and loadings, consideration of differential settlement should be taken between those areas where limestone might lie directly beneath the foundation and where foundations are underlain by cohesive weathered limestone or Clays. Based on this variability in likely founding strata, strip foundations are not recommended for long rows of terraced houses without the inclusion of flexible movement joints and/or frequent gaps.

No Made Ground was recorded in any of the exploratory holes, however if Made Ground or soft material is encountered in any of the excavations for foundations then this material should be excavated and replaced with suitably compacted, granular fill. All shallow foundations should be inspected by a suitably qualified Geotechnical Engineer, to confirm that a suitable founding stratum is available.

5.7 Excavations

Prior to excavation, any utilities services are to be disconnected and removed under the footprints of the proposed areas of works. Excavations for foundations although slow in the dense gravel, should prove straightforward with a standard backhoe machine excavator, as proven by the trial pitting during the ground investigation.

All pits were stable during the ground investigation, water ingress occurred in one exploratory hole, TP1, however this was below the proposed depth of foundation excavation. Excavations for ground investigation within the surrounding area were carried out following heavy rain and encountered shallower groundwater inflow, above the limestone. Where foundations are based at shallow level on top of the limestone, some water inflow may be expected following heavy rain where the water is perched above the limestone, and some form of dewatering during temporary works may be required.

If any excavations for other infrastructure are required to greater depth, there is an increased possibility of encountering groundwater.

5.8 General Construction Issues

Should significant changes in ground level be required as part of the proposed development of the Exemplar site, the excavatability of the limestone must be considered, as the ground investigation proved that this material is extremely difficult to dig. The overlying superficial and weathered deposits also present difficult/slow digging conditions. Excavations for drains, services and infrastructure may also prove difficult and time consuming, particularly where the limestone is at a shallower depth.

Where the ground slopes steeply towards the water course that passes across the site in an east – west orientation, consideration of slope stability is required to ensure that no instability of the superficial deposits is induced through foundation loading, and/or cuttings for roads and other infrastructure. It is recommended that the foundations to proposed properties in steeply sloping areas are deepened to found below any potential zone of influence to the slope.

A badger sett is located in the centre of the site. The development must follow current guidelines, and the recommendations of the appointed ecologist when constructing in the vicinity of this habitat.

Any soft material encountered should not be re-used as backfill beneath any planned structures, road pavements, hard standing areas or other areas that may be sensitive to future settlement.

5.8.1 Building Near Trees

Where the development is proposed adjacent to existing or proposed planting, foundations should comply with the requirements of NHBC Guidelines Chapter 4.2 (Ref. 7). In which case, it may be necessary to extend the foundation depths quoted in Section 5.5.

5.8.2 Solution Cavities/Swallow Holes

Although no evidence of solution cavities or swallow holes were recorded during the preliminary ground investigation, these features may be present within the site, particularly in the limestone deposits. Any evidence of such features discovered during excavations should be investigated further by an experienced Geotechnical Engineer, and an appropriate remediation scheme adopted if deemed necessary.

5.9 Roads

The roads on site should be constructed in accordance with Design Manual for Roads and Bridges (DMRB) Volume 4, Section 1, Part 1 (HA44/91), (Ref 8) and Volume 7, Section 2, Part 2 (HD25/94). Further ground investigation should include CBR testing, once founding levels and layouts for the roads are known, in order to assist in the design of roads and bridges.

Particular care should be taken to avoid excessive trafficking in areas of proposed roads, and pavements should be constructed soon after excavation in order to limit deterioration and softening of the formation.

5.10 Radon Protection

As part of the Desk Study Report (Ref. 1), a detailed BR 211 Radon Report was obtained from the British Geological Survey (BGS), which states that basic radon protection measures are required for the site area as the estimated probability of a property being above the Action Level for radon is 3-5%.

Details on the technical specifications for basic radon protection measures are given in document BRE Report BR211 (Ref. 9).

5.11 Protection of Buried Concrete

The pH values tested in the superficial material are greater than 6.4 and the groundwater regime is considered as ‘mobile’ water. The laboratory testing for sulphate and pH has recorded results indicative of ACEC Class AC-1 as described in BRE Special Digest 1 3rd Edition, (2005).

5.12 Permeability Testing

Two falling head tests were undertaken within boreholes BH1 and BH2 at the Exemplar site.

Soakaway testing was undertaken in TP3, TP4 and TP6 within the limestone rock and indicates a coefficient of permeability (K) between 0 (failed test with limited or no soakage) and $3.95 \times 10^{-5} ms^{-1}$.

The full permeability test results are shown in the Hyder factual report (Ref. 2) and the Hyder Exemplar Site Drainage Strategy Report (Ref.3).

6 CONTAMINATED LAND

6.1 Introduction

This Section of the report relates to the potential risks to human health and controlled waters that development of the site may represent. This Section also describes:

- The current baseline conditions at the Exemplar site;
- Any potential impacts and the mitigation measures required to prevent, reduce or offset any potentially significant adverse effects; and
- The likely residual effects after these measures have been implemented.

To assist the understanding of the principles of this subject and their particular application within the context of the proposed development, it is recommended that the reader refers to the associated Hyder Consulting (UK) Ltd. (HCL) Desk Study Report (Ref. 1).

Establishment of Baseline Conditions

The baseline conditions for the Exemplar site and vicinity have been determined based on the Phase 1 Desk Study Report and from laboratory testing results obtained from the follow-up preliminary intrusive ground investigation undertaken on site in August 2010.

Assessment of Effects

The potential effects on the identified receptors from contaminants at baseline conditions at the Exemplar site have been assessed under the headings ‘Human Health Risk Assessment’, ‘Ground Gas Risk Assessment’ and ‘Controlled Waters Risk Assessment’.

6.2 Human Health Risk Assessment

The Statutory Guidance on Part IIA of the Environmental Protection Act 1990, as set out in DEFRA Circular 01/2006, and Contaminated Land Report 11 (CLR 11) form the basis on which this contaminated land assessment has been undertaken.

Current legislation and guidance on the assessment of potentially contaminated sites acknowledges the need for a tiered risk based approach comprising:

- Tier 1 Assessment: Comparison of site contaminant levels against generic standards and compliance criteria including an assessment of risk using a source-pathway-receptor model.
- Tier 2 Assessment: Derivation of site-specific risk assessment criteria and calculation of site-specific clean-up goals.

The assessment has therefore been undertaken in a phased approach, focussing initially on the Tier 1 Assessment. The Tier 1 assessment includes the following stages, which were completed where applicable:

- Zoning of data/site averaging areas;
- Maximum Concentration Assessment - comparison of maximum detected concentrations against relevant Generic Assessment Criteria (GAC);
- Mean and Maximum Value Statistical Analysis – consideration of statistical outliers and 95% Upper Confidence Levels (UCLs) against relevant GAC;

- Risk Evaluation/Assessment of Significant Results; and
- Identification of the need for Tier 2 Assessment and derivation of Site Specific Assessment Criteria (SSAC).

The current philosophy in the assessment and remediation of contaminated land in the UK is to adopt an 'end use' approach whereby the significance of contamination at a site is evaluated according to either the existing use or to a proposed development end use.

For the Tier 1 Assessment, Environment Agency published generic Soil Guideline Values (SGVs) derived using the Agency's CLEA model, was used. Where these are not available, GAC published by LQM/CIEH were utilised (Ref 11).

The assessment criteria relevant to the standard sensitive receptor setting within the CLEA model has been used i.e. a female receptor aged 1 to 6 years, a residential building (small terraced house) and a sandy loam soil with a pH7 and SOM 1%. Given the proposed site end use, the stringent "residential with plant uptake" land use scenario has been adopted.

Zoning of Data/Site Averaging Areas

The development is expected to comprise predominantly residential properties, therefore the site has been considered to comprise one zone and averaging area for the purposes of this assessment.

Tier 1 Assessment

In order to focus on contaminants of potential concern (COPC), the laboratory testing results have been compared with the respective SGVs/GAC. The results and respective screening criteria are presented in Tables 6.1 to 6.4.

Any contaminants that exceed the SGVs/GAC are considered to be COPC. Those that do not exceed the respective SGVs/GAC are not considered to be COPC and do not require further assessment in relation to the proposed development of the site.

Table 6.1 Summary of Analytical Chemical Testing Results (Inorganic)

Determinand	Number of Samples Tested	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)	SGV/GAC (mg/kg) Res. with Plant Uptake	No. of Exceedances
Arsenic	7	10.5	21	32(1)	0
Barium	7	21	221	1300(2)*	0
Beryllium	7	0.4	3.7	51(2)	0
Cadmium	7	<0.2	0.4	10(1)	0
Chromium	7	11.3	31	3000(2)	0
Copper	7	7.1	17.1	2330(2)	0
Lead	7	7	68.8	450(3)	0
Mercury	7	<0.5	<0.5	1(1)	0
Nickel	7	16.4	28.9	130(1)	0
Selenium	7	<0.5	0.6	350(1)	0

Zinc	7	18.5	65	3750(2)	0
Cyanide (free)	7	<0.5	<0.6	53(2)	0
Cyanide (complex)	7	<0.5	<0.6	266(2)	0
Asbestos	1	Not detected	N/A	N/A	N/A

1 EA published SGV
2 LQM/CIEH published GAC (2nd Edition)
3 Previous EA published SGV (currently withdrawn)
*Residential without plant uptake scenario

Table 6.2 Summary of Analytical Chemical Testing Results (PAH)

Determinand	Number of Samples Tested	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)	GAC (mg/kg) Res. with Plant Uptake	No. of Exceedances
Naphthalene	6	<0.1	<0.1	1.5(1)	0
Acenaphthylene	6	<0.1	<0.1	170(1)	0
Phenanthrene	6	<0.1	1.6	92(1)	0
Benzo(a)anthracene	6	<0.1	2.3	3.1(1)	0
Benzo(b)fluoranthene	6	<0.1	1.9	5.6(1)	0
Benzo(k)fluoranthene	6	<0.1	1.1	8.5(1)	0
Benzo(ghi)perylene	6	<0.1	2.0	44(1)	0
Pyrene	6	<0.1	4.5	560(1)	0
Benzo(a)pyrene	6	<0.1	<0.1	0.83(1)	0
Fluorene	6	<0.1	0.2	160(1)	0
Fluoranthene	6	<0.1	4.9	260(1)	0
Acenaphthene	6	<0.1	<0.1	210(1)	0
Anthracene	6	<0.1	0.6	2300(1)	0
Chrysene	6	<0.1	2.4	6(1)	0
Dibenzo(ah)anthracene	6	<0.1	0.3	0.76(1)	0
Indeno(123cd)pyrene	6	<0.1	1.6	3.2(1)	0
Total PAH (USEPA 16)	6	<1.40	<1.53	No value	N/A

1 LQM/CIEH published GAC (2nd Edition)

Table 6.3 Summary of Analytical Chemical Testing Results (TPH)

Determinand	Number of Samples Tested	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)	GAC (mg/kg) Res. with Plant Uptake	No. of Exceedances
Gasoline Range Organics (GRO)					
C5-6	6	<0.2	<0.2	30 (1)	0
C6-7	6	<0.2	<0.2	73 (1)	0
C7-8	6	<0.2	<0.2	73 (1)	0
C8-10	6	<0.2	<0.2	19 (1)	0
Aliphatic Fractions					
C8-10	6	<4	<5.25	19 (1)	0
C10-12	6	<4	<5.25	93 (48) (1)	0
C12-16	6	<4	5.03	740 (24) (1)	0
C16-21	6	<4	<5	45000 (8.48) (1)	0
C21-35	6	<9.61	<10.43	45000 (8.48) (1)	0
Aromatic Fractions					
C8-10	6	<4	<5	27 (1)	0
C10-12	6	<4	<5	69 (1)	0
C12-16	6	<4	<5	140 (1)	0
C16-21	6	<4	<5	250 (1)	0
C21-35	6	<9.61	<10.43	890 (1)	0

Table 6.4 Summary of Analytical Chemical Testing Results for Soils (BTEX)

Determinand	Number of Samples Tested	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)	GAC (mg/kg) Res. with Plant Uptake	No. of Exceedances
BTEX					
Benzene	6	<0.01	<0.01	0.33 (1)	0
Toluene	6	<0.01	<0.01	610 (1)	0
Ethyl Benzene	6	<0.01	<0.01	350 (1)	0
m/p-Xylene	6	<0.01	<0.01	230 (1)	0
o-Xylene	6	<0.01	<0.01	250 (1)	0

1 LQM/CIEH published GAC (2nd Edition)

Values in blue are solubility saturation limits. Values in green are vapour saturation limits.

Contaminants of Potential Concern

There are no contaminants that exceed the respective SGVs/GAC.

Human Health Risk Assessment Conclusions

None of the contaminants tested returned values greater that the respective SGVs/GAC, therefore the soil that has been tested is deemed suitable for use in gardens (including growing edible plants) without the need for treatment or other remedial action.

During site construction works, site workers should remain vigilant to the possible risk of encountering isolated areas of contaminated material. Should potentially contaminated material be encountered, further testing will be required to assess the risks to the health and safety of site workers and the environment. All persons engaged in site construction works should be made aware of the findings of the intrusive investigation and the hazards associated with handling potentially contaminated materials. It is recommended that all works are conducted in accordance with the Health and Safety Executive publication entitled “Protection of Workers and the General Public during the Development of Contaminated Land” (Ref. 13).

6.3 Ground Gas Risk Assessment

It should be noted that, in accordance with current best practice and guidance, the number and frequency of ground gas monitoring rounds is dependent on the sensitivity of the development and the generation potential of any ground gas source. In this case, the ground gas monitoring programme has been devised in order to establish a preliminary indication of the ground gas regime at the site.

Monitoring of the ground gas regime is to be undertaken on 4 occasions between August and November 2010. The full results are to be included in the associated Addendum to the Hyder Consulting Factual Report (Ref. 2).

The results of monitoring have and will be assessed using the current guidance document: CIRIA C665 “Assessing Risks Posed by Hazardous Ground Gases to Buildings” and BS8485:2007 “Code of Practice for the Characterization and Remediation from Ground Gas in Affected Developments”.

Gas Screening Values (GSV)/hazardous gas flow rates for methane and carbon dioxide have been calculated and are summarised in Table 6.5. The corresponding Characteristic Gas Situation (CGS) is also presented in this table. It is understood that the proposed development is to comprise mainly residential houses and therefore the CGS for ‘Situation A’, defined in the guidance as ‘*all development types except those in Situation B*’ has been considered (Situation B is defined as ‘*low rise housing with a ventilated underfloor void*’).

Table 6.5 Maximum Gas Concentrations (Borehole 5) and GSVs

Max. CH_4 (v/v %)	Max. CO_2 (v/v %)	Max. Flow Rate (l/h)	Max. CH_4 GSV (l/h)	Max. CO_2 GSV (l/h)	Characteristic Gas Situation A
0	3.6	0.3	0	0.0108	1

Radon Gas

The above gas situation does not account for radon. As such, as part of the Desk Study Report, a detailed BR 211 Radon Report was obtained from the British Geological Survey (BGS), which states that basic radon protection measures are required for the site area. This is because the estimated probability of a property being above the Action Level for radon is 3-5%.

Details on the technical specifications for basic radon protection measures are given in document BRE Report BR211: Radon – Guidance on Protective Measures for New Buildings (Ref. 9).

Ground Gas Risk Assessment Conclusions

The results of the gas monitoring to date indicate a very low risk classification for the proposed development from methane and carbon dioxide. However, basic radon protection measures will be necessary in the construction of all new dwellings or extensions on site. Once the addendum report is available for the gas monitoring and risk assessment, the recommendations in the addendum should supersede the guidance in this section.

6.4 Controlled Waters Risk Assessment

The Controlled Waters Risk Assessment (CWRA) has been undertaken in accordance with the guidance suggested in the Model Procedures for the Management of Land Contamination (Contaminated Land Report 11, CLR 11) and comprised a staged approach (referred to as 'Levels'). A Level 2 Assessment has been undertaken for the purposes of this CWRA. For information, all Levels (1 to 4) are summarised in Table 6.6 below.

Table 6.6 – Quantitative Risk Assessment Levels

Level	Soil	Groundwater
1	Pore water contamination compared directly to receptor target concentration	Not applicable
2	Attenuation in unsaturated zone and dilution at the water table	Groundwater below source - groundwater data is compared directly to target concentrations
3	Attenuation in the aquifer	Attenuation and down gradient receptor or compliance point – groundwater concentration at the receptor/compliance point is predicted using numerical modelling
4	Dilution in the receptor	Dilution in the receptor - dilution in a receiving watercourse or pumping abstraction borehole (only with approval of EA)

The basis for the screening criteria is to ensure that the selected screening values are protective of the identified receptor. For groundwater the general approach is to use an environmental standard as experience shows that remediation of contaminated groundwater to background quality is not achievable (Environment Agency 2006a). The standard should be relevant to the current and future receptors and the standards compliance criteria should be considered.

Standards that are applicable to this study are:

- UK Environmental Quality Standards (EQS) for the protection of aquatic life (in both freshwater and saline environments);
- UK Water Supply (Water Quality) Regulations, 2000 and 1989.

The groundwater beneath the site is considered to be the receptor in the first instance and therefore the UK Drinking Water Standards (UKDWS) have been selected as the appropriate screening criteria for the Level 2 Assessment.

Level 2 Assessment

The Level 2 Assessment has been undertaken assuming that there is one hydrogeological unit (at a depth affected by the development) underlying the site (groundwater within the Cornbrash Formation Secondary ‘A’ Aquifer).

There are no contaminants that exceed their respective UKDWS.

Controlled Waters Risk Assessment Conclusions

As noted none of the contaminants tested returned values greater that the respective UKDWS, therefore the waters that has been tested indicate that no remedial action with regards to ground water is required.

7 Description of Existing Baseline Conditions

The Desk Study Report (Ref. 1) was undertaken for the entire NW Bicester Masterplan eco development site (which encompassed the Exemplar site) to determine likely soil, groundwater and contamination conditions.

A summary of the findings from the Desk Study Report and ground investigation, as relevant to the Exemplar site, is as follows:

- Since the earliest available historical map of 1881 to the present day, the site has been dominated by agricultural activity.
- There are two streams on site; one minor, unnamed stream (flowing in a NW to SE direction), which feeds the N to S flowing River Bure in the southern part of the site.
- Geologically, the site is summarised as follows:
  - 0-0.2m thickness of Topsoil;
  - 0.2-0.6m (up to 0.8m deep in places) of Subsoil, comprising an orange/brown gravelly/sandy Clay or sandy clayey Gravel;
  - 0.6m to 1.9m (up to 2.9m deep in places) of yellow sandy Gravel and in places yellow/grey Clay, grading to completely weathered Limestone (Cornbrash Formation);
  - From 1.9 to 7m depth, alternating Limestone and Clay bands of the Cornbrash Formation are represented.
- No water strikes were recorded within the Cornbrash formation or superficial deposits during drilling. Follow-up groundwater monitoring recorded groundwater standing at in excess of 3m depth on average.
- There are no historic or current sources of industrial activity; farming being the only use of the land. If contamination is present on site, it is not expected to be widespread or significant. However, naturally occurring radon is present and basic radon protection measures will be required for the construction of new dwellings and extensions.

The intrusive ground investigation undertaken on site confirms that there are no contaminants present above the relevant human health and controlled waters assessment criteria, therefore the baseline conditions on site are such that remedial action in terms of contamination is not necessary prior to redevelopment.

7.1 Design and Mitigation

In the following section, the criteria used to define the significance of the effects, both adverse and beneficial, are:

- Major impact – where the development would cause a large change to the existing environment;
- Moderate impact – where the development would cause a noticeable change to the existing environment;
- Minor impact – where the development would cause a small change to the existing environment; and
- Neutral – where no impact will occur on the environment.

7.1.1 Construction

Effects likely to arise on-site through construction activities are outlined below. All construction works have the potential to generate the following potential effects relevant to this assessment:

- Creation of areas of contamination e.g. through spillage;
- Waste generation;
- Dust generation;
- Risk to contamination of workers; and
- Mobilisation of contamination and migration into controlled waters.

As the contamination testing has not identified any COPC, it is not considered that construction work will lead to exposure of construction workers and members of the public to any existing contamination present within soils, nor is it expected that the work will mobilise existing contaminants into ground or controlled water (surface water and groundwater). However, the scale of the site is such that complete coverage of all land area during the ground investigation was uneconomical and impractical, and as such, there is always a possibility that contaminants may be present in previously unexplored areas. These possibilities are discussed below in the context of existing site conditions, i.e. pre-remediation:

7.1.2 Dust

Whilst likely not contaminated, dust and silt can result from ground disturbance during construction, which can lead to accidental ingestion, dermal contact or inhalation of particles by site workers and possibly the general public. In some cases, generation of dust and silt may also lead to deposition on nearby surface waters. These risks would be most severe in the event that construction works were to take place on contaminated land, however, as previously stated it is considered unlikely that the site is contaminated.

As no significant contamination sources have been identified, **the impact is assessed to be neutral to minor adverse**. Nevertheless, mitigation measures such as damping down, covering of stockpiles, use of wheel washes and covering of lorries during transportation will be implemented as part of a general, good site management plan to ensure that the potential effects associated with airborne dust are minimised.

7.1.3 Water

Construction activities can result in the mobilisation of contaminants within the soil and the creation of a pathway for contaminants to migrate to underlying groundwater. Pathways can also be created for the transport of contaminants to surface water via airborne dust and through overland flow from poorly managed stockpiles. However, as previously stated, negligible contaminant concentrations in the soil and groundwater have been measured in the explored areas of the site, therefore it is considered unlikely that the construction works will introduce new contamination from the shallow soil to the underlying Secondary ‘A’ Aquifer (Cornbrash Formation) and the two on-site streams. **The impact is assessed to be neutral**.

7.1.4 Work in Previously Unexplored Areas

In the event that construction activities are undertaken in areas where previously unknown contamination is encountered during construction, a management strategy would be devised to ensure that any risks associated with its mobilisation are minimised. If required, suitable arrangements for stockpiling will be implemented to minimise the potential for the leaching of contaminated liquids and run-off of sediment through loading and exposure to rainwater. Mitigation measures will include stockpiling in bunded areas underlain by impermeable material away from watercourses. Stockpiles will be covered to prevent leaching of the material.

If excavation works are undertaken in areas where locally contamination water is identified, water may enter the excavations and lead to contaminants migrating vertically and horizontally. Abstraction of potentially contaminated water from excavations will need to be controlled to prevent cross contamination of soils and potential impact upon the Secondary ‘A’ Aquifer. Mitigation could include the abstraction and disposal of water to a foul sewer or to surface water following appropriate treatment (and with the appropriate consent in place).

It is prudent in unexplored areas for a suitably qualified Geo-environmental Engineer to be present during the construction works tasked with a watching brief, in order to ensure that correct measures are taken if unexpected contamination is encountered.

7.1.5 Waste

In general, material removed from an excavation will not normally be regarded as waste if:

- It is intended to be reused on site and meets risk based values;
- It is suitable for use as backfill and meets risk based values; and
- It does not need to be processed before it can be reused.

In such cases, the material is unlikely to be subject, at that point in time, to the duty of care for waste and environmental permitting. This should be agreed with the Environment Agency Waste Officer prior to works commencing. The document published by CL:AIRE The Definition of Waste: Development Industry Code of Practice provides further details about the criteria which should be meet for re-use of soils on site.

If it is not possible to reuse excavated material on site, then off-site disposal to an appropriately licensed landfill may be required. In this case, due consideration should be given to the UK Landfill Directive. Furthermore, any materials without a defined use on site can be considered as waste.

As of July 2009, the final phase of the landfill regulations from 2002 came into force and developers should be aware of the impact that it could have on their developments.

With measures already in place, the final phase of the regulations means that specified wastes can no longer be disposed off site to landfill and all wastes intended for landfill must receive prior treatment. Options for treatment (which include chemical, biological, mechanical separation and sorting) exist for most wastes and exemptions to this requirement are only limited to: inert wastes where treatment is not technically possible and wastes where viable treatment would not reduce the quality or the hazard(s) posed to human health or the environment.

The basic Government policy applies in the management of waste, and sites should adhere to the following protocol:

I. Reduction of the waste generated by managing the development to keep the amount of 'waste soil' to a minimum;

II. Re-use or re-distribution of soil on site (this will require the necessary authorisation);

III. Recovery or recycling by way of treatment on site (this will require the necessary authorisation); and finally

IV. Disposal, following pre-treatment (with necessary authorisation) to landfill.

If, having followed the above hierarchy, off-site disposal of soil is necessary; there is a requirement to determine whether the waste soil is "hazardous" or "non-hazardous". This is undertaken by means of CATWASTE^{SOIL}, as described below.

CATWASTESOIL

The results of the investigation have been input into CATWASTE^{SOIL} (Ref. 14), which has determined from the total contaminant concentrations that the soil is non-hazardous.

Disposal

The geology identified at the site indicates that shallow spread foundations may be suitable for all anticipated low-load structures; therefore, the generation of spoil is expected to be minimal.

It is anticipated that any spoil generated may be reused on site for landscaping or other purposes, therefore it is expected that only minimal volumes of material may require disposal off-site.

In general, for offsite disposal, Waste Acceptance Criteria (WAC) testing is necessary once a waste has been characterised as hazardous or if a non-hazardous waste is to be disposed at an "inert" landfill site. Non-hazardous waste does not require WAC testing unless disposal to an "inert" landfill is being considered.

In the event that large volumes of material will require off-site disposal, WAC testing is recommended to confirm whether the material is inert and can therefore be disposed at an "inert" landfill (thereby attracting less landfill tax).

7.1.6 Accidental Spillage of Construction Related Material

During any construction work, there always some potential for accidental spillage of contaminated materials. The main source of spillages is considered to be from construction plant and materials stored on site, particularly fuel and lubricating hydrocarbons. **The impact is assessed as neutral to minor adverse** depending on the nature, frequency and volume of the spillage. Mitigation measures will include the storage of chemicals and contaminative material in accordance with the Environment Agency guidance; regular servicing and inspection of vehicles used on-site; restriction of refuelling of vehicles to bunded areas underlain by hard standing, or other impermeable materials and the restriction of vehicle movements within close proximity of the surface watercourses.

Overall, it is considered that the effect during construction will be neutral to minor adverse.

7.1.7 Operation

For the proposed primarily housing end use, it is expected that receptors will come into regular contact with the soil, therefore potential for accidental ingestion, dermal contact or inhalation of dust particles exists. However, as no contaminant sources have been identified from the historical or current use of the site (confirmed by laboratory testing of the soil and groundwater) **the impact is assessed as neutral**. If contaminated material were discovered in previously unexplored areas of the site, remedial measures would be implemented where a complete pollution linkage would be possible, e.g. if contaminated soil were discovered in an area earmarked for residential gardens, then appropriate remedial action would occur, such as excavating the soil and replacement by clean material. Alternatively, a cover system could be employed.

It is anticipated that a small proportion of the site may contain retail/leisure facilities. During operation, there may be limited potential for accidental spillage of potentially contaminating materials from delivery locations and plant operational locations. Due to the expected hard standing in these areas with appropriate drainage infrastructure and the adoption of standard materials handling and storage procedures, **the impact is assessed as neutral**.

Overall, it is considered that the effect during operation would be neutral.

7.2 Assessment of Residual Effects

7.2.1 Construction and Operation

In those areas of the site covered by the intrusive ground investigation, no contaminated soil or groundwater was discovered. In those unexplored areas of the site, it cannot be conclusively stated that there are no contaminants present. However, should localised contaminated areas be encountered, the degree of contamination is not expected to be significant, and it is considered that the previously described mitigation measures would significantly reduced or completely mitigated any potential impacts. No residual effects are identified.

7.3 Summary

The intrusive ground investigation has demonstrated that no elevated concentrations of contaminants are present in the soil or groundwater in explored areas of the site. In unexplored areas of the site, the Desk Study Report indicates that it is unlikely that contaminants will be present in significant concentrations.

Construction impacts are considered to be neutral to minor adverse and will be mitigated thorough the use of appropriate PPE and good site management practices.

Operational impacts are considered to be neutral and therefore require no mitigation measures.

Overall, the contamination risks associated with the Exemplar site are considered to be very low, though the risks from naturally occurring radon gas require basic radon protection measures to be incorporated in the construction of new dwellings and extensions.

8 CONCLUSIONS

8.1 Ground and Groundwater Conditions

The ground investigation generally confirms the expected geology, the site being underlain by Topsoil overlying granular and in places cohesive superficial/head deposits to a depth of 0.6m, with weathered limestone (Possibly the Cornbrash formation) to depths of up to 2.9m and interbedded Limestone and Clay below the weathered layer. Laboratory and in situ testing of the soils has been carried out and are discussed in section 5.

Groundwater was encountered in exploratory hole TP1 at a depth of 2.9m within the Limestone beds, and following heavy rain, in other trial pits carried out in the surrounding area, groundwater was encountered as a perched water table above the limestone.

In subsequent monitoring visits, ground water was encountered at depths of 3.1m and 6.3m in BH1 and BH5 respectively.

8.2 Engineering Considerations

Shallow foundations are expected to be a suitable option for residential and low rise structures proposed at the site, however suitable precautions should be taken in line with NHBC Foundation guidance with respect to the presence of medium volume change potential cohesive strata. In areas of low grade sloping ground, slope stability must be considered when assessing structural loadings and any road cuttings.

Excavations for foundations and infrastructure should prove straightforward, though if deeper excavations are required, extremely difficult digging conditions are likely to be encountered below the top of the interbedded Limestone/Clay strata. Excavation sides are expected to remain stable, except following heavy rain and are expected to be dry up to <2m below ground existing level.

Excavations should be inspected by a suitably qualified geotechnical engineer to confirm that a suitable formation is present. Any soft or Made Ground materials should be removed to prevent differential settlement. Due to the variable depth to the interbedded Limestone and Clays, it is recommended that strip foundations be designed to prevent differential settlement, with movement joints incorporated. Test results for concrete classification to BRE standards for sulphate and pH testing has recorded results indicative of ACEC Class AC-1.

8.3 Contamination

None of the soil or water samples analysed contained contaminant concentrations above the relevant, corresponding screening values and no noteworthy elevated ground gas concentrations were observed. As such, the risks posed to human health and the environment is considered to be very low and no remedial action is required.

The risks posed to humans including site and maintenance workers are considered to be very low from pre-construction contamination. However, contamination from materials brought on to site during the construction phase must also be considered as harmful to human health and the environment.

9 REFERENCES

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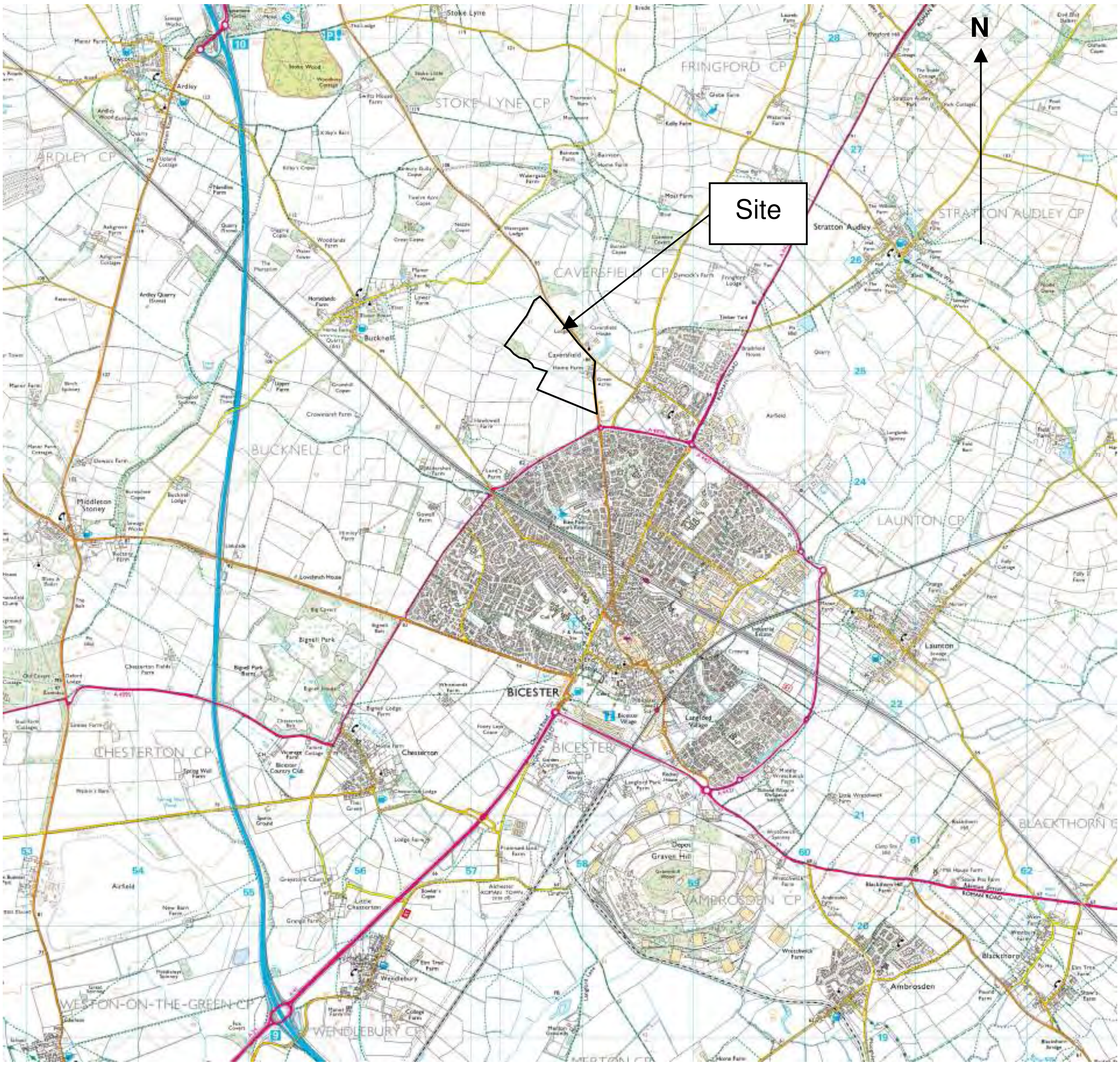
Figures



Client	Project	
a2dominion P3Eco Ltd	Bicester Eco Town Exemplar Site	Hyder Consulting
	Title Site Location Plan	

Hyder Consulting Ltd
5th Floor, The Pithay, All Saints St
Bristol BS1 2NL

Tel: 0870 000 3003
Fax: 0870 000 3903

Scale	Datum	Project Code	Drawing Number	Issue
N/A	N/A	UA001881	001	A

KEY

ACCESS ROUTES TO EXPLORATORY LOCATIONS

MR PHIPPS

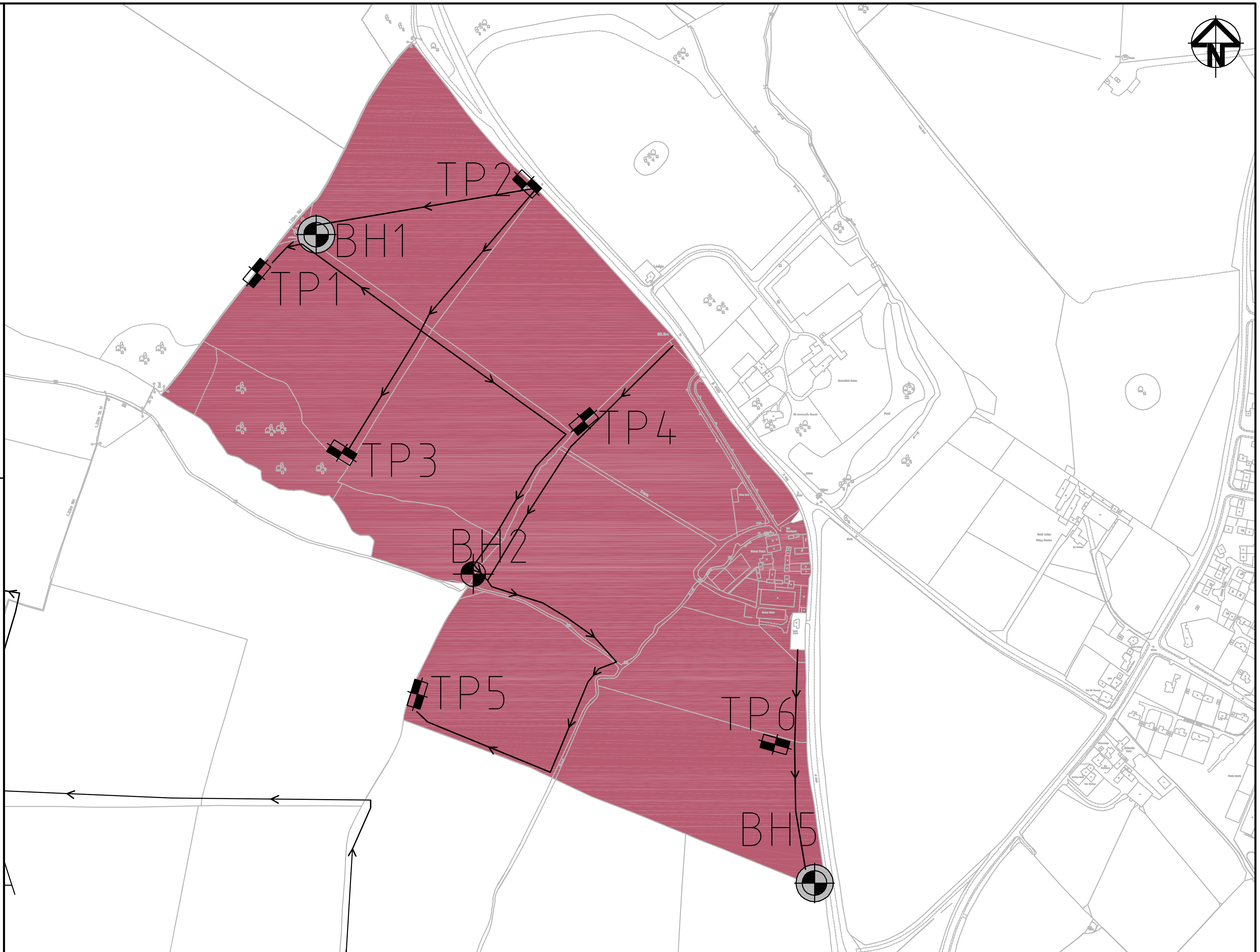
PROPOSED EXPLORATORY HOLES NOT COMPLETED DUE TO ACCESS RESTRICTIONS

BH4 ROTARY BOREHOLE - ALL CORED TO 7.0m

TP1 TRIAL PIT

BH4 ROTARY BOREHOLE - ALL CORED TO 7.0m WITH MONITORING WELLS

TP8, BH4A AND BH4 ARE APPROXIMATE LOCATIONS ONLY. ALL OTHER LOCATIONS RECORDED USING GPS.



Issue	Description	Date
01	FIRST ISSUE	16/09/10

Client

a2dominion

P3Eco Ltd

Status **PRELIMINARY** NOT TO BE USED FOR CONSTRUCTION

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		Author R.JORDAN	
Original Size	A3	Checker D.THOMAS	
Height Datum	-	Approver C.PLUMB	
Grid	GRID	© Copyright reserved	
Filename	2004-UA001881-UP33D-01.DWG		

Project

BICESTER ECO TOWN

Title

EXEMPLAR SITE WITH EXPLORATORY HOLE LOCATIONS

Hyder Consulting

Hyder Consulting (UK) Limited
29, Bressenden Place
London
SW15 5DZ

Tel: +44 (0)870 000 3006
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Drawing No.	Project No.	Issue
2004	UA001881	01

50mm on Original

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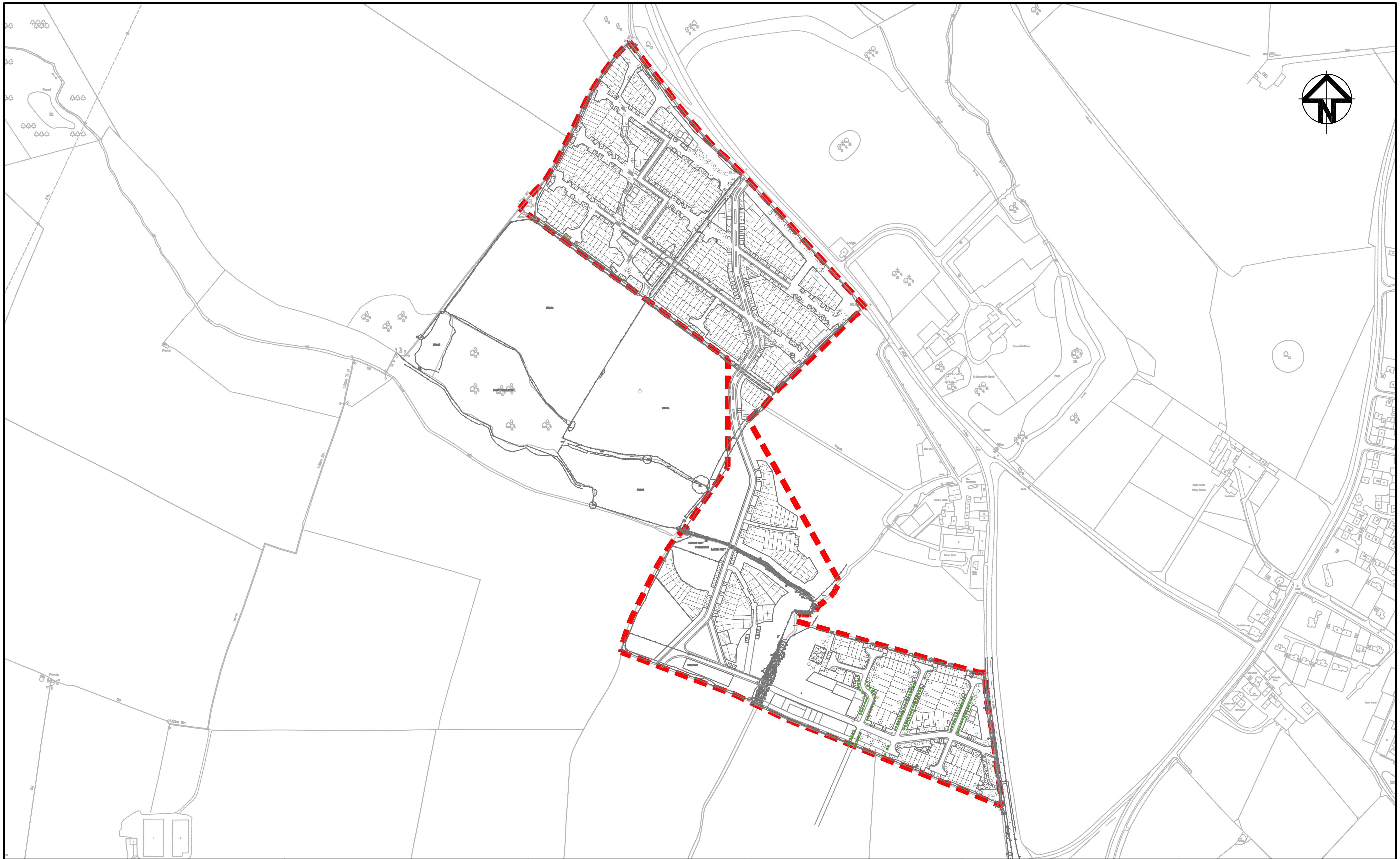

Issue	Description	Date

KEY

EXEMPLAR BOUNDARY

NOTE:

HOUSING LAYOUT IS ILLUSTRATIVE ONLY

Client

a2dominion

P3Eco Ltd

Status	PRELIMINARY		
Scales	1:5000	Current Issue Signatures	
		Author M.LLEWELLIN	
Original Size	A3	Checker M.LUNDIE	
Height Datum		Approver M.LUNDIE	
Grid	GRID	© Copyright reserved	
Filename:	FIGURE 3-EXEMPLAR PLAN AREA.DWG		

Project

BICESTER ECO TOWN

Title

EXEMPLAR SITE

Hyder Consulting

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Drawing No.	Project No.	Issue
FIGURE 3 —	UA001881 —	01

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29/Sep/2010 10:43 AM K:\UA001881_BicesterEco\E-OurDrawings\Geotech Interp Report Figures\FIGURE 3-EXEMPLAR PLAN AREA.dwg V1

Appendix A: Risk Assessment Definitions

Risk assessment considers the identified sources, the potential receptors and the pathways linking them together.

In the pollutant linkage table of this report, the column designated as 'Hazard (severity)' gives an indication of the sensitivity of a given receptor to a particular source being considered. It is a worst case classification and is based on full exposure via the particular linkage being examined. The derivation of the classes used to rank this particular aspect are given in the table below

Classification of Potential Consequence (Severity)

Classification	Human Health	Controlled Water	Built Environment	Ecosystems
Severe	Irreversible damage to human health. Short term (acute) risk to human health likely to result in "significant harm" as defined by Part 2a.	Substantial pollution of sensitive water resources	Catastrophic damage to buildings, structures or the environment	A short-term risk to a particular ecosystem or organism forming part of such ecosystem.
Medium	Chronic damage to human health. Non-permanent health effects to humans	Pollution of sensitive water resources or small scale pollution of sensitive water resources	Damage to buildings, structures or the environment	A significant change in a particular ecosystem or forming part of such ecosystem
Mild	Slight short term health effects to humans	Pollution to non-sensitive water resources	Damage to sensitive buildings, structures services or the environment.	Significant damage to crops
Minor	Non permanent health effects to human health (easily prevented by means such as personal protective clothing etc)	Insubstantial pollution to non-sensitive water resources	Easily repairable effects of damage to buildings or structures	Harm (although not necessarily significant harm which may result in financial loss or expenditure to resolve. e.g. loss of plants in a landscape scheme.

Subsequently, in the column entitled 'Likelihood of Occurrence", in the Pollutant Linkage table, an assessment is made of the probability of the selected source and receptor being linked by the identified pathway. This assessment is ranked based on site specific conditions as detailed in the table that follows

Classification of probability

High likelihood	There is a pollution linkage and an event that either appears very likely in the short term and almost inevitable over the long term or there is evidence at the receptor of harm or pollution.
Likely	There is a pollution linkage and all the elements are present and in the right place, which means that there us a probable that an even will occur. Circumstances are such that an event is not inevitable, but possible in the short term and likely over the long term.
Low Likelihood	There is a pollution linkage and circumstances are possible under which an even could occur. However it is by no means certain that even over a longer period such event would take place and in less likely in the shorter term.
Unlikely	There is a pollution linkage but circumstances are such that it is improbable that an event would occur even in the very long term.

In the Pollutant Linkage table of this report, the 'Potential Risk' column is an overall assessment of the actual risk, which considers the likely consequence of a given risk being realised and the likelihood of that risk being realised. The risk classifications are assigned using the following consequence/likelihood matrix:

Potential Consequence				
Severe	Moderate/Low	Moderate	High	**Very High**
Medium	Low	Moderate/Low	Moderate	High
Mild	Very Low	Low	Moderate/Low	Moderate
Minor	Very Low	Very Low	Low	Moderate/Low
Likelihood	**Unlikely**	**Low**	**Likely**	**High**

Table below describes the risk classifications

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