

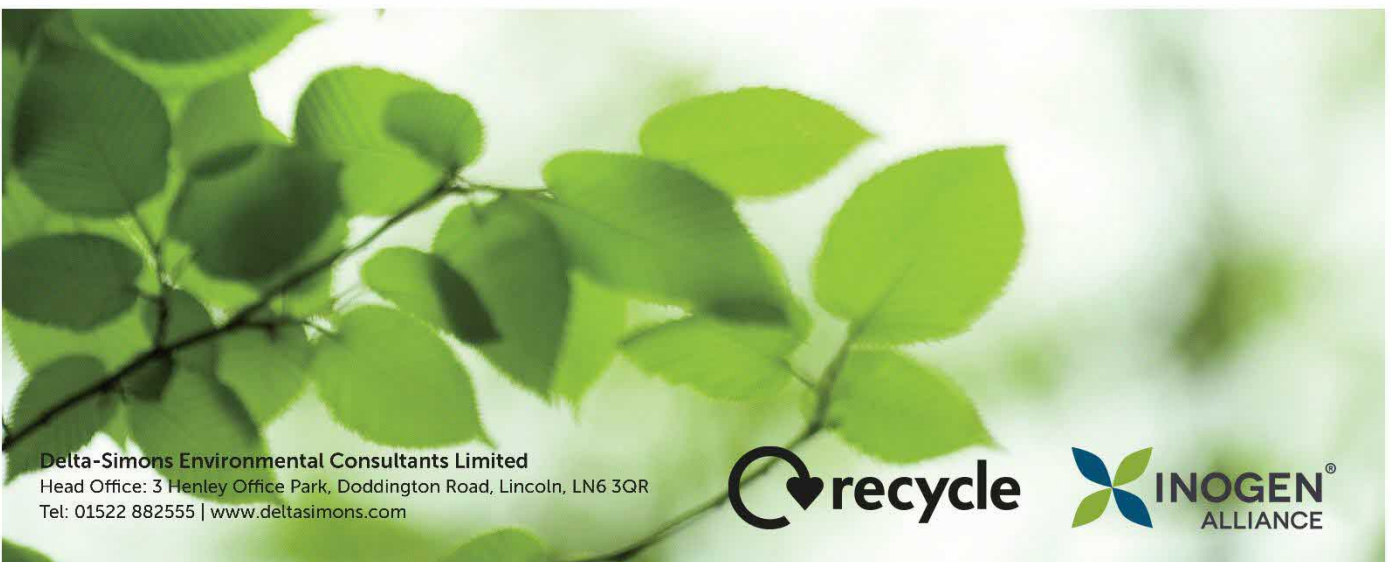
Preliminary Risk Assessment & Geo-Environmental Assessment

Torgate Lane, Bassingham

Presented to: **Lindum Group**

Issued: October 2021

Delta-Simons Project No: 12-0310.03



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Figure 2 – Relevant Features Plan

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APPENDICES

Appendix A – Limitations

Appendix B – Selected Historical Maps

Appendix C – Envirocheck Report

Appendix D – Risk Definitions

Appendix E – Exploratory Hole Logs and SPT Calibration Certificate

Appendix F – Geotechnical Analysis Results

Appendix G – Soil Chemical Analysis Results

Appendix H – Gas Monitoring Data

Appendix I – BRE365 Soakaway Results

1.0 Introduction

1.1 Appointment

Delta-Simons Environmental Consultants Limited (“Delta-Simons”) was instructed by Lindum Group (the “Client”) to prepare a Preliminary Risk Assessment and Geo-Environmental Assessment for land off Torgate Lane, Bassingham, LN5 9FU (the “Site”). A Site Location Map is included as Figure 1.

1.2 Context & Purpose

The aim of the study was to support the submission of a planning application for the proposed development area. The investigation has obtained information regarding ground conditions, from which risks to end-users, the environment and structures have been assessed, with mitigation measures suggested where necessary.

The investigation has also gathered geotechnical information to comment on the preliminary design of foundations and infrastructure. The Report provides recommendations for further work (where appropriate) based on the findings of the investigation.

1.3 Scope of Works

The scope of the investigation and layout of this Report has been designed with consideration of guidance on Land Contamination: Risk Management pages of the [GOV.UK](https://www.gov.uk) web pages, the relevant requirements of the National Planning Policy Framework (NPPF) (as revised 2021) (paragraphs 174 & 183-184)¹ and the Planning Practice Guidance (Land Affected by Contamination)²

The project was undertaken to an agreed brief as set out in Delta-Simons’ proposal (reference 12-0310.03, dated 21st April 2021).

A detailed scope of works is outlined in Section 3.0.

Specific sections of this Report may generally follow guidance set out in Eurocode 7 for a Ground Investigation Report (GIR), as defined in BS EN 1997-1:2004 and BS EN 1997-2:2007. Eurocode 7 includes specific guidance on the number and spacing of investigation positions, methods of investigation and sample quality to be achieved which may not have been met by this investigation. The Report also includes information which may support a Geotechnical Design Report (GDR) as defined in BS EN 1997-1:2004; however, unless otherwise explicitly stated, the investigation has not been undertaken in accordance with Eurocode 7 and the preliminary geotechnical interpretation, assessments and recommendations presented within this Report may not meet the full requirements of a GDR.

1.4 Proposed Development

The Site is proposed for the development of 20 No. residential dwellings with associated vehicular access, infrastructure, private gardens and attenuation features. A Proposed Development Plan is included as Drawing 1.

1.5 Data Sources

The following information has been used within the Assessment:

- ▲ Current and Historical Ordnance Survey (OS) maps;
- ▲ British Geological Survey (BGS) data;
- ▲ Environment Agency (EA) online data;
- ▲ Coal Authority (CA) online data;
- ▲ A Landmark Envirocheck Report for the Site (Ref. 284210589_1_1), dated September 2021;
- ▲ Historical Maps included as part of the Envirocheck Report; and
- ▲ Information provided by North Kesteven District Council.

¹ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1004408/NPPF_JULY_2021.pdf

² <https://www.gov.uk/guidance/land-affected-by-contamination>

1.6 Existing Information

Delta-Simons has previously undertaken investigation for a parcel of land located adjacent to the northern boundary;

- ▲ Summary Site Investigation Report Desk Study and Sampling, Torgate Lane, Bassingham, Delta-Simons Project No. 12-0310.01, dated November 2012;
- ▲ Ground Conditions and In-Situ CBR Analysis Report, Torgate Lane, Bassingham, Delta-Simons Project No. 12-0310.02, dated October 2013; and
- ▲ Laboratory CBR Analysis Report, Torgate Lane, Bassingham, Delta-Simons Project No. 12-0310.02, dated January 2014.

The previous Delta-Simons reports are summarised and reviewed in Section 2.7.

1.7 Limitations

The assessment is limited to the issues agreed within the proposal for the works. General notes on limitations associated with this assessment are provided in Appendix A and the following specific limitations apply;

- ▲ A land drain which contained water was encountered within SA102, as such the trial pit was relocated north and referenced as SA102a; and
- ▲ All three BRE365 infiltration tests failed to reach the 25% effective storage depth in a 24 hour period and as such, were classified as failed tests.

2.0 Site Context & Data Review

The following sections provide a summary of the key site features based on the data sources listed in Section 1.5. All distances, measurements and dates are approximate and the accuracy limitations of the data sources should be noted.

2.1 Site Information

Co-ordinates	Centred at National Grid Reference 491370, 359650.	Elevation	14.0 m AOD
		Area	0.45 Ha
Site Address and Location	The Site is located off Torgate Lane in the south-west of Bassingham, Lincolnshire. A Site Location Map is included as Figure 1.		
Site Description	<p>A Delta-Simons representative undertook a Site visit on 31st August 2021. Pertinent information that was observed or reported on-Site is summarised below and shown on Figure 2, with supporting photographs.</p> <p>The Site was noted to comprise fallow agricultural land that at the time of investigation was recently harvested. The south, east and western boundaries were open to wider agricultural land and the northern boundary was noted to comprise close board wooden fencing associated with adjacent residential properties.</p> <p>The Site was noted to be flat and in accordance with the local topography.</p> <p>No evidence of fly tipped materials, fuel storage or surface staining was noted.</p>		
Description of Adjacent and Surrounding Land Uses	The Site is located within a semi-rural area with agricultural farmland to the south, east and west. Residential dwellings and a medical centre are present to the north.		

2.2 Physical Setting

The physical setting of the subject property can influence the susceptibility to, and relative magnitude of, environmental impacts and liabilities associated with on- and off-Site sources of contamination. The following table provides physical setting information for the subject property and surrounding area.

Published Geology	From the British Geological Survey (BGS) online viewer the Site is indicated as being underlain by superficial deposits of the Balderton Sand and Gravel Member and bedrock of the Scunthorpe Mudstone Formation.
Site-Specific Geology	<p>There are three BGS boreholes (Ref. SK95NW5, SK95NW18 and SK95NW17) located between approximately 85 m and 195 m north and north west, respectively. The geology recorded comprises topsoil underlain by gravelly silts and sands to a maximum depth of 2.80 m bgl. The sands area recorded as loose to medium dense. Soft silts which transitioned to mudstone were identified beneath the superficial deposits to a maximum drilled depth of 4.00 m bgl. Groundwater was identified at 2.50 m bgl.</p> <p>Ground conditions encountered within the previous Delta-Simons investigation for land adjacent to the north are summarised in Section 2.7.</p>
Aquifers and Groundwater Receptors	<p>The Environment Agency (EA) classifies the superficial deposits of the Balderton Sand and Gravel Member as a Secondary A Aquifer. The underlying Scunthorpe Mudstone Formation is classified as a Secondary B Aquifer.</p> <p>The EA data also indicates that the Site is not located within a groundwater Source Protection Zone (SPZ).</p>

	According to the Envirocheck Report, there are no licensed water abstraction records from groundwater located within 1 km of the Site.
Groundwater Levels and Flow Direction	Groundwater was encountered during the previous Delta-Simons investigation for land adjacent to the northern boundary at depths between 0.60 m bgl to 2.80 m bgl. It is considered that groundwater is present within the granular Balderton Sand and Gravel Member. Groundwater is likely to flow in a westerly direction, towards the River Witham.
Hydrology	The nearest surface water feature is an unnamed land drain located approximately 185 m south. The River Witham is located approximately 590 m west of the Site and is classified as a GQA 'River Quality A' river. According to the Envirocheck Report, there are no licensed surface water abstractions within 500 m of the Site.
Mining & Quarrying	Reference to the Coal Authority on-line viewer indicates that the Site is not with a Coal Mining Reporting Area and is not within a Development High Risk Area. Consequently, a Coal Mining Risk Assessment (CMRA) is not required under the planning regime. There are no BGS Recorded Mineral Sites within 1 km of the Site.
Radon Gas	The Site lies within a Lower probability radon area (less than 1% of homes are estimated to be at or above the Action Level). BRE211 (2015) indicates that no radon protective measures are necessary in the construction of new buildings at the Site.
Flood Risk	From readily available flood risk data the Site is located within a Flood Zone 1 (low probability of flooding), as such a flood risk assessment is unlikely to be required.
Agricultural Buried Waste	Legal burial of waste, including asbestos containing materials (ACM) for agriculture was banned in 2006. Prior to that date it is understood farmers were required to make a record of waste burial locations and recommended use a clean cover of soil. There are no known records of agricultural buried waste for this Site.

2.3 Sensitive Land Uses

Ecological Receptors	It is understood from information provided within the Envirocheck Report, there are no ecological receptors within 500 m of the Site.
Heritage Interest	Historic England Records (historicengland.org.uk) indicate that no areas of designated heritage interest are located on or adjacent to the Site.

2.4 Historical Use of the Site & Surrounding Area

2.4.1 Approach

The historical development of the Site and surrounding area has been assessed through a review of historical maps, aerial photographs and Google Earth historical satellite imagery. A summary of the key historical Site uses and developments in the surrounding area is presented below. Copies of selected historical maps are included as Appendix B.

2.4.2 Historical Information Review

The following table provides a review of the historical information for the Site, adjacent and surrounding area.

Historical Features On-Site	From the earliest map edition dated 1887 the Site is undeveloped and likely in agricultural use. A hedgerow is mapped in the western area of the Site until the 1905 map edition. No further alterations are noted, and the Site remains consistent until present day.
Potentially Contaminative Historical Features Off-Site	Potential sources of contamination within 250 m of the Site are limited to the development of the adjacent residential dwellings and medical centre to the north of the Site by the 2009 and 2016 map edition, respectively, however the risk is considered very low.

2.4.3 Unexploded Ordnance (UXO)

The Zetica Regional Unexploded Bomb Risk Map for the area of the Site indicates that there is a low risk of UXO in the area of the Site.

2.5 Environmental Database Review

The Landmark Envirocheck® Report provides a database of environmental information held by various statutory bodies including the EA, Local Authority (LA), Health & Safety Executive (HSE) and Public Health England amongst others. A copy of the Envirocheck Report is provided in Appendix C and the most relevant information is summarised below.

Features On-Site	The Landmark Envirocheck Report does not list any entries for the Site.
Potentially Contaminative Features Off-Site	The Landmark Envirocheck Report lists a single Contemporary Trade Directory entry within 250 m of the Site. The entry is located approximately 10 m north-east and relates to an active air conditioning and refrigeration contractors. There are no BGS, LA or Historical Landfills within 1 km of the Site.

2.6 Planning Review/Regulatory Enquiries

On-line Planning Review	North Kesteven District Council	Date Accessed	14/09/2021
On-Site Applications	There are no planning applications listed for the Site. No additional potentially contaminative activities or other information pertinent to this assessment was identified on-Site from the historical planning records.		
Off-Site Applications	There are five planning applications listed for the parcel of land adjacent to the northern boundary. The main application Ref. 13/0647/FUL related to the construction of 23 No. residential dwellings. No land contamination conditions were imposed on this application. No additional potentially contaminative activities or other information pertinent to this assessment was identified from the historical planning records.		

2.7 Previous Reports

Previous Report Review	Delta-Simons has previously undertaken investigation for a parcel of land located adjacent to the northern boundary: <ul style="list-style-type: none"> ▲ Summary Site Investigation Report Desk Study and Sampling, Torgate Lane, Bassingham, Delta-Simons Project No. 12-0310.01, dated November 2012; ▲ Ground Conditions and In-Situ CBR Analysis Report, Torgate Lane, Bassingham, Delta-Simons Project No. 12-0310.02, dated October 2013; and ▲ Laboratory CBR Analysis Report, Torgate Lane, Bassingham, Delta-Simons Project No. 12-0310.02, dated January 2014.
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Summary Site Investigation Report Desk Study and Sampling, November 2012

Delta-Simons undertook a desk study and Site investigation in October 2012 to provide data on the chemical and geotechnical ground conditions at the Site.

Following the desktop investigation, potential sources of contamination were limited to the historical agricultural use of the Site including unrecorded spillages or buried waste. No significant off-Site sources of contamination were identified.

The Site investigation (25th September 2012) included the drilling of 5 No. dynamic sampler boreholes (DS101 to DS105) to a maximum depth of 3.60 m bgl, the construction of 2 No. BRE365 soakaways (SA101 and SA102), 3 No. trial pits (TP101 to TP103) to a maximum depth of 3.50 m bgl and the installation of 2 No. standpipes (DS101 and DS104) for post-works monitoring.

The ground conditions were recorded to generally comprise topsoil underlain by gravelly sands and occasional sandy clays to a maximum depth of 3.30 m bgl. Bedrock comprising sandy silt/clay and mudstone was identified below the granular superficial deposits to a maximum drilled depth of 3.60 m bgl. Resistance to penetration was noted to generally increase with depth to 1.80 m bgl, followed by a rapid decrease. This decrease was considered to likely represent the water table and/or the depth of historical near surface compaction due to agricultural activity. Groundwater was identified in all locations with the exception of TP103 at depths between 0.60 m bgl and 2.80 m bgl.

Infiltration testing was recorded as failed tests given the water level did not change over the 24 hour test period within either location. As such, surface water discharge to land was not considered feasible.

Following a single round of post-works monitoring groundwater was identified at 0.88 and 0.93 m bgl in DS101 and DS104 and significant ground gases were not identified, as such the Site was provisionally classified as a Characteristic Situation 1 (CS1), where ground gas protection measures were not required.

Soil chemical analysis did not identify any exceedances above the applied Generic Assessment Criteria (GAC) for a residential with plant uptake end use.

Given the variable ground conditions of sands and clays, the suitability of traditional strip or trench fill foundations was not considered suitable subject to further assessment. Raft foundations, ground improvement or piled foundations were considered appropriate subject to consultation with an experienced engineer.

Ground Conditions and In-Situ CBR Analysis Report, October 2013

Delta-Simons undertook further intrusive works in October 2013 given the identification of variable ground conditions in the initial Site investigation.

The scope of works comprised the excavation of 6 No. trial pits (TP201 to TP206) to a maximum depth of 2.60 m bgl and the completion of 4 No. in-situ plate load California bearing ratio (CBR101 to CBR104) tests.

The ground conditions comprised topsoil underlain by gravelly sand with localised bands of soft sandy gravelly clay in two locations. Firm blueish brown clay was encountered at the base of TP201 to TP203 from a depth of 1.90 m bgl, considered to represent the weathered upper surface of the underlying mudstone bedrock. Groundwater was encountered during excavation at depths between 1.80 m bgl to 2.20 m bgl.

In-situ CBR values below the topsoil ranged from 13.3% to 28.5%.

Based on the further investigation, traditional foundations were considered suitable founded at a minimum depth of 600 mm bgl within undisturbed natural gravelly sand with an allowable bearing capacity of 100 kN/m². It was highlighted that the formation should be inspected for soft spots (loose sand/soft clay), these soft spots removed

and the material replaced with well compacted granular fill or the foundations deepened.

Laboratory CBR Analysis Report, January 2014

Delta-Simons undertook 4 No. trial pits (CBR201 to CBR204) to collect samples for laboratory CBR analysis in accordance with Lincolnshire Highways Specification.

The ground conditions were consistent with the previous reports comprising topsoil underlain by gravelly sand with localised silty clayey sands.

The CBR results were recorded between 0.4% and 3.2%.

3.0 Conceptual Site Model

3.1 Introduction

A Conceptual Site Model (CSM) represents the relationships between contaminant sources, pathways and receptors, to support the identification and assessment of contaminant linkages.

3.2 Potential Contamination Sources

A source is a contaminant or pollutant that is in, on or under the land that has the potential to cause harm or pollution.

The following identified potential contamination sources are considered in the CSM:

Reference	Source	Location	Dates Present	Potential Associated Contaminants of Concern
S1	Agricultural use including small scale fuel spills/leaks from machinery.	Site wide	Pre 1887 to present	Heavy metals, and hydrocarbon compounds.
S2	Potential buried unknown fill, including asbestos containing materials.	Site-wide	Pre 1887 to present	Heavy metals, hydrocarbons, Asbestos and ground gas.
S3	Unrecorded on and off-Site sources.	On-site and immediate vicinity	Unknown	Heavy metals, hydrocarbon compounds, asbestos and hazardous ground gas.

3.3 Potential Pathways

A pathway is a route by which a receptor is or could be affected by contaminant.

The potential pathways are considered to be as follows:

- ▲ Direct contact, ingestion or inhalation of soil bound contaminants / dust during or following redevelopment.
- ▲ Inhalation of organic vapours associated with contamination.
- ▲ Migration of ground gas / vapours into on-Site buildings causing asphyxiation or risk of explosion.
- ▲ Leaching of contamination into groundwater followed by migration of groundwater to the wider groundwater environment or discharge to surface waters.
- ▲ Direct contact between aggressive ground conditions and new infrastructure.
- ▲ Plant uptake in landscaped or garden areas.

3.4 Potential Receptors

A receptor is something that could be adversely affected by a contaminant, for example a person, controlled waters, an organism, an ecosystem, or Part 2A receptors such as buildings crops or animals.

Relevant potential receptors are considered to include:

- ▲ Construction workers;
- ▲ Third parties during construction (adjacent Site users and adjacent residents);
- ▲ Future Site users and maintenance workers;
- ▲ Controlled waters including the underlying Secondary A and B Aquifers; and
- ▲ The Built Environment (new buildings and infrastructure / utilities).

The River Witham located approximately 590 m west of the Site is not considered a plausible receptor given the distance to the Site.

Contaminant Linkage Assessment				
Source(s)	Pathway(s)	Receptor(s)	Risk Rating	Justification & Mitigation (if required)
Sources identified within Section 3.2.	Direct contact/ ingestion and inhalation of dust, vapours, and asbestos fibres.	Future Site users. Groundworkers during the redevelopment or during any sub-surface maintenance works.	Very Low Risk	<p>Limited potential sources of contamination have been identified at the Site associated with its former agricultural use. Furthermore, elevated levels of contamination was not identified above the most stringent guidance values during Delta-Simons previous investigation located adjacent to the northern Site boundary.</p> <p>A 'hotspot' protocol should be in place during the redevelopment for ground workers to act upon should suspected contamination be identified.</p> <p>A clean layer of certified suitable for use topsoil will be required in landscaped areas. Existing topsoil may be suitable for reuse subject to appropriate frequency of testing and confirmation with the Local Authority. A limited soil sampling exercise is recommended at the time of any geotechnical assessment to assess the potential for topsoil re-use.</p> <p>Groundworkers should use appropriate personal protective equipment (PPE), including respiratory protective equipment (RPE), if required and maintain good standards of hygiene to be protected from any soil contamination which may be present.</p>
	Leaching of contamination into groundwater followed by migration of groundwater to the wider groundwater environment or discharge to surface waters.	Controlled waters.	Very Low Risk	<p>Limited on-Site sources of contamination have been identified from the Site reconnaissance and desktop study associated with the Sites former agricultural use, as such the risk to controlled waters is consider very low. Furthermore, elevated levels of contamination was not identified above the most stringent guidance values during Delta-Simons previous investigation located adjacent to the northern Site boundary.</p>
	Direct infiltration in water supply pipes.	Service conduits.	Very Low Risk	<p>Hydrocarbons, especially aromatics and chlorinated solvents, are known to permeate plastic pipes. Assessment of the risk to water pipes for any new supply will have to be undertaken as a requirement of the statutory undertakers who should be provided with a copy of this Assessment and provide recommendations for upgrading of potable water supply pipes, if considered necessary. No evidence of fuel or chemical storage is noted on or in close proximity to the Site.</p>

Contaminant Linkage Assessment				
Source(s)	Pathway(s)	Receptor(s)	Risk Rating	Justification & Mitigation (if required)
Hazardous ground gas and Radon	Accumulation of gas in enclosed spaces and sub-floor voids.	Buildings and future Site users.	Very Low Risk	<p>No significant on or off-Site sources of ground gas have been identified and as such the risk to the identified receptors from hazardous ground gas is considered very low. Furthermore, elevated levels of ground gas were not identified during Delta-Simons previous investigation immediately to the north of the Site.</p> <p>No Radon protection measures are required.</p>

4.0 Ground Investigation

4.1 Intrusive Investigation

Delta-Simons undertook intrusive investigation work on 31st August 2021 to assess the potential linkages identified in the outline conceptual model (see Section 3.0 above) and to provide geotechnical information.

4.2 Ground Investigation and Rationale

4.2.1 Intrusive Works

The ground investigation comprised the following items:

- ▲ Service avoidance exercise and topographic survey of exploratory holes to x,y,z co-ordinates;
- ▲ Supervision of all works by a Delta-Simons Geo-Environmental engineer. All intrusive locations were logged in general accordance with BS 5930:2015+A1:2020 Code of Practice for Site Investigations;
- ▲ Excavation of 3 No. BRE365 Infiltration Tests (SA101, SA102a and SA103) to a maximum depth of 1.85 m bgl;
- ▲ Drilling of 5 No. dynamic sampler boreholes (DS101 to DS105) to a maximum depth of 3.0 m bgl;
- ▲ Excavation of 2 No. Hand Dug Trial Pits (HP101/CBR101 and HP102/CBR102) to a maximum depth of 0.90 m bgl; and
- ▲ Ground gas and groundwater level monitoring on three occasions.

An approximate intrusive location plan is presented as Figure 3.

4.2.2 Rationale

Location	Rationale	Key Contaminants of Concern
DS101 to DS105	To provide Site coverage.	Asbestos, heavy metals, hydrocarbon compounds and sulphates.
DS101 and DS105	To enable groundwater and ground gas monitoring.	Hazardous ground gas and groundwater level monitoring.
SA101, SA102a and SA103	To provide infiltration data for the Site.	-
HP101 and HP102	To enable the collection of samples for laboratory CBR analysis in accordance with Lincolnshire Highways Specification.	-

4.3 Geotechnical Sampling and In-Situ Testing

4.3.1 Sampling

Sampling comprised disturbed jar/tub and bulk samples as detailed on the borehole logs.

4.3.2 In-Situ Tests

SPT tests were undertaken in all boreholes at 1.00 m intervals to a maximum depth of 3.00 m bgl. The results of these tests are presented on the borehole logs included as Appendix E with the associated SPT calibration certificate.

4.3.3 Soakaway Tests

Soakage testing was undertaken in 3 No. locations (SA101, SA102a and SA103) in accordance with BRE Digest 365 methodology.

4.4 Geotechnical Laboratory Testing

A selection of soil samples were submitted to the UKAS accredited laboratory for a range of geotechnical testing, the results of which are included in Appendix F. The rationale for the laboratory tests undertaken is provided in the table below.

Laboratory Test	Test Standard	Number of Samples Tested	Rationale
Classification			
Moisture Content	BS1377-2:3	5	To assess the potential for cohesive soils to shrink and swell due to changes in the water content of a soil associated with the presence, removal or addition of trees and shrubs.
Liquid and Plastic Limits	BS1377-2:4 – 5	4	
Particle Size Analysis	BS1377-2:9.2 & 9.3	1	To assess the composition of natural soils.
Pavement Design			
Soaked California Bearing Ratio (CBR)	BS1377-4:7	2	To provide preliminary data for pavement design.
Unsoaked California Bearing Ratio (CBR)	BS1377-4:7	2	
Geo-Chemical – Soil Samples			
pH	BRE Special Digest 1	7	To assess the soil and groundwater conditions of the Site in accordance with BRE Special Digest 1 Concrete in aggressive ground and specify an appropriate concrete class to resist chemical attack.
Water-Soluble Sulphate (2:1 water/soil extract)		7	
Total Sulphur		7	

4.5 Environmental Sampling and Laboratory Analysis

Soils collected for laboratory analysis were placed in a variety of containers appropriate to the anticipated testing suite. Records of the samples taken as part of the Site investigation works, including their depths and location, are included within the exploratory hole records in Appendix E.

Samples were stored in accordance with Delta-Simons' quality procedures to maintain sample integrity and preservation and to minimise the chance of cross contamination. Samples analysed for environmental purposes were placed in chilled cool boxes on site and transported to the laboratory for analysis on completion of the Site investigation works.

The rationale for chemical analysis is presented in the table below and the results of the chemical laboratory testing are included in Appendix G.

Analytes	No. of Samples Tested	Rationale
	Soil	
Asbestos	3	Common potential contaminant of concern.
pH, As, Cd, Cu, Cr, Hg, Pb, Ni, Zn, speciated Polycyclic Aromatic Hydrocarbons (PAH)	3	Potential contaminants of concern, common to many sites.
Total Petroleum Hydrocarbons, Criteria Working Group Method (TPHCWG), Benzene, Toluene, Ethylbenzene and Xylene (BTEX)	3	Potential contaminants of concern, common to many sites.
pH, sulphate	7	To assess potential for chemical attack on buried concrete.
Waste Acceptance Criteria (WAC) Testing	2	To assist in preliminary off-Site disposal routes.

4.6 Monitoring Programme

Three rounds of groundwater level and preliminary ground gas monitoring were undertaken on both newly installed wells (DS101 and DS105) between 6th and 22nd September 2021.

Measurements of the depth to groundwater within the monitoring wells were taken using an electronic dip meter.

To characterise the ground gas regime at the Site, an infrared gas meter was used to measure gas flow, concentrations of carbon dioxide (CO₂), methane (CH₄) and oxygen (O₂) in percentage by volume. Initial and steady state concentrations were recorded. The atmospheric pressure before and during monitoring, together with the weather conditions, was recorded.

All monitoring results obtained to date are contained within Appendix H.

5.0 Ground Summary

5.1 Introduction

The sections below summarise the ground and groundwater conditions encountered during the Site investigation.

5.2 Ground Summary

A summary of the observed ground conditions at the Site is provided below.

Strata	Typical Strata Description	Depth Range of Strata Top (m)	Depth Range of Strata Base (m)	Thickness Range (m)	Comments
Topsoil	Topsoil was identified in all locations and was noted to comprise dark brown gravelly sand with frequent fine rootlets.	0.00	0.25 – 0.80	0.25 – 0.80	Average depth of 0.43 m thick.
Balderton Sand and Gravel Member	Loose to medium dense gravelly sand was identified across the Site with bands of soft to firm sandy occasionally gravelly clay.	0.25 – 0.80	1.90 – 2.70	1.40 - 2.20	-
Scunthorpe Mudstone Formation	Soft to very stiff blueish grey slightly gravelly sandy clay was identified below the Balderton Sand and Gravel Member.	1.90 – 2.70	Depth Not Proven	Depth Not Proven	-

The ground conditions encountered on-Site were that of the expected mapped geology and consistent with the previous Delta-Simons investigation at land to the north of the Site.

5.3 Groundwater

5.3.1 Strikes During Investigations

The groundwater strikes during the ground investigation are summarised below.

Exploratory Hole	Water strike during drilling (m bgl)	Water strike during drilling (m AOD)	Stratum	Comment
DS101	2.00	12.32	Balderton Sand and Gravel	-
DS103	1.60	12.47		-
DS104	1.80	12.58		-
DS105	1.90	12.10		-
SA102	0.70	13.45		Water level rose to 1.80 m bgl after 20 minutes from land drain.
SA103	1.80	12.25		-

5.3.2 Levels During Monitoring Programme

Groundwater levels were monitored on a total of three occasions between 6th and 22nd September 2021.

Exploratory Hole	Water level during monitoring Max to Min Range		Stratum
	m bgl	m AOD	
DS101	1.43 - 1.50	12.89 - 12.82	Balderton Sand and Gravel Member
DS105	1.18 - 1.25	12.82 - 12.75	

Groundwater levels during monitoring varied between 1.18 and 1.50 m bgl (12.75 and 12.82 m AOD) within the Balderton Sand and Gravel Member.

5.4 Visual and Olfactory Evidence of Contamination

No visual or olfactory evidence of potential gross contamination was observed during the investigation.

5.5 Material Properties

The table below summarises the factual material properties based upon the results of in-situ and laboratory test data and where appropriate provides derived geotechnical parameters.

Parameter	Unit	Range	Justification
Balderton Sand and Gravel Member			
w (Moisture Content)	%	11 - 21	Laboratory Testing
IP (Plasticity Index)	-	3 - 9	Laboratory Testing
PL (Plastic Limit)	%	15 - 16	Laboratory Testing
LL (Liquid Limit)	%	18 - 25	Laboratory Testing
Volume Change Potential	-	Very Low	NHBC
Uncorrected SPT 'N'	Blows	5 - 44	In Situ Testing
Corrected SPT 'N60'	-	6 - 54	SPT N values corrected for energy ratio (Er) after BS EN ISO 22476-3:2005.
γ (Bulk Density)	Mg/m ³	2.02 - 2.19	Laboratory Testing
γ _d (Dry Density)	Mg/m ³	1.67 - 1.96	Laboratory Testing
Soaked CBR	%	1.2 - 4.3	Laboratory Testing
Unsoaked CBR		1.2 - 3.3	
Scunthorpe Mudstone Formation			
w (Moisture Content)	%	11 - 18	Laboratory Testing
IP (Plasticity Index)	-	11 - 15	Laboratory Testing
PL (Plastic Limit)	%	18	Laboratory Testing
LL (Liquid Limit)	%	29 - 33	Laboratory Testing
Volume Change Potential	-	Low	NHBC
Uncorrected SPT 'N'	Blows	5 - 50	In Situ Testing
Corrected SPT 'N60'	-	6 - 61	SPT N values corrected for energy ratio (Er) after BS EN ISO 22476-3:2005.

5.6 Geochemical Testing

Geochemical analysis was undertaken on seven soil samples of Balderton Sand and Gravel Member and Scunthorpe Mudstone Formation, tested for selective contaminants (BRE Special Digest 1:2005 (3rd Edition), Concrete in Aggressive Ground, the results of which are summarised in the table below.

Tests	No. of Tests	Minimum	Maximum
Balderton Sand and Gravel Member			
Soil - pH	5	6.7	8.4
Soil - Water Soluble Sulphate	5	6.3 mg/L	17.9 mg/L
Weathered Scunthorpe Mudstone Formation			
Soil - pH	2	8.2	8.7
Soil - Water Soluble Sulphate	2	29.8 mg/L	36.7 mg/L

6.0 Geotechnical Assessment

6.1 Introduction

6.1.1 Summary of Development Proposals

The Site is proposed for the development of 20 No. residential dwellings with associated private gardens, vehicular access and attenuation features. A Proposed Development Plan is included as Drawing 1.

At the time of writing, structural and floor loadings and final levels were unknown. Consequently, the information provided below should be treated as preliminary and will be subject to review once a scheme and levels have been finalised, and further detailed assessment may be required.

6.2 Foundations

6.2.1 Spread Foundations

The Site generally comprises Topsoil (average thickness of 0.43 m) underlain by gravelly sands with layers of sandy gravelly clays. The sands were noted to be loose to medium dense in nature. Groundwater has been identified during drilling between depths of 1.60 m bgl and 2.00 m bgl and between depths of 1.18 m bgl and 1.50 m bgl during return monitoring.

Based on the Site investigation undertaken shallow strip foundations are considered to be suitable, founded at a minimum depth of 0.60 m bgl within natural undisturbed medium dense gravelly sands in dry conditions with a maximum allowable bearing pressure of 100 kPa assuming a 600 mm wide foundation. Given the presence of cohesive materials in discrete bands within the Balderton Sand and Gravel Member all foundation excavations should be inspected by a suitably qualified engineer to ensure foundations are founded wholly within one material and strength characteristics have been achieved.

Should obviously loose/soft zones be encountered such as soft clays, foundation depth should be increased to more component strata or the foundation designed to span the zone/ removed and replaced with well compacted granular fill. Given the identification of groundwater at depths below approximately 1.20 m bgl, foundations should not be advanced beyond this depth.

All foundations should be cast in dry conditions.

6.2.2 Volume Change Potential

The volume change potential should be considered in any foundation schedule for structures and services located within the influence zone of trees or bushes (proposed, existing or to be removed) and appropriate precautions and/or founding depths should be designed accordingly. In cohesive soils, it is recommended that foundations should be designed in accordance with NHBC Standard Chapter 4.2 "*Building Near Trees*".

Significant cohesive materials are not anticipated at founding depth, however, clay bands of the Balderton Sand and Gravel Member have been identified which were noted to have a very low volume change potential.

6.2.3 Alternative Foundations

Should proposed loads exceed the bearing capacity of the shallow soils, alternatives such as a raft or pile foundation solution may be required.

The precise method of pile installation and applicability of proprietary systems, diameters and depths required would need to be discussed with a suitably experienced piling contractor.

There will be a requirement for the placement of a suitably engineered piling mat, which should be designed and validated by a suitably qualified and experienced engineer.

6.3 Roads and Pavements

CBR values for the Balderton Sand and Gravel Member are shown in the table below:

Exploratory Hole	Testing Depth (m bgl)	Stratum	Soaked Average CBR Result (%)	Un-Soaked Average CBR Result (%)
HP101/CBR101	0.60 – 0.80	Balderton Sand and Gravel Member	1.2	1.1
HP102/CBR102	0.50 – 0.70		4.3	3.2

CBR is dependent on the condition of the strata and could be different upon excavation to the formation subject to seasonal conditions. Clay soils are likely to be frost susceptible.

The use of a geotextile is recommended where variable ground conditions are encountered or across changes in strata to protect against potential differential settlement.

6.4 Drainage and Soakage Tests

Soakaway tests were undertaken in general accordance within BRE365 methodology in SA101, SA102a and SA103. All three tests failed to reach 25% effective storage depth within a 24-hour period and as such are classified as failed tests. As such, drainage to land is not considered suitable and alternatives such as discharge to an existing facility should be explored.

See Appendix I for details.

6.5 Excavations & Obstructions

It is expected that conventional mechanical excavators will readily remove the Topsoil, Balderton Sand and Gravel Member and Weathered Scunthorpe Mudstone Formation likely to be encountered in shallow excavations.

All shallow foundation or services excavations at the Site should be considered unstable, therefore, temporary support of all excavations should be considered when excavating on-site.

6.6 Groundwater

Groundwater levels during monitoring varied between 1.18 and 1.50 m bgl (12.82 and 12.82 m AOD) within the Balderton Sand and Gravel Member.

Excavations that extend beyond approximately 1.20 m bgl are likely to encounter groundwater and groundwater control measures may be required. Specialist contractor advice should be sought.

6.7 Chemical Attack on Buried Concrete

Water soluble sulphate concentrations were generally found to be low across the Site, as such, the Site can be provisionally classified as Design Sulphate Class DS1 and Aggressive Chemical Environment Class AC-1s in accordance with BRE Special Digest 1:2005 '*Building in Aggressive Ground*'.

7.0 Generic Quantitative Risk Assessment

7.1 Introduction

The presence of hazardous substances in or on a Site is generally only of concern if an actual or potential unacceptable risk exists. Legislation and guidance on the assessment of contaminated sites, consistent with UK best practice, acknowledges the need for a tiered risk-based approach. This section represents a Generic Quantitative Risk Assessment (GQRA) being a comparison of Site contaminant levels against Generic Assessment Criteria.

7.2 Human Health GQRA

The assessment of risks in relation to human health has been undertaken using Generic Assessment Criteria (GAC) as detailed within the appropriate tables. Risks from soil, groundwater and Non-Aqueous Phase Liquids (NAPL) have been considered. The GAC are predominantly based on long term (chronic) risk to health. However, in the limited circumstances where short-term (acute) risks are more pronounced, these GAC have been utilised to ensure a thorough and conservative initial assessment is undertaken.

Based on the proposed residential end use, the soil chemical data has been compared against a residential end use with plant uptake GAC for 1% soil organic matter (SOM) content.

7.2.1 Risks from Soil Sources

Detectable concentrations of heavy metals have been identified, however, none are above the applied GAC.

TPHs and PAHs have not been identified above the laboratory detection limit.

None of the contaminant concentrations reported in soil exceeded the relevant GAC. Therefore, the soil contaminant concentrations are not considered likely to represent a risk to human health.

In addition, topsoil from DS101 does not exceed the applied GAC and the topsoil is considered suitable for re-use, subject to increased frequency of testing and confirmation with the Local Authority.

7.3 Waste Management

In recent years a number of mechanisms have aimed to change the way in which waste materials have traditionally been managed (*i.e.* a move away from less sustainable options such as landfill disposal). These include:

- ▲ Legislation and guidance (e.g. the Waste Framework Directive [2008, as amended]; the Waste [England and Wales] Regulations, 2011; the Definition of Waste: Development Industry Code of Practice, Version 2 [DoWCoP; CL:AIRE, 2011]).
- ▲ Fiscal drivers (e.g. the landfill tax escalator).
- ▲ Corporate responsibility campaigns (e.g. WRAP: Halving waste to landfill & Quality Protocol projects; Ellen Macarthur Foundation).

There is now a greater focus on waste re-use, treatment and recovery as organisations try and move their waste materials up the Waste Hierarchy and move to more circular models of material supply and re-use.

In accordance with current industry best practice, guidance and legislation Delta-Simons would always recommend options including managing materials on site through the DoWCoP, waste treatment and waste recovery be considered ahead of landfill disposal. Landfill disposal should be seen as an option of last resort given that in terms of cost, environment and social outcomes it is less sustainable. However, the availability of alternatives to landfill disposal depends on the timescales of the project, proactive involvement of qualified advisors and the nature and status of the materials being considered.

7.4 Waste Classification

Two Waste Acceptance Criteria (WAC) tests have been undertaken as part of this assessment included as Appendix E. The results should be forwarded to a haulier/ground worker/ the receiving facility to confirm disposal rates and for budgeting purposes.

8.0 Bulk Ground Gas Risk Assessment

8.1 Ground Gas Conceptual Site Model

8.1.1 Sources

- ▲ Although potential sources of ground gas were not identified from the desktop assessment preliminary ground gas monitoring was undertaken at the time of the groundwater level monitoring.

8.1.2 Pathways

Shallow natural granular deposits have been identified at the Site which represent a pathway for vertical and lateral migration of ground gas.

The most significant pathways with respect to future residents relate to the potential for gases to enter future dwellings. At present, no gas protection measures are assumed. Consequently, ingress into dwellings may be possible through voids in the floor including service entry points and cracks.

8.1.3 Receptors

The principal receptors under consideration are future residents and buildings.

8.2 Duration & Extent of Monitoring

Gas monitoring has been carried out upon the Site on three occasions between 6th and 22nd September 2021.

The locations of the monitoring wells are highlighted on Figure 3 and indicate representative coverage across the whole study area.

Barometric pressures during the gas monitoring period ranged from 1011 mBar (Round 2) to 1025 mBar. (Round3). The second round of monitoring was undertaken during a period of falling atmospheric pressure.

8.3 Ground Gas Risk Assessment

8.3.1 Background

Based on the proposed residential end use, the following documents have been consulted when assessing the gas regime at the Site:

- ▲ NHBC/RSK Group PLC (2007), Guidance on Evaluation of Development Proposals on Sites where Methane and Carbon Dioxide are Present, Report Edition No. 4.
- ▲ CIRIA C665 (2007), Assessing risks posed by hazardous ground gases to buildings.
- ▲ British Standards Institute (BSI, 2019): Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings, BS:8485:2015+A1:2019.

The presence of a source of hazardous gas within the ground does not necessarily indicate a risk will be present. Consideration of recorded gas flows together with source concentrations can allow an initial assessment to be made of the potential both for generation and subsequent migration of gas. A Characteristic Situation (CS) is derived from an assessment of the ground gas data and forms the basis of determining mitigation measures.

8.3.2 Gas Screening Value (GSV)

The Gas Screening Value (gas concentration as a fraction x maximum recorded flow) is used to provide an initial assessment of risks to future Site users. The GSVs calculated for the monitoring wells are presented in the following table.

Location	Maximum Steady Methane (%v/v)	Maximum Steady Carbon Dioxide (%v/v)	Maximum Steady Flow Rate (l/hr)	GSV/Classification				Flooded
				Methane		Carbon Dioxide		
				GSV	CS	GSV	CS	
DS101	<0.1	0.6	<0.1	0.0001	CS1	0.0006	CS1	N
DS105	<0.1	0.6	<0.1	0.0001	CS1	0.0006	CS1	N

The data confirms the desktop assessment that the Site can be classified as CS1 (very low hazard potential) in accordance with BS 8485:2015 Table 2 for and Green in accordance with NHBC classification for low rise housing, where no ground gas protection measures are required.

8.4 Radon

The Site is located within an area where radon protective measures are not required.

9.0 Revised Conceptual Site Model

A revised CSM is presented in the table below, and has been formulated taking into account all of the available data from the Delta-Simons intrusive investigation, suitable for a site with a proposed residential end-use with consumption of home grown produce.

Revised Conceptual Site Model				
Source	Pathways	Receptors	Risk	Mitigation
Detectable concentrations of heavy metals within shallow soils. Potential contamination in areas not directly investigated.	Direct contact, ingestion and/or inhalation of soil/dust/vapours	Human health – future Site users	Low Risk	Although detectable concentrations of heavy metals have been detected within shallow soils, none have been recorded in excess of their respective stringent GAC. PAHs and TPH have not been identified above the laboratory detection limit. Volatile contaminants have not been identified. A clean cover layer of suitable for use topsoil will be required in landscaped areas (i.e. private gardens) to act as a growing medium. Existing topsoil is likely be suitable, subject to increase in frequency of testing in accordance with the Yorkshire and Lincolnshire Pollution Advisory Guidance (YALPAG) and confirmation with the Local Authority.
		Human health – construction workers	Low Risk	Despite no elevated contamination concentrations being recorded within the soils at the Site, short-term risk to construction workers would be mitigated by the use of PPE and provision of suitable welfare facilities. This recommendation should be captured in Site health and safety documentation and in maintenance plans. A hotspot protocol should be in place for groundworkers to act upon should potential contamination be identified.
	Migration of contaminants into groundwater	Secondary A and Secondary B Aquifer	Very Low Risk	The Site has historically been in agricultural use. Significant contamination has not been identified at the Site within shallow soils, as such, the risk to controlled waters is considered very low. In addition, the Site is not located within an SPZ.
	Migration of contaminants into surface waters	Off-Site land drain		
	Direct infiltration in water supply pipes	Service conduits	Low Risk	Hydrocarbons, especially aromatics and chlorinated solvents, are known to permeate plastic pipes. Assessment of the risk to water pipes for any

Revised Conceptual Site Model				
Source	Pathways	Receptors	Risk	Mitigation
				new supply will have to be undertaken as a requirement of the statutory undertakers who should be provided with a copy of this Assessment and provide recommendations for upgrading of potable water supply pipes, if considered necessary. However, given the Site has been undeveloped throughout its history, there is no evidence of chemical/ solvent or fuel storage on or in the immediate vicinity of the Site and concentrations of hydrocarbons have not been identified above laboratory detection limits, standard PE potable water pipes are considered likely.
Hazardous Ground Gas	Indoor exposure / explosive hazard via enclosed space accumulation of ground gas	Future Site users and buildings	Very Low Risk	Based upon the results of the preliminary ground gas monitoring undertaken at the Site to date, the Site has been classified as CS1 – Very Low Risk and Green in accordance with NHBC guidance. No ground gas protection measures are necessary.
Potentially unidentified 'hotspots' of contamination, which may be present in areas of the Site that have not been directly investigated	All pathways	All receptors	Unknown	As with all redevelopment works, a 'hotspot' protocol should be in place for groundworkers to act upon during any future redevelopment of the Site.

10.0 Conclusions & Recommendations

10.1 Ground Model Summary

The Site generally comprises Topsoil (average of 0.43 m bgl) underlain by gravelly sands with layers of sandy gravelly clays. The sands were noted to be loose to medium dense in nature. Groundwater has been identified during drilling between depths of 1.60 m bgl and 2.00 m bgl and between depths of 1.18 m bgl and 1.50 m bgl during return monitoring.

10.2 Geotechnical Summary

Based on the Site investigation undertaken shallow strip foundations are considered to be suitable, founded at a minimum depth of 0.60 m bgl within natural undisturbed medium dense gravelly sands in dry conditions with a maximum allowable bearing pressure of 100 kPa assuming a 600 mm wide foundation. Given the presence of cohesive materials in discrete bands within the Balderton Sand and Gravel Member all foundation excavations should be inspected by a suitably qualified engineer to ensure foundations are founded wholly within one material the founding depth and strength characteristics have been achieved.

Should obviously loose/soft zones be encountered such as soft clays, foundation depth should be increased to more competent strata or the foundation designed to span the zone. Given the identification of groundwater at depths below approximately 1.20 m bgl, foundations should not be advanced beyond this depth.

Soakaway tests were undertaken in general accordance with BRE365 methodology in SA101, SA102a and SA103. All three locations failed to reach 25% effective storage within a 24-hour period and as such are classified as failed tests. As such, drainage to land may not be suitable and advice should be sought from a drainage specialist.

Water soluble sulphate concentrations were generally found to be low across the Site, as such, the Site can be provisionally classified as Design Sulphate Class DS1 and Aggressive Chemical Environment Class AC-1s in accordance with BRE Special Digest 1:2005 '*Building in Aggressive Ground*'.

10.3 Contamination Summary

The investigation has been carried out in order to provide information on the quality of the soil and beneath the Site in the context of land contamination and provide information on the ground gas regime beneath the Site for a residential end use.

10.3.1 Human Health

Although detectable concentrations of heavy metals have been detected within shallow soils, none have been recorded in excess of their respective GAC. PAHs and TPH have not been identified above the laboratory detection limit. Volatile contaminants have not been identified.

Groundworkers and sub-surface maintenance workers should be made aware of the possibility of encountering contaminated soils through toolbox talks and an appropriate protocol to mitigate exposure of the workforce and general public should be in place

10.3.2 Controlled Waters

Significant contamination has not been identified at the Site within shallow soils, as such, the risk to controlled waters is considered very low. In addition, the Site is not located within an SPZ.

10.3.3 Ground Gas

The ground gas regime at the site has been classified as CS1 in accordance with BS8485:2015 and Green in accordance with NHBC guidance, as such no ground gas protection measures are considered to be required for the development.

10.3.4 Volatile Vapours

No potential sources of volatile contaminants have been identified.

10.3.5 Built Environment

The ground investigation was not designed to assess ground conditions in full accordance with the UKWIR guidance for water supply pipes. However, based on the general absence of petroleum hydrocarbons including hydrocarbons in the ground, the use of standard plastic infrastructure is likely to be suitable in the event that new water supply pipes are required.

10.4 Recommendations

No further investigation / assessment works are considered to be necessary for the redevelopment of the Site based on the current proposals.

The following recommendations for the development of the Site are made:

- ▲ A clean cover layer of suitable for use topsoil will be required in landscaped areas. Existing materials are considered suitable, subject to confirmation with the Local Authority. Should any topsoil be imported to the Site as part of proposed landscaping works, this should be tested to confirm it is suitable for use within the proposed development. Depths of topsoil for each area should be agreed with the LA;
- ▲ Groundworkers and sub-surface maintenance workers should be made aware of the possibility of encountering contaminated soils through toolbox talks and in particular the potential presence of asbestos and an appropriate protocol and risk assessments to mitigate exposure of the workforce and general public should be in place. Good standards of personal hygiene should be observed, and appropriate levels of PPE / RPE utilised where necessary;
- ▲ Unidentified localised areas of contamination may exist at the Site and an appropriate 'hotspot' protocol should be in place for groundworkers to act upon should such contamination be identified during the construction process;
- ▲ Suitable dust suppression techniques and prevention of nuisance/environmental impacts will need to be implemented by the groundworkers during construction works;
- ▲ Confirmation should be sought from the Local Water Authority as to whether they will require upgraded pipework to be installed for new service installations, although this is considered to be likely; and
- ▲ A Remediation Strategy will be required to detail the methodology for any construction phase remediation works.

Drawings

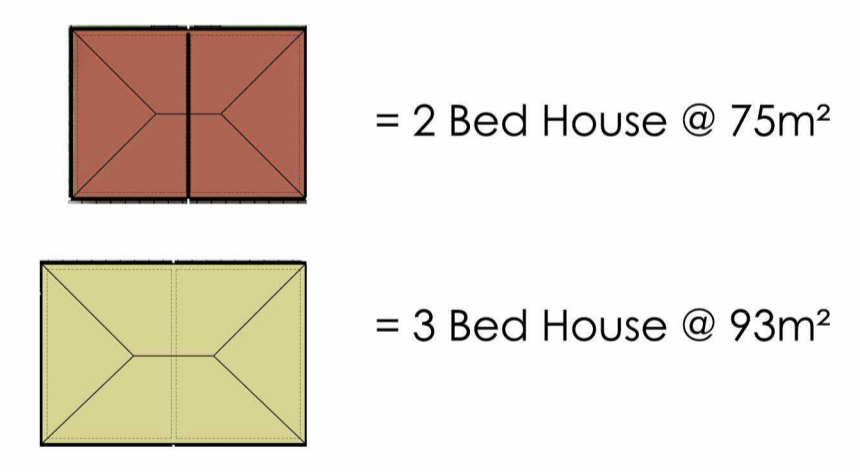
Drawing 1 – Proposed Development Plan

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Rev	Description	Date
A	Unit GIA increased as per client instruction. Number of units increased to 20 from 16	12.02.18



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Client
Lindum Developments

Project
**Torgate Lane Ph2
 Bassingham, Lincolnshire**

Drawing
 Proposed Site Plan

Scale
 1.250@A1/1.500@A3

Drawn by
 SJP

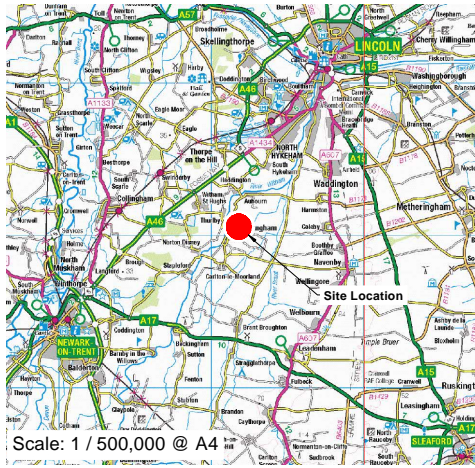
Checked by
 CAH

Drawing Number
 L5_636_02

Revision
 A

Figures

Figure 1 – Site Location Map



LEGEND

Site Boundary



Scale: 1 / 5,000 @ A4

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TITLE:
Site Location Map
Torgate Lane
Bassingham

DRAWN BY: YA	SCALE: To Scale @ A4	PROJECT NO: 12-0310.03
CHECKED BY: JR	REVISION: 1	FIGURE NO: 1
DATE: 01 September 2021		

PROJECT NO:
12-0310.03

FIGURE NO:
1

Figure 2 – Relevant Features Plan

PH01: View across eastern area.



PH02: View across northern area.



PH03: View across western area.



PH04: Northern boundary.



PH05: View across southern area.



COMMENTS: There is uncertainty as unrecorded land use may have occurred and caused contamination that has not been identified by the observations.

Figure 3 – Approximate Intrusive Location Plan