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## Geoenvironmental Assessment - Factual Report, Northstowe Phase 1

Gallagher

February 2012

# QUALITY MANAGEMENT

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# 1 INTRODUCTION

## 1.1 AUTHORISATION

WSP Environment & Energy (WSP) was commissioned by Gallagher to undertake a Geoenvironmental Assessment on at the location of the proposed new town of Northstowe, near Longstanton, Cambridgeshire. The site location is shown on **Figure 1** and the site boundary on **Figure 2**.

## 1.2 DEVELOPMENT DETAILS

The proposed Northstowe development is located within South Cambridgeshire, approximately 10km to the north-west of Cambridge, to the east of Longstanton and to the north of Oakington.

The application site is split into two parts: the Primary Development Site comprising 97 hectares; and the Hatton's Road Attenuation Ponds Area (from herein referred to as the Hatton's Road Area) comprising 35 hectares. The proposed development includes residential development, a local centre, a primary school, a community centre, formal and informal open space, outdoor, sports hub and recreational facilities, employment use (B1, B2 and B8), a household waste recycling facility, a foul water pumping station, and surface water attenuation features.

## 1.3 AIMS AND OBJECTIVES

The main aim of the assessment is to identify potential geotechnical and environmental issues that may represent a constraint to the proposed development of the subject site.

## 1.4 SCOPE OF WORKS

The following Geoenvironmental Assessment considers the following elements:

- Intrusive ground investigation over accessible areas of the site enabling consideration of geoenvironmental issues;
- Surveying of exploratory locations to Ordnance Survey co-ordinates;
- Installation of groundwater and gas monitoring wells, measurement of groundwater levels, collection of groundwater samples and a period of ground gas monitoring;
- Chemical and geotechnical laboratory testing of soils and groundwater; and
- Factual and interpretative reporting.

The general limitations to the nature of the assessment are outlined in the Notes on Limitations presented in **Annex A**. Specific limitations imposed by the subject site are discussed where relevant throughout the report.

This report should be read in conjunction with the following report containing interpretive assessment of the information from the ground investigation works:

- WSP Environmental, Interpretive Report: Northstowe Phase 1, Cambridgeshire, Report Reference 22881-R01, December 2011.

The investigation has been undertaken in general accordance with the WSP Environmental 'Proposed Strategy for Geo-Environmental Assessment' dated December 2004. Since the production of this strategy document, some changes to the proposed scope of works have been made generally resulting in a more comprehensive investigation being undertaken. However, after discussions with the client, the following elements have not been undertaken:

- Soakaway tests (access restrictions); and
- In-situ CBR tests (to be completed at a later date).

In addition, cable percussion boreholes were only advanced to around 7m below ground level.

The original ground investigation considered the full proposed 2007 Northstowe site and was divided into four zones (A-D):

Zone	Location
A	Northern Infrastructure Area – golf course and farmland to the north of the airfield and Rampton Road.
B	Former Oakington Airfield.
C	Former Oakington Barracks (including the former Immigration Centre) and farmland to the west.
D	Southern Infrastructure Area – farmland to the south of the airfield to the A14.

Factual reports were produced for the four zones and submitted as part of the 2007 planning application. However, the Northstowe Phase 1 application boundary is made up of parts of Zones A and D and this report collates the relevant information relating to the Phase 1 site only.

## 1.5 PREVIOUS REPORTS

### 1.5.1 General

The following pertinent reports have been considered as part of this assessment and in the planning of the ground investigations undertaken:

- WSP Environmental, Preliminary Ground Investigation Report, Longstanton/Oakington Barracks, Gallagher Estates, Report Reference 12040122, July 2002.
- WSP Environmental, Phase 1 Environmental Audit, Oakington Barracks, Gallagher Estates, Report Reference 12020566, August 2002.
- ARP (Paul Francis), RAF Oakington: An Operational History & Gazetteer of Surviving Structures, WSP Environmental, January 2005.
- Entec UK Ltd, Oakington Barracks APCs, Land Quality Assessment: Phase 2A Site Investigation, September 2007, Report Reference 12924.
- Oxford Archaeotechnics, Cambridge Golf Course and Land North of Rampton Road, Longstanton, Magnetometer (Gradiometer) Survey, Report 3090406/OAC/JJG, 2006.
- Oxford Archaeotechnics Land North of Rampton Road, Longstanton, Magnetometer (Gradiometer) Survey, Report Reference 309A0406/OAC/JJG, October 2006.
- Bactec International Limited, Explosive Ordnance Threat Assessment, RAF Oakington, Cambridgeshire, Report Reference 8863TA, Preliminary August 2005 and Final January 2006.
- Bactec International Limited, Report on Explosive Ordnance Disposal (EOD) Support to Site Investigation Works (2005), RAF Oakington, Cambridgeshire. Bactec International Limited, Report Reference 8863 SI, January 2006.
- WSP Risk Management Services, Asbestos Survey Report (Type 2), Former Oakington Barracks, Longstanton, Cambridgeshire. Revision 1, November 2007.
- Landmark Envirocheck Reports dated May 2002 updated November 2011.

Where relevant, more details on these reports are provided below.

### 1.5.2 WSP, Preliminary Ground Investigation Report

The preliminary ground investigation was undertaken in 2002 and comprised the advancement of ten cable percussion boreholes and excavation of five trial pits across the airfield and land to the north. Of these, two cable percussion boreholes (BH1 and BH9) and one trial pit (TP5) were located on the Primary Development Site along the northern boundary of the golf course (see **Figure 3**).

Made Ground was only encountered in BH1 located in the car park of the golf course. It comprised soft dark brown/black sandy gravelly CLAY with occasional fragments of asphalt. The Made Ground overlies very sandy GRAVEL and slightly clayey silty SAND (River Terrace Deposits) proven to 5m bgl. Groundwater was encountered at 3.4m bgl.

Borehole BH9, located on the eastern boundary of the Primary Development Site, encountered topsoil over soft brown grey mottled CLAY, soft grey CLAY and firm to stiff grey CLAY (all Ampthill Clay) to the base of the borehole at 5m bgl. Trial pit TP5, located roughly equidistant between BH1 and BH9, encountered firm to stiff brown grey mottled silty CLAY (Amthill Clay) to 2m bgl.

A soakaway test was conducted in TP5 and no discernible change in water level was observed during the test.

One soil sample from TP5 (0-0.5m) was tested for metals, a petroleum hydrocarbon screen, total phenols, pH and water soluble sulphate. None of the results were found to be over the current WSP Generic Assessment Criteria for a residential with gardens end use.

Laboratory shear testing undertaken on undisturbed samples of clay from BH9 identified shear strengths of 24kPa (at 1m bgl) and 53kPa (3m bgl). Clays were found to be of similar plasticity (plasticity index range 42% and 43%) and moisture contents (ranged 29% to 32%); with bulk densities of between 1.89Mg/m<sup>3</sup> and 1.94Mg/m<sup>3</sup>. SPT 'N' values were also found to be highly variable across the site. Within River Terrace Deposits the SPT 'N' ranged from 3 to 44 with blow counts decreasing with depth to 3m bgl. Within cohesive deposits on the eastern end of the site, blow counts were 10 and 13.

### 1.5.3 WSP, Phase 1 Environmental Audit

The report considered all of the Phase 1 application boundary and parts of the wider Northstowe site.

The report identified the following potential environmental issues which may be associated with the current and historical use of the Phase 1 development site:

Potential for farm related contaminants such as use and storage of chemicals and pesticides and the potential for the historical burial of animal carcasses.

- Possibility of buried munitions from former bomb storage activities.
- Possible use of asbestos containing materials within farm buildings and bulk storage of fuels.

No information to confirm or discount the above issues was identified by the report.

In order to update the baseline information for the risk assessments discussed within the Interpretive Report, a Landmark Envirocheck report (reference 36663250\_1\_1, November 2011) has been obtained for the Primary Development Site.

### 1.5.4 Entec UK Ltd, Oakington Barracks APCs, Land Quality Assessment

This investigation focussed on the south-eastern part of the Primary Development Site (former bomb storage area and field corner) identified by Entec as 'Areas of Potential Concern' from their previous Land Quality Assessment relating to the airfield and additional information including geophysical surveys. Only two trial pits from this investigation were located on the site TP144 and TP145 (see **Figure 3**).

Ground conditions at both locations were found to comprise: clay topsoil overlying slightly gravelly sandy CLAY (River Terrace Deposits); in turn overlying white grey laminated orange mottled slightly gravelly sandy CLAY, and/or weak highly weathered CLAYSTONE/MUDSTONE, and/or stiff grey mottled slightly sandy CLAY (all Ampthill Clay).

Analysis of soil samples was undertaken for a range of contaminants including chemical warfare agents, associated breakdown products and explosives, all of which were found to be below the laboratory detection limits. No evidence for the burial and disposal of ordnance was identified within these two trial pits. The results from the general contaminant suites were also found to be below the WSP adopted screening criteria or below detection limits.

## 2 SITE LOCATION AND SETTING

### 2.1 SITE DETAILS

Table 2.1: Site Details

<b>Site Address:</b>	<b>Land to the North of Rampton Road, Cambridge Golf Club and surrounding land</b>
<b>Primary Development Site:</b>	97 Hectares (Centred on 540500, 267250)
<b>Hatton's Road Area:</b>	35 Hectares (Centred on 538900, 265400)
<b>Description of Primary Development Site:</b>	Cambridge Golf Club forms the majority of the Primary Development Site with agricultural land to the east and north. The site is bounded to the south-east by Rampton Road and the former Oakington Airfield; to the north-east by agricultural land beyond a former railway which has been redeveloped as Cambridgeshire Guided Busway; and to the west by the village of Longstanton. Station Road crosses the north-western corner of the site.
<b>Description of Hatton's Road Area:</b>	The Hatton's Road Area is currently arable farmland divided by drainage ditches and farm access tracks.
<b>Description of Surrounding Area:</b>	The surrounding area predominantly comprises agricultural land. The former Oakington Airfield, army barracks and immigration centre are located to the south of the Primary Development Site, with the residential development of Longstanton situated adjacent to the west. Land around the Hatton's Road Area is predominantly agricultural.

The location of the site and site boundaries are presented on **Figure 1** and **Figure 2**.

### 2.2 CURRENT SITE USE AND SURROUNDING LAND

#### 2.2.1 Primary Development Area

The site currently supports predominantly pastoral and arable agricultural land on the south-eastern and northern parts of the site, and a golf course through the centre which includes a club house and associated buildings and infrastructure. Station Road crosses the north-western corner of the site.

Brookfield Farm is located immediately adjacent to the south of the site, off Rampton Road. A second farm and residential properties are also located off the southern boundary of the site along Rampton Road. The village of Longstanton is present to the west of the site with farmland, some residential development, nurseries and commercial premises to the north. Land to the east beyond the Cambridgeshire Guided Busway is predominantly agricultural. The former Oakington Airfield and Barracks is present to the south of Rampton Road as well as a small residential development known as Rampton Drift.

#### 2.2.2 Hatton's Road Area

The Hatton's Road Area is currently arable farmland divided by drainage ditches, Longstanton Brook and farm access tracks. Land around the Hatton's Road Area is predominantly agricultural.

### 2.3 SITE HISTORY

#### 2.3.1 General

The history of the site and immediate surrounds has been assessed from historical mapping and aerial photographs of the site. Pertinent historical maps are presented as **Annex B**.

### 2.3.2 Primary Development Area

The site has historically supported open agricultural land prior to the development of the golf course on the central and northern areas. The primary historical site features are considered to have been:

Table 2.2: Site Details

Site Features	Site Area	Dates
Open Agricultural Land	Whole Site	Pre 1891 - Current
Sand Pit	North-west beyond Station Road	Pre 1891 - Pre 1927
MOD Land	South-east	1958
Then: part of Brookfield Farm		1981 - Current
Moveable Greenhouses and Unidentified Buildings	South	1981 - Current

The surrounding land has predominantly been in agricultural use with scattered residential development, nurseries and orchards. Oakington Airfield to the south of the site was opened in 1940 and included a sewage treatment works located close to the south-eastern corner of the site. Longstanton is shown to the west of the site on the 1891 mapping and most of the current residential development was completed between the 1958 and 1981 map editions. The former G.E.R railway (later L.N.E.R. railway and now the Cambridgeshire Guided Busway) is shown along the eastern boundary of the site from pre-1891 to present. Longstanton Station was located approximately 90m to the north of the site from pre 1891 to post 1958.

### 2.3.3 Hatton's Road Area

The Hatton's Road Area has supported arable farmland to the present day. Surrounding land use has also been agricultural with a number of farms located in the local vicinity of the site.

## 2.4 HYDROLOGY

Surface water features are identified on **Figure 5**. The main surface water features in the vicinity of the site are presented in Tables 2.3 and 2.4 below.

Table 2.3: Surface Water Features – Primary Development Site

Surface Water Feature	GQA <sup>1+2</sup> Classification	Distance from Site	Direction from Site
Unnamed Drains	Unclassified	On Site	-
Reynolds Drain	Unclassified	Adjacent	East
Unnamed Drain Nethergrove Lake	Unclassified	Adjacent	South-west
Longstanton Brook	Unclassified	110m	South
	Fair (D)	240m	South-west

1 - Overall chemical water quality as classified under the Environment Agency's General Quality Assessment (GQA) Scheme, now withdrawn. 2 – All of the watercourses above are classified as 'not requiring assessment' under the Environment Agency River Basin Management Plan for the region.

There are three main ditches crossing the site which drain from south-west to north-east into Reynolds Drain. Reynolds Drain eventually flows into Cottenham Lode or Burgess Drain to the east depending on flow conditions.

A drainage ditch is also present on the north-eastern part of the site which flows northwards towards Willingham and flows into Willingham Lode or Dockeral Brook.

In addition, to the above, there are also fifteen ponds or lakes on site and a further six in the immediate vicinity. These are indicated on **Figure 5**.



Table 2.4: Surface Water Features – Hatton’s Road Area

Surface Water Feature	GQA <sup>1+2</sup> Classification	Distance from Site	Direction from Site
Longstanton Brook	Fair (D)	On-site	Flows south to north
Balancing Ponds (32 and 34)	Unclassified	800m	South-west

1 - Overall chemical water quality as classified under the Environment Agency’s General Quality Assessment (GQA) Scheme – now withdrawn. Numbers in brackets relate to surface water features identified in **Figure 5. 2** – All of the watercourses above are classified as ‘not requiring assessment’ under the Environment Agency River Basin Management Plan for the region.

Information obtained from the Environment Agency indicates there is one surface water abstraction within 1km of the site. Details of the abstraction are shown in Table 2.2 below.

Table 2.2: Summary of Surface Water Abstraction Licenses

No.	NGR	Source	Operator	Permit Start Date	Status	Purpose
SW1	539960 267910	Surface	Edmund Nuthall Ltd	27 <sup>th</sup> August 2008	Current	Construction – Dust Suppression

Note: Number relates to surface water features identified in **Figure 5**.

The surface water abstraction is for “*construction: dust suppression*” and was utilised during the construction of the Cambridgeshire Guided Busway. Given that the busway is now complete, it is unlikely to be further utilised.

## 2.5 PUBLISHED GEOLOGY

Geological Mapping at 1:50,000 scale, Sheet 187 (Drift) Huntingdon, published 1975, and Sheet 188 (Solid and Drift) Cambridge, published 1981, indicates that the following geological sequence underlies the site:

Table 2.5: Geology beneath the Primary Development Site

Geological Unit	Indicative Thickness	Aquifer Status
River Terrace Deposits (3rd and 4th Terraces)	5 – 10m	Secondary A
Amphill Clay	Up to 50m	Unproductive Strata

The geological map indicates the presence of River Terrace Deposits (gravels) beneath the western half of the Primary Development Site. These are predominantly the 3<sup>rd</sup> Terrace Deposits, with a small area of 2<sup>nd</sup> Terrace Deposits on the southern part of the site opposite Long Lane. The superficial deposits are underlain by the Amphill Clay which is reportedly present at the surface across the eastern half of the site.

Table 2.6: Geology beneath the Hatton’s Road Area

Geological Unit	Indicative Thickness	Aquifer Status
Kimmeridge Clay	Up to 30m	Unproductive Strata
Amphill Clay	Up to 50m	Unproductive Strata

A digitised extract from the BGS geological map for the site and surrounding area is presented as **Figure 6**.

The following more detailed information has been obtained from the BGS Geological Memoir ‘Geology of the Country around Cambridge’ (EM188) published in 1975.

### 2.5.1 Recent Deposits - Terrace Deposits

Terrace deposits reportedly comprise well bedded to poorly bedded sandy flint and chalk gravels, locally with a clay matrix. Terrace levels one to three are rich in fossil plants, molluscs and vertebrates and levels two to four are

cryoturbated (disturbed by frost action). It is generally not possible to differentiate the different terraces in the field without detailed analysis of fossil faunas and pollen.

### 2.5.2 Amphill Clay - Corallian Beds (Jurassic)

The Amphill Clay is the oldest unit immediately beneath the site and was not mapped as a distinct unit from the Oxford or Kimmeridge Clays until the early 1900's. The Amphill Clay typically comprises dark grey shelly pyritic clays that weather to brown and yellow clays rich in selenite.

### 2.5.3 Kimmeridge Clay (Jurassic)

The Kimmeridge Clay overlies the Amphill Clay and is generally up to 12-15m in thickness. The unit comprises dark grey clay and pale grey calcareous clays with thin beds of oil shale and abundant ammonites.

The beds are mainly blue and grey clay, weathering to brown and are often laminated or shaley. Some argillaceous (clay-like) limestone occurs as thin layers or nodules.

## 2.6 HYDROGEOLOGY

Information contained within the Environmental Statement (2007) has been updated based on Landmark database information (November 2011). The Landmark Envirocheck report indicates one groundwater abstraction on the western part of the Primary Development Site (no. 8 on **Figure 5**) for spray irrigation use.

Details of the abstractions within 1km of the Primary Development Site are shown in Table 2.7 below. Some of these abstraction permits may not be current although it has not been possible to determine this at this stage.

The locations of the abstractions are identified on **Figure 5**.

Table 2.7: Summary of Groundwater Abstraction Licenses – Primary Development Site

No.	NGR	Operator	Permit Start Date	Status	Purpose
1	540200 266520	Cambridge Fish Preservation & Angling Society	2 <sup>nd</sup> Feb 1998	T	Amenity: Make-Up Or Top Up Water
2	540400 269600	Mr. C S Hayden	20 <sup>th</sup> Feb 2004	NS	General Agriculture: Spray Irrigation - Direct
3	539950 267230	Cambridge Golf Club	2 <sup>nd</sup> May 2008	NS	Golf Courses: Spray Irrigation - Direct
4	539980 268240	C P Munns	1 <sup>st</sup> June 1966	P	General Farming And Domestic

(1). NS = Not Supplied, P = Perpetuity, T = Temporary.

(2). For abstractions at the same locations the most recent permit date has been listed. Revoked abstractions have not been listed.

Five abstractions are also listed as 'Revoked', however, this may mean they remain active but have been deregulated as they abstract less than 20m<sup>3</sup> per year. The nearest is located 250m north of the Primary Development Site with the remainder 384m to 469m to the north.

Reference has been made to the Environment Agency Source Protection Zone (SPZ) plan for the area. The plan indicates that the site is not located within a SPZ.

Based on the above information, the underlying Secondary A aquifer is considered to have a medium sensitivity.

## 2.7 REGULATORY DATABASE INFORMATION

A registered waste management and waste transfer station is located approximately 150m to the north of the Primary Development Site. This is a small facility that is licensed to transfer <10,000 tonnes per annum of waste ferrous and non-ferrous metal.

A second waste transfer station is located approximately 250m to the north of the Primary Development Site. Waste licensed to be handled within this facility includes tyres and scrap tubing.

Waste transfer stations are licensed to sort wastes of similar types, which can then be transferred into larger containers and sent to other waste facilities for further treatment, recovery or disposal. Wastes can be bulked up for disposal or recovery elsewhere and can be manually sorted or separated for recovery, but their licence does not allow any waste treatment activities such as screening and crushing.

## 2.8 REGULATORY ENQUIRIES

As part of the WSP Phase I Geo-Environmental Audit (2002) and the 2007 planning application, representatives from the regulatory authorities were contacted for any information relevant to the site.

- The Environmental Health Department of SCDC revealed that they were not aware of any contaminated land on the former airfield to the south of the site, farmland within the site boundary, or on immediately adjacent sites. Furthermore, the site has not to date been fully investigated for contaminated land under Part IIA of the Environmental Protection Act 1990. The officer confirmed that there are three known areas of infill material (content unknown) located within the airfield to the south of the primary development site. WSP has confirmed their locations as part of wider works and they are not considered to represent a risk to the site.
- Owing to the absence of significant development in the area, no specific information was available from the building control officer at SCDC.
- South Cambridgeshire District Council was also contacted with regard to information held in their Private Water Supply Register. The officer indicated that they did not have any information relating to abstractions within 2km of the site. The officer commented that there may be some water supplies used for irrigation purposes but the council does not hold records for such abstractions.
- The Environment Agency (EA) was contacted specifically regarding the details of the waste transfer station identified on the northern tip of the primary development site at the time of the enquiry. The relevant officer was able to confirm that the waste transfer station operates a license to sort and segregate <10,000 tonnes of inert waste comprising pipelines, cables, soil and rubble. At the time of the enquiry, the officer stated that there were no significant concerns relating to this waste transfer station.

# 3 GROUND INVESTIGATION

## 3.1 INVESTIGATION RATIONALE

The ground investigation has been designed to provide information on the general ground and groundwater conditions at the site together with general information on potential contamination issues. The scope of works was set out in the *Proposed Strategy for Geo-Environmental Assessment (2004)*.

The overall objectives for the investigation were to:

- Identify and benchmark contamination conditions at the site.
- Investigate areas of potential concern as identified by Entec and the WSP reviews.
- Establish environmental risks and potential liabilities associated with contamination conditions at the site.
- Identify suitable contamination mitigation measures within the context of the proposed use.
- Assess engineering properties of site conditions and identify engineering requirements for future redevelopment of the site with specific consideration given to foundation requirements, cut and fill issues, use of soakaways and the requirement for significant balancing ponds.

The strategy considered that the Phase 1 area was *Low Risk* with respect to geoenvironmental issues and an appropriate investigation density was proposed as indicated below (the site was referred to as Zones A and D within the strategy).

Area	Land use	Perceived Risk	Characteristics
Primary Development Site	Golf Course and Agricultural	Low	Agricultural land and golf course, no historical use as part of barracks but a small corner of the south-eastern field was part of the airfield. Some limited contamination issues from agricultural activities.
Hatton's Road Area	Agricultural	Low	Agricultural land, no historical use as part of airfield or barracks. Some limited contamination issues from agricultural activities.

Exploratory holes and trial pits on the site were located to provide general data on ground conditions across areas where development is proposed (i.e. within the application boundary).

Investigation Phase	Zone Area	Grid Basis
Primary Development Site	Whole Area	100m x 100m
	Geophysics Anomalies	Targeted
Hatton's Road Area	Line of roads etc.	100m spacing
	Balancing ponds	100m x 100m
	Geophysics Anomalies	Targeted

The grid system will be supported by additional scope for extra exploratory holes to delineate any issues of concern e.g. contamination hot-spots, geophysics anomalies, landfill, adverse ground conditions (loose gravel and soft clay) encountered during the course of the site works.

## 3.2 FIELDWORK

### 3.2.1 General

The ground investigation was undertaken in general accordance with techniques outlined in BS5930:1999 and BS1377:1990, as appropriate, at the positions shown on **Figures 3 and 4**. The exploratory hole records are presented in **Annex C**. The investigation was carried out under the supervision of engineers from WSP.

#### *Primary Development Site*

Ground investigation works have been undertaken between November 2005 and September 2007 to date have comprised the following:

All excavations on the south-eastern area of the site (land north of Rampton Road excluding golf course) were assessed for unexploded ordnance. Trial pits were scanned using handheld magnetometers under the supervision of an Explosive Ordnance Engineer from Bactec International Ltd, and boreholes and window sample locations were probed using Bactec's down-hole intrusive magnetometer rig. Exploratory locations on the golf course were assessed using a handheld magnetometer only due to the operational nature of this area of the site at the time of the investigation works.

No Cone Penetration Testing (CPT) was undertaken across the golf course and northern agricultural fields due to access restrictions. The CPT work will also be undertaken when access is available.

#### *Hatton's Road Area*

The ground investigation works were carried out between August and September 2005.

### 3.2.2 Cable Percussion Boreholes

The borehole investigation comprised the drilling of 28 no. cable percussive boreholes to depths of between 7.0m and 8.2m below ground level (bgl) on the Primary Development Site; and 5 no. to depths of 7.0m bgl on the Hatton's Road Area. Geotechnical testing, including Standard Penetration Tests (SPTs) and collection of U100 samples, was undertaken as appropriate at the majority of locations.

Monitoring wells were installed in selected boreholes, as detailed on the logs presented as **Annex C**.

### 3.2.3 Trial Pits

The trial pit investigation comprised the excavation of 21 no. trial pits on the agricultural land forming the northern, north-western, and south-eastern parts of the Primary Development Site, to depths of between 1.5m and 3.0m bgl; and 16 no. to depths of between 3.4m and 3.8m bgl on the Hatton's Road Area. Geotechnical strength testing was undertaken at selected locations on stable trial pit faces down to 1.2m or on excavated intact pieces of cohesive strata using a hand shear vane. Trial pits were backfilled with arisings and nominally compacted using the excavator bucket.

### 3.2.4 Windowless Sampler Boreholes

A total of 9 no. window samples were advanced to depths of between 4.0m and 5.0m below ground level on the Primary Development Site. A monitoring well was also installed in WSA4.

### 3.2.5 Cone Penetration Tests (CPT)

Five CPT holes were advanced on the Hatton's Road Area within the south-eastern field. Records are presented in **Annex C**.

### 3.2.6 Gas and Groundwater Monitoring Well Installations

Gas and groundwater monitoring wells were installed in selected boreholes and were constructed from 50mm perforated plastic pipe with a pea gravel surround and fitted with air tight gas valves. As a minimum requirement, each

monitoring well comprised plain pipe from ground level to 1m with a bentonite pellet surround. Exact details of each installation are shown on the borehole records. Monitoring installations were finished with flush fitted protective covers.

### 3.2.7 Groundwater Sampling and Well Development

Prior to sampling, monitoring wells were developed by the removal of approximately three well volumes where possible. Wells were developed using dedicated Waterra inertia pumps or disposable plastic bailers.

Groundwater samples were taken from each monitoring well using dedicated Waterra inertia pumps or disposable plastic bailers. Groundwater samples were retained in appropriate containers (1-litre glass and plastic bottles and 40ml glass volatile vials) and transported to the testing laboratory on the same day as sampling.

### 3.2.8 In-situ Permeability Testing

Permeability testing was undertaken in selected boreholes which consisted of rapidly submerging a closed cylindrical slug below the water table in the well and measuring the rise and subsequent fall of the water table, as described in Kruseman and de Ridder, 2000. These measurements were analysed with computer programme AquiferWin32 Version 3 using the Bower and Rice method of analysis to determine the hydraulic conductivity of the geological unit containing the water table.

The testing was undertaken on granular River Terrace Deposits and Ampthill Clay deposits and the results are presented as **Annex D**.

### 3.2.9 Surface Water Sampling

Surface water sampling has been undertaken from Beck Brook, Oakington Brook and Longstanton Brook upstream, adjacent to the site and downstream (**Figure 5**).

### 3.2.10 Gas and Groundwater Monitoring

Installed boreholes and window samples were monitored for ground gas levels using an infra-red gas analyser. Water levels were measured using an electrical contact dip meter. Monitoring details are summarised in Table 3.4 below.

Table 3.4: Summary of Monitoring Visits

Monitoring Round	Dates	Monitoring Undertaken		
		Groundwater Dip	Gas Monitoring	In-situ Redox
1	1st – 3rd February 2006	✓	✓	
2	25th – 26th May 2006	✓		
3	6th – 7th September 2006	✓		
4	13th – 22nd November 2006	✓	✓	
5	29th January – 1st February 2007	✓	✓	
6	19th – 21st February 2007	✓	✓	
7	28th – 29th March 2007	✓	✓	
8	17th – 19th April 2007	✓	✓	✓
9	22nd – 29th May 2007	✓	✓	
10	18th – 22nd June 2007	✓	✓	
11	23rd – 26th July 2007	✓	✓	

Monitoring Round	Dates	Monitoring Undertaken		
		Groundwater Dip	Gas Monitoring	In-situ Redox
12	13th – 15th August 2007	✓	✓	✓
13	3rd – 5th September 2007	✓	✓	
14	23rd – 25th October 2007	✓	✓	

The results of the gas and groundwater monitoring are presented in **Annex D** with redox data presented in **Annex F**.

### 3.3 CHEMICAL TESTING

#### 3.3.1 Chemical Testing Strategy

Selected soil samples were submitted for chemical analysis at the WSP Environmental laboratory in Nottingham, ALcontrol Technichem Laboratories in Slough and ALcontrol Geochem in Deeside.

The chemical testing suite has been designed to achieve the following:

- Characterise near surface contamination levels in order to provide an assessment of the risks associated contamination on the site in its current state and enable CLR7 statistical analysis for the assessment of risks to human health.
- Provide information on the solubility of contaminants and therefore the potential for impact on controlled waters.
- Provide information to enable assessment of risks to buildings and buried utilities from aggressive chemicals.

#### 3.3.2 Soils – General Contaminants

Selected samples were tested for the following contaminants on a total and leachable concentration basis:

- Arsenic, cadmium, chromium, copper, nickel, lead, zinc, mercury, selenium, boron and sulphate.
- Cyanide.
- Speciated Polycyclic Aromatic Hydrocarbons (PAHs) and Phenols.
- Total Petroleum Hydrocarbons (TPH).
- Sulphate and pH.

#### 3.3.3 Soils – Targeted Testing

In addition, targeted samples were analysed for the following detailed organic characterisation tests:

- Volatile Organic Compounds (VOC's).
- TPH Criteria Working Group (CWG) suite.
- Semi-Volatile Organic Compounds (SVOC's).
- PAH Speciation.
- Phenols Speciation.
- Asbestos Screen.

The results of the contamination testing on soils are presented in **Annex E**.

### 3.3.4 Groundwater – General Contaminants

Groundwater samples were analysed for the following contaminants to provide information on general contamination levels and overall water quality:

- Arsenic, cadmium, chromium, copper, nickel, lead, zinc, barium, beryllium, vanadium, mercury, selenium and boron.
- Cyanide.
- pH, sulphate, chloride, ammonium, nitrate and nitrite.
- TPH, VOCs, Phenols and SVOCs.

### 3.3.5 Surface Water – General Contaminants

Surface water will be analysed for the following contaminants to provide information on general contamination levels and overall water quality:

- Arsenic, cadmium, chromium, copper, nickel, lead, zinc, barium, beryllium, vanadium, mercury, selenium and boron.
- Cyanide.
- pH, sulphate, sulphide, chloride, ammonium, nitrate and alkalinity.
- TPH (CWG), VOCs and SVOCs.
- Chemical and Biological Oxygen Demand (COD and BOD).

The results of the chemical analysis testing on groundwater and surface water are presented in **Annex F**.

### 3.3.6 Field Testing – Groundwater and Surface Water

Field analysis of surface water and groundwater from selected boreholes was undertaken in April and August 2007 to determine the following parameters to assist in groundwater characterisation:

- Dissolved Oxygen.
- pH.
- Reduction-Oxidation Potential (Eh).
- Electrical Conductivity.

The field data is presented in **Annex F**.

## 3.4 GEOTECHNICAL TESTING

Selected soil samples were tested for the following geotechnical parameters:

- Moisture content, Atterberg Limits, particle size distribution, sedimentation, undrained shear strength, compaction and consolidation properties, particle density, bulk density, permeability (in CBR mould), sulphate, pH and organic matter content.

The results of the geotechnical testing are presented in **Annex G**.



## 4 GROUND AND GROUNDWATER CONDITIONS

The ground conditions encountered during the investigation are generally consistent with the anticipated sequence of strata indicated within the desk study information. Based on the information obtained during the ground investigation the ground conditions were found to comprise River Terrace Deposits underlain by Ampthill Clay and Kimmeridge Clay. Exploratory Hole Location plans included as **Figures 3 and 4**.

The general sequence of the strata and associated geotechnical properties for each of the site areas are summarised in Table 4.1 and Table 4.2.

Table 4.1: Summary of Strata Encountered – Primary Development Site

Parameter	Stratum		
	Made Ground	River Terrace Deposits	Ampthill Clay
Description	Grass over dark brown slightly sandy gravelly CLAY (gravel comprising flint, granite and brick). Reworked slightly clayey slightly gravelly sandy TOPSOIL or soft grey sandy organic clay with rare fine gravel.	Predominantly medium dense to dense orange brown sandy flint and chalk GRAVEL, SAND AND GRAVEL or gravelly SAND with variable amounts of clay.	Generally fissured firm to hard grey or blue grey occasionally mottled brown or orange brown CLAY with rare bands of siltstone. Locally slightly sandy with selenite crystals and pyrite.
Depth to base of strata (m)	0.3 – 1.4	0.4 – 8.0	Unproven
SPT 'N' Values	NT	7 - 50	7 - 37
Shear Strength (kPa)	NT	43 – 188	69 – 158
Moisture Content (%)	NT	8 – 33	17 – 33
Liquid Limit (%)	NT	31 – 81	46 – 75
Plastic Limit (%)	NT	17 – 30	19 – 28
Plasticity Index (%)	NT	14 – 54	27 – 47
Plasticity Category	NT	Low to Very High	Low to Very High
Particle Density (Mg/m <sup>3</sup> )	NT	2.58 (single result)	2.65 – 2.69
Bulk Density (Mg/m <sup>3</sup> )	NT	1.66 – 2.23	1.75 – 2.01
Dry Density (Mg/m <sup>3</sup> )	NT	1.49 – 1.95	1.4 – 1.58
California Bearing Ratio (CBR)	NT	1.56 – 53.73	NT
Optimum Moisture Content (%)	NT	11	NT
Particle Size Distribution	NT	Gravel 20.0 – 76.3 Sand 22.0 – 58.0 Clay/Silt 0.68 – 22.0	NT
Hand Shear Vane Result (kPa)	NT	86 – 164	90 – 260
Coefficient of Volume compressibility (Mv) M <sup>2</sup> /MN	NT	NT	0.08 – 0.37

Parameter	Stratum		
	Made Ground	River Terrace Deposits	Amphill Clay
Coefficient of Consolidation (Cv) M <sup>2</sup> /yr	NT	NT	0.07 – 32.77
Water Soluble Sulphate (mg/l)	<50 (single result)	<50 – 3,513 (generally <50 – 118)	82 – 3,600
pH	7.4 (single result)	7.3 – 8.3	7.5 – 8.5

NP = Not Proven; NT = Not Tested.

Table 4.2: Summary of Strata Encountered – Hatton's Road Area

Parameter	Stratum		
	River Terrace Deposits	Amphill Clay	Kimmeridge Clay
Description	Firm yellow brown slightly gravelly sandy to very sandy CLAY locally with grey mottling.  Loose to medium dense brown slightly gravelly very clayey SAND.  Firm to stiff grey mottled orange brown slightly gravelly slightly sandy SILT (one location).	Generally fissured firm to hard grey or blue grey occasionally mottled brown or orange brown CLAY with rare bands of siltstone. Locally slightly sandy with selenite crystals and pyrite.	Generally fissured firm to hard grey or blue grey occasionally mottled brown or orange brown CLAY with rare bands of siltstone. Locally slightly sandy with selenite crystals and pyrite.
Depth to base of strata (m)	GL – 2.6	Unproven	Unproven
SPT 'N' Values	10 - 21	14 - 32	9 - 38
Shear Strength (kPa)	NT	NT	NT
Moisture Content (%)	7 – 25	8 – 26	14 – 28
Liquid Limit (%)	26 – 59	59 (single result)	61 – 64
Plastic Limit (%)	17 – 27	24 (single result)	26 – 27
Plasticity Index (%)	9 – 32	35 (single result)	34 – 38
Plasticity Category	Low to High	High (single result)	High
Particle Density (Mg/m <sup>3</sup> )	NT	NT	NT
Bulk Density (Mg/m <sup>3</sup> )	1.96 (single result)	1.95 (single result)	NT
Dry Density (Mg/m <sup>3</sup> )	1.57 (single result)	NT	NT
California Bearing Ratio (CBR)	NT	NT	NT
Optimum Moisture Content (%)	8 - 23	24 (single result)	24 – 25
Particle Size Distribution	NT	NT	NT
Hand Shear Vane Result (kPa)	64 – 248	56 – >260	98 – >260
Coefficient of Volume	NT	NT	NT

Parameter	Stratum		
	River Terrace Deposits	Amphill Clay	Kimmeridge Clay
compressibility (Mv) M <sup>2</sup> /MN			
Coefficient of Consolidation (Cv) M <sup>2</sup> /yr	NT	NT	NT
Water Soluble Sulphate (mg/l)	137 (single result)	108 – 1,588	4,397 (single result)
pH	7.8 (single result)	6.4 – 7.7	7.5 (single result)

NP = Not Proven; NT = Not Tested.

#### 4.1 GEOLOGY

The ground conditions encountered during the investigation were found to be generally consistent with the anticipated sequence of strata indicated by the desk study information.

##### 4.1.1 Primary Development Site

###### *Made Ground*

Made Ground was identified in four locations on the western area of the site (WSA1, BHA30, TPA3 and PTM1).

The Made Ground was found to comprise dark brown reworked slightly clayey slightly sandy topsoil; grass over brown slightly gravelly sandy topsoil; dark brown slightly sandy gravelly clay with brick, granite and flint gravel; and black/brown slightly clayey very gravelly sand with roadstone and clinker gravel.

However, Made Ground comprising soft sandy organic clay with rare fine gravel and a single metal rod was identified in TPA3, in the northern and eastern faces of the trial pit between 0.8m and 1.4m bgl. TPA3A was excavated adjacent to TPA3 to confirm the lateral extent of Made Ground in this area, and no Made Ground was encountered. It is possible that the observed organic material in TPA3 is resultant from a backfilled pond or pit.

###### *Topsoil*

Topsoil was encountered within all exploratory holes where Made Ground was absent (except BHA13, 16, 17 and 22) between ground level and 1.2m bgl (generally 0.3 - 0.7m bgl). The deepest deposits were recorded on the golf course and it is considered likely that a proportion of the deeper deposits are reworked across this area, resulting from the re-grading of shallow soils to form the fairways. Topsoil was generally sandy towards the west and clayey towards the east.

###### *Superficial Deposits*

The natural strata underlying the site were found to be consistent with the geological map information comprising River Terrace Deposits underlain by Amphill Clay. The superficial deposits were encountered in the western part of the Primary Development Site and predominantly comprise medium dense to dense orange brown sands and gravels, with some silt bands, recorded to a maximum depth of 8.0m below ground level (BHA22, although depth was not proven at several other borehole locations). Some areas of the central and southern portion of the Primary Development Site exhibited River Terrace Deposits channelised into the underlying solid geology.

###### *Solid Geology*

The Amphill Clay was encountered beneath the superficial deposits in the western part of the site (deepest in BHA22 from 8.0m bgl) and at shallower depths to the east, generally beneath cohesive River Terrace Deposits.

The lithology comprised firm to hard grey or blue grey clay, occasionally mottled brown. The clay was found to be slightly sandy and fissured in several locations, with a band of siltstone in WSA5 at 2.6m to 3m bgl. Siltstone bands are more common on the former airfield to the south of the site.

### *Obstructions*

Below ground obstructions were not identified during the investigation although their presence, particularly in the southern area of the site close to where airfield infrastructure was formerly present, cannot be discounted.

#### 4.1.2 Hatton's Road Area

##### *Made Ground*

Made Ground was not encountered within the application boundary.

##### *Topsoil*

Clayey Topsoil was encountered within all exploratory holes (except BHD3, and TPD32) between ground level and 0.5m bgl (generally circa 0.3m bgl). This generally correlates with the plough depth across the site.

##### *Superficial Deposits*

The natural strata underlying the site were found to be consistent with the geological map information comprising River Terrace Deposits underlain by Ampthill Clay or Kimmeridge Clay. Generally thin superficial River Terrace Deposits were encountered above the solid strata. They predominantly comprised sandy clay with irregular granular deposits often channelised into the underlying solid strata.

##### *Solid Geology*

The Ampthill Clay was encountered beneath the superficial deposits in the northern part of the site and Kimmeridge Clay in southern parts of the site.

The lithologies of the two clays were generally similar comprising firm to hard grey or blue clay, occasional mottled brown or orange brown. The clay was found to be slightly sandy and fissured in several locations, with occasional bands of siltstone. The siltstone bands were not encountered fully as one unit but were generally recorded on the eastern half of the site. There did appear to be a general dip in the bands between exploratory holes towards the north-west.

### *Obstructions*

Below ground obstructions were not identified during the investigation.

## 4.2 HYDROGEOLOGY

### 4.2.1 Primary Development Site

#### *General*

Groundwater was predominantly encountered in exploratory holes across the western part of the site. The majority of groundwater strikes were recorded between one and two metres below ground level within the River Terrace Deposits (Secondary A Aquifer). Depth to groundwater during the monitoring in the River Terrace Deposits was 0.33m bgl to 2.03m bgl. Groundwater was also encountered across the eastern half of the site where response zones are within the Ampthill Clay or cohesive River Terrace Deposits and depth to groundwater ranged from 'at surface' to 6.9m bgl. The groundwater elevations recorded during the groundwater monitoring period are presented in Table 4.3.

Table 4.3: Summary of Recorded Groundwater Elevations – Primary Development Site

Borehole	02/02/2006	25/05/2006	06/09/2006	13/11/2006	29/01/2007	19/02/2007	28/03/2007	17/04/2007	22/05/2007	18/06/2007	23/07/2007	10/08/2007	03/09/2007	23/10/2007	20/11/2007	03/12/2007	18/02/2008	01/06/2008	15/06/2008	17/09/2008
BH1 (WSPD)	-	6.86	6.56	6.57	7.27	7.38	7.32	7.17	7.00	7.09	6.98	6.89	6.83	-	7.32	6.92	7.31	7.33	7.21	6.76
BH9 (WSPD)	-	3.65	3.39	4.27	4.84	5.09	4.70	1.83	1.97	3.67	3.65	3.59	3.51	5.14	4.70	5.18	4.60	4.98	4.78	4.31
WSA4	7.25	-	-	-	-	7.43	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BHA1	7.57	7.93	7.15	7.26	8.11	8.17	5.73	7.82	7.56	7.69	7.72	7.54	7.55	7.09	7.51	7.60	8.01	7.94	7.73	7.49
BHA2	1.35	5.53	4.57	4.39	5.74	6.14	5.59	4.47	4.43	5.39	5.05	4.80	4.57	4.72	5.73	4.75	5.64	5.84	5.51	4.61
BHA3	6.92	6.38	-	6.58	7.30	7.38	7.27	7.10	6.07	7.01	6.93	6.81	6.88	7.07	-	7.06	7.33	7.30	7.09	-
BHA10	-	-	-	-	-	4.86	5.08	-	2.42	-	-	-	4.78	-	-	-	-	-	-	-
BHA12	-	-	-	3.66	4.83	4.81	4.68	4.55	4.44	4.57	4.61	4.38	4.31	-	-	-	5.31	5.14	4.98	-
BHA13 (deep)	-	-	-	-	-	-	-	-	-	-	7.37	7.37	7.42	7.60	7.37	7.47	7.24	7.25	7.33	7.17
BHA13 (shallow)	-	-	-	-	-	-	-	-	-	-	7.40	7.21	7.63	7.44	7.39	7.67	7.42	7.59	7.47	7.06
BHA14	-	-	-	-	-	-	-	-	-	-	7.68	7.56	2.63	1.77	7.70	7.88	7.94	7.68	7.71	7.52
BHA15	-	-	-	-	-	-	-	-	-	-	1.20	4.51	2.56	2.73	3.01	3.73	7.76	7.84	7.51	-
BHA16	-	-	-	-	-	-	-	-	-	-	0.88	1.16	-0.04	1.05	1.31	1.42	-0.07	1.05	2.16	2.27
BHA17	-	-	-	-	-	-	-	-	-	-	-	-	4.92	-0.06	0.12	0.22	0.49	1.05	1.53	1.68
BHA18	-	-	-	-	-	-	-	-	-	-	2.93	6.33	6.56	7.06	6.88	7.55	6.85	7.71	6.85	-
BHA19 (shallow)	-	-	-	-	-	-	-	-	-	-	7.66	7.54	7.64	7.74	7.62	7.74	7.95	7.78	7.84	7.41
BHA19 (deep)	-	-	-	-	-	-	-	-	-	-	7.67	7.65	7.41	7.52	7.62	8.24	7.94	7.98	7.66	7.52
BHA21	-	-	-	-	-	-	-	-	-	-	7.36	-	6.81	7.16	7.14	7.30	7.72	7.74	7.57	-
BHA22	-	-	-	-	-	-	-	-	-	-	7.42	7.30	7.59	7.23	7.82	7.22	7.79	7.78	7.66	-
BHA23 (deep)	-	-	-	-	-	-	-	-	-	-	7.23	7.22	-	6.77	7.01	-	7.07	7.09	7.05	6.77
BHA24	-	-	-	-	-	-	-	-	-	-	5.40	-	-	5.12	1.57	1.84	2.48	3.75	-	5.32
BHA25	-	-	-	-	-	-	-	-	-	-	-	4.65	4.69	-	4.74	5.42	5.12	5.49	5.05	3.99

Borehole	02/02/2006	25/05/2006	06/09/2006	13/11/2006	29/01/2007	19/02/2007	28/03/2007	17/04/2007	22/05/2007	18/06/2007	23/07/2007	10/08/2007	03/09/2007	23/10/2007	20/11/2007	03/12/2007	18/02/2008	01/06/2008	15/06/2008	17/09/2008
BHA26	-	-	-	-	-	-	-	-	-	-	-1.22	-0.06	0.31	5.00	1.03	1.25	4.56	5.17	4.57	3.79
BHA27	-	-	-	-	-	-	-	-	-	-	-1.15	-0.16	0.63	0.25	2.01	2.68	3.91	4.59	4.46	4.17
BHA28	-	-	-	-	-	-	-	-	-	-	1.50	7.25	7.23	3.57	7.27	7.45	7.52	7.55	7.44	7.18
BHA30 (deep)	-	-	-	-	-	-	-	-	-	-	7.45	7.25	7.18	7.19	7.20	7.24	7.67	7.60	7.59	-
BHA30 (shallow)	-	-	-	-	-	-	-	-	-	-	7.40	7.25	7.17	7.19	7.22	7.25	7.76	7.79	7.59	-
BHA31	-	-	-	-	-	-	-	-	-	-	7.46	7.32	7.26	7.34	7.35	7.36	7.82	7.81	7.65	-
BHA32	-	-	-	-	-	-	-	-	-	-	8.43	7.49	7.43	7.48	7.74	7.49	7.92	8.90	7.75	-
BHA33	-	-	-	-	-	-	-	-	-	-	7.25	-	7.37	7.50	-	7.46	7.73	7.72	7.59	7.32

Note: All elevations in m AOD

Groundwater level monitoring has confirmed that the groundwater flow direction is to the north and north-east of the site within the River Terrace Deposits in line with the flow of local surface water features and drainage. Some groundwater flow to the east and north-east is likely within the Ampthill Clay, in line with the general topography of the eastern half of the site. Based on the recorded groundwater elevations, the calculated hydraulic gradient within the River Terrace Deposits is approximately 0.0032 to 0.0078.

### Permeability

Permeability testing was undertaken at several borehole locations across the site. The data which is presented within **Annex D**. The testing indicated hydraulic conductivities between 0.09m/day and 16.15m/day within the clay strata. Permeability testing was undertaken in the granular River Terrace Deposits (BHA33 deep) recording hydraulic conductivities between 7.94m/day and 12.18m/day.

### Geochemical Parameters

In-situ measurements of geochemical parameters were undertaken on two occasions in April and August 2007. The results are contained within **Annex F**.

The results from the April round of monitoring indicate generally reducing conditions (low Eh) with generally neutral pH and dissolved oxygen readings in the range typical of oxygenated water. The recorded pH during the August monitoring round also appeared neutral but the recorded Eh values were generally higher indicating neutral to slightly reducing conditions.

## 4.2.1 Hatton's Road Area

### General

Groundwater was generally encountered in exploratory holes within the Ampthill / Kimmeridge Clay (Unproductive Strata). Groundwater levels during the monitoring period were between 0.54m bgl and 2.09m bgl. The groundwater elevations recorded during the groundwater monitoring period are presented in Table 4.4.

Table 4.4: Summary of Recorded Groundwater Elevations – Hatton's Road Area

Borehole	02/02/2006	06/09/2006	13/11/2006	29/01/2007	19/02/2007	28/03/2007	17/04/2007	22/05/2007	18/06/2007	23/07/2007	10/08/2007	03/09/2007	20/11/2007	03/12/2007
BHD2	9.92	9.91	10.09	10.1	9.96	9.95	9.87	9.9	10.08	9.99	9.88	9.92	9.98	10.11
BHD3	9.14	8.8	8.76	9.84	10.04	9.67	9.48	9.28	8.92	9.50	9.33	9.47	9.63	9.82
BHD5	11.88	12.36	11.32	12.18	12.26	12.02	11.85	11.67	11.75	11.83	11.65	11.62	-	-
BHD6	13.08	13.02	13.23	13.49	13.88	13.32	13.16	13.02	13.37	13.27	13.07	12.9	13.18	12.94

Note: All elevations in m AOD

The direction of groundwater flow beneath the site is to the north or north-west. Groundwater flow across the site appears to be influenced by local surface water features with flows parallel to the open surface drains and Longstanton Brook that flows through the site.

Based on the recorded groundwater elevations, the calculated hydraulic gradient is approximately 0.0076.

### Permeability

Based on the descriptions from the exploratory hole records, River Terrace Deposits are considered to be of variable permeability. Although River Terrace Deposits are technically classified as a Secondary A Aquifer, it is considered unlikely that they hold notable volumes of groundwater due to the variable nature of the strata (alternates between granular and cohesive deposits) and their likely limited vertical and lateral extent across the site. The Kimmeridge and Ampthill Clay non-aquifers and are considered to be of low permeability, although secondary porosity in the form of fissuring may be present. Permeability testing was not undertaken within exploratory holes on the site.

### *Geochemical Parameters*

In-situ measurements of geochemical parameters were undertaken in April and August 2007 on the site and in the surrounding area. The results are contained within the data summary sheets presented in **Annex F**.

The results from the April round of monitoring indicated generally reducing conditions (low Eh) with generally neutral pH and dissolved oxygen readings in the range typical of oxygenated water. The recorded pH during the August monitoring round also appeared neutral but the recorded Eh values were generally higher than the previous monitoring round and some of the dissolved oxygen concentrations were lower suggesting anaerobic groundwater conditions.

#### 4.3 GROUND GAS

The gas monitoring identified concentrations of methane gas at or below 0.1% throughout the monitoring period. Carbon Dioxide was generally detected at concentrations <5% although concentrations up to 7.8% were recorded locally. Gas flows were generally negative, low or zero.

Full details of the gas monitoring undertaken are presented within **Annex D**.

#### 4.4 CONTAMINATION OBSERVATIONS

No visual or olfactory evidence of significant contamination was recorded during the ground investigation.

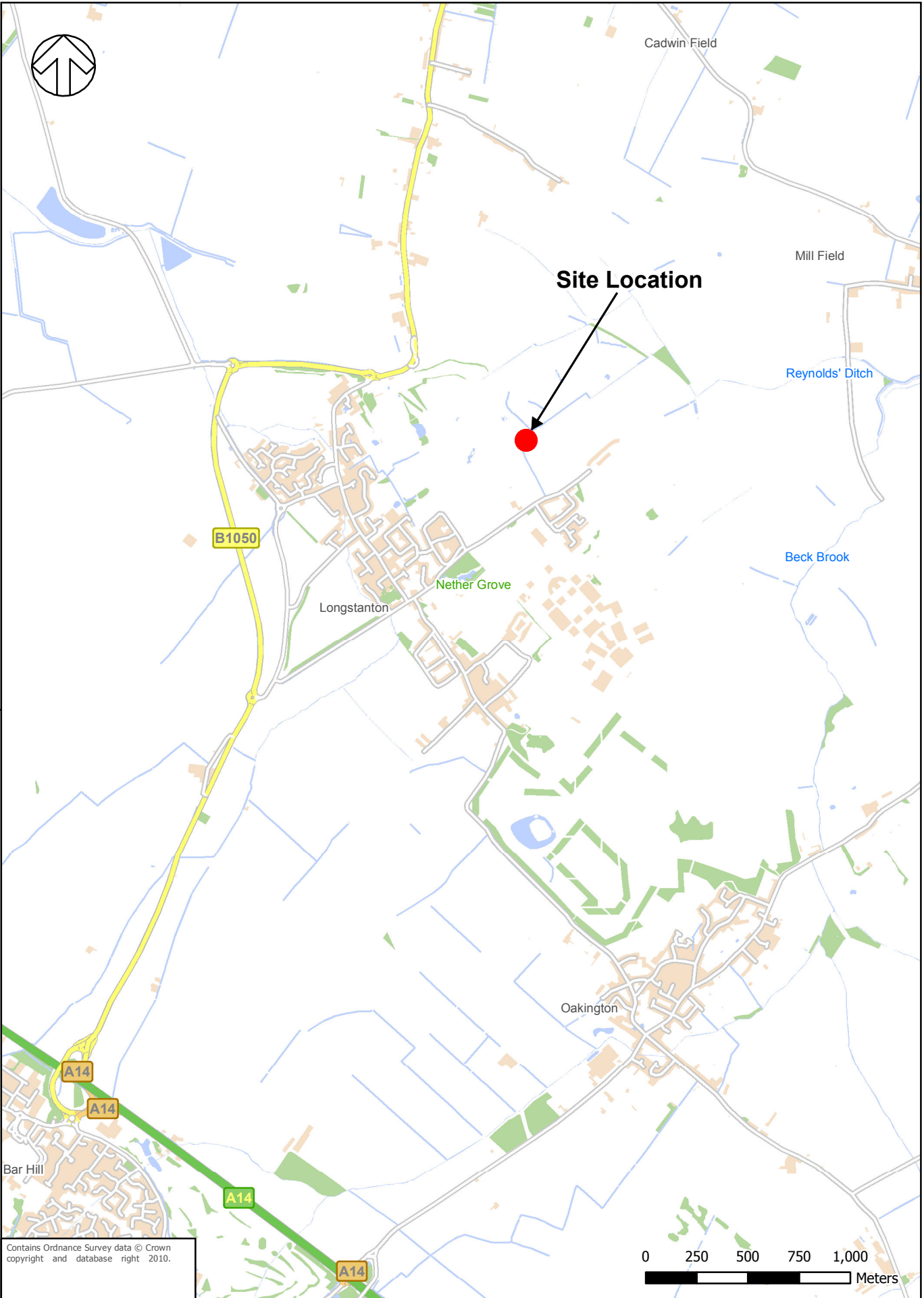
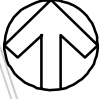
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# FIGURES

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File:

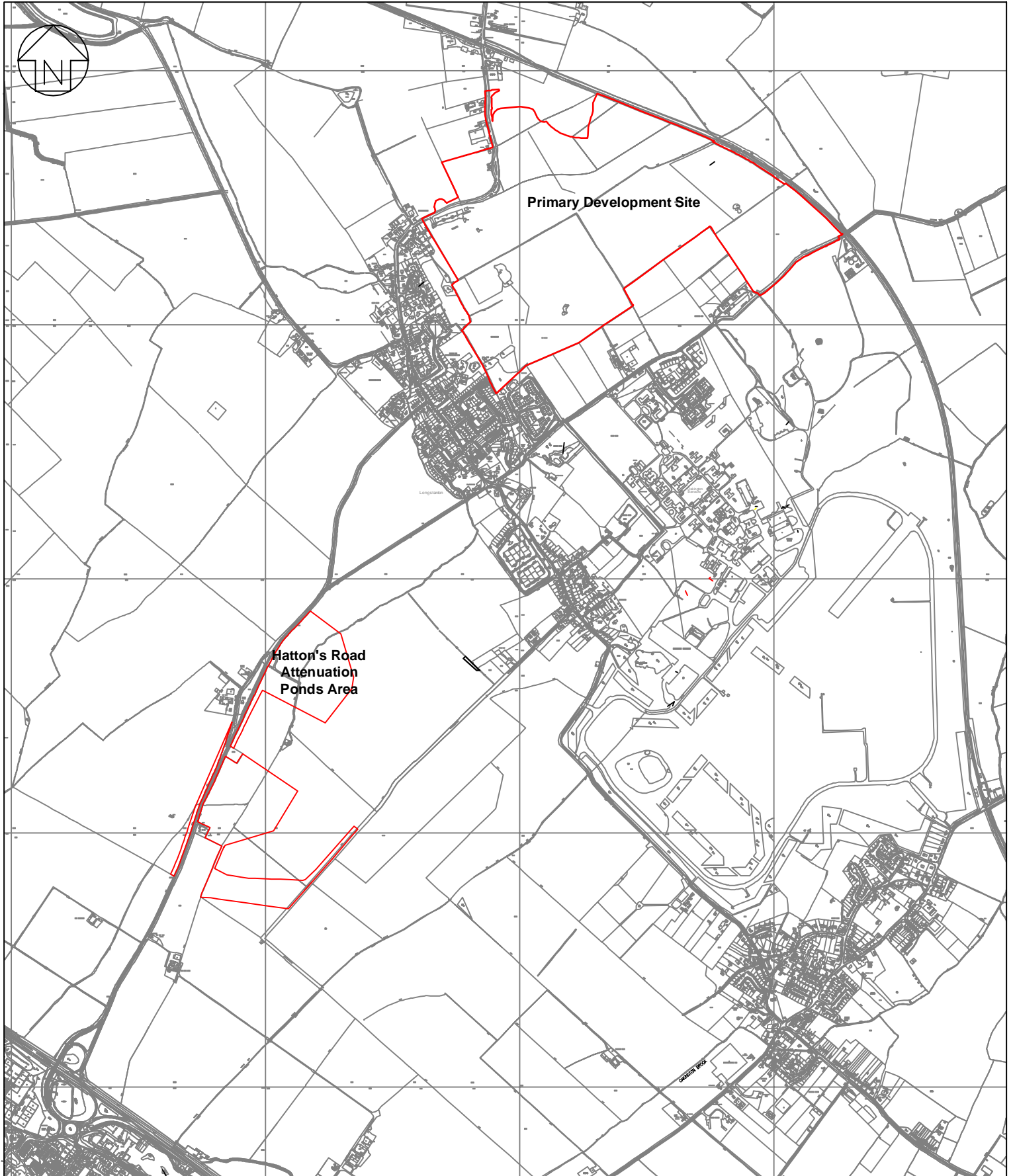



TITLE:

Northstowe - Phase 1  
Site Location Plan

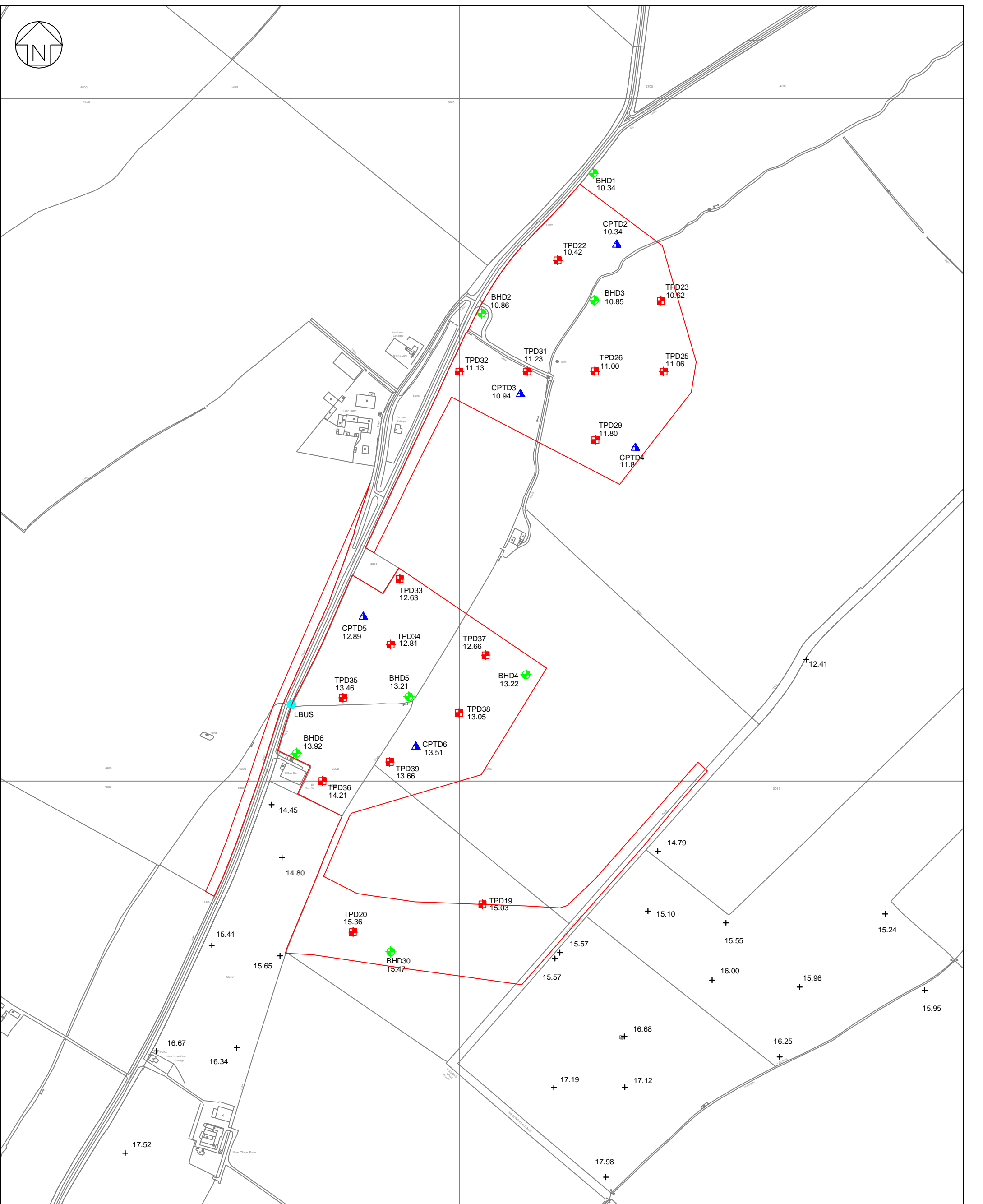
FIGURE No:

Figure 1



PROJECT: <b>NORTHSTOWE - PHASE 1</b>		SCALE@SIZE: 1:20,000 @ A4	CHECKED: EA	 One Queens Drive, Birmingham B1 4PJ Tel: +44 (0) 121 352 4700 Fax: +44 (0) 121 352 4701 <a href="http://www.wspgroup.com">http://www.wspgroup.com</a>
TITLE: <b>SITE BOUNDARY PLAN</b>		DATE: FEB 2012	DESIGN/DRAWN: JMC	
		CAD FILE:	APPROVED: EA	
PROJECT No: <b>22881-001</b>	DRAWING No: <b>FIGURE 2</b>	REV: <b>A</b>	<b>© WSP Group plc</b>	





DO NOT SCALE

- Redline Boundary
- ⊕ Cable Percussive Borehole
- ⊕ Trial Pit
- ▲ Cone Penetration Test (CPT) Location
- Surface Water Sampling Location

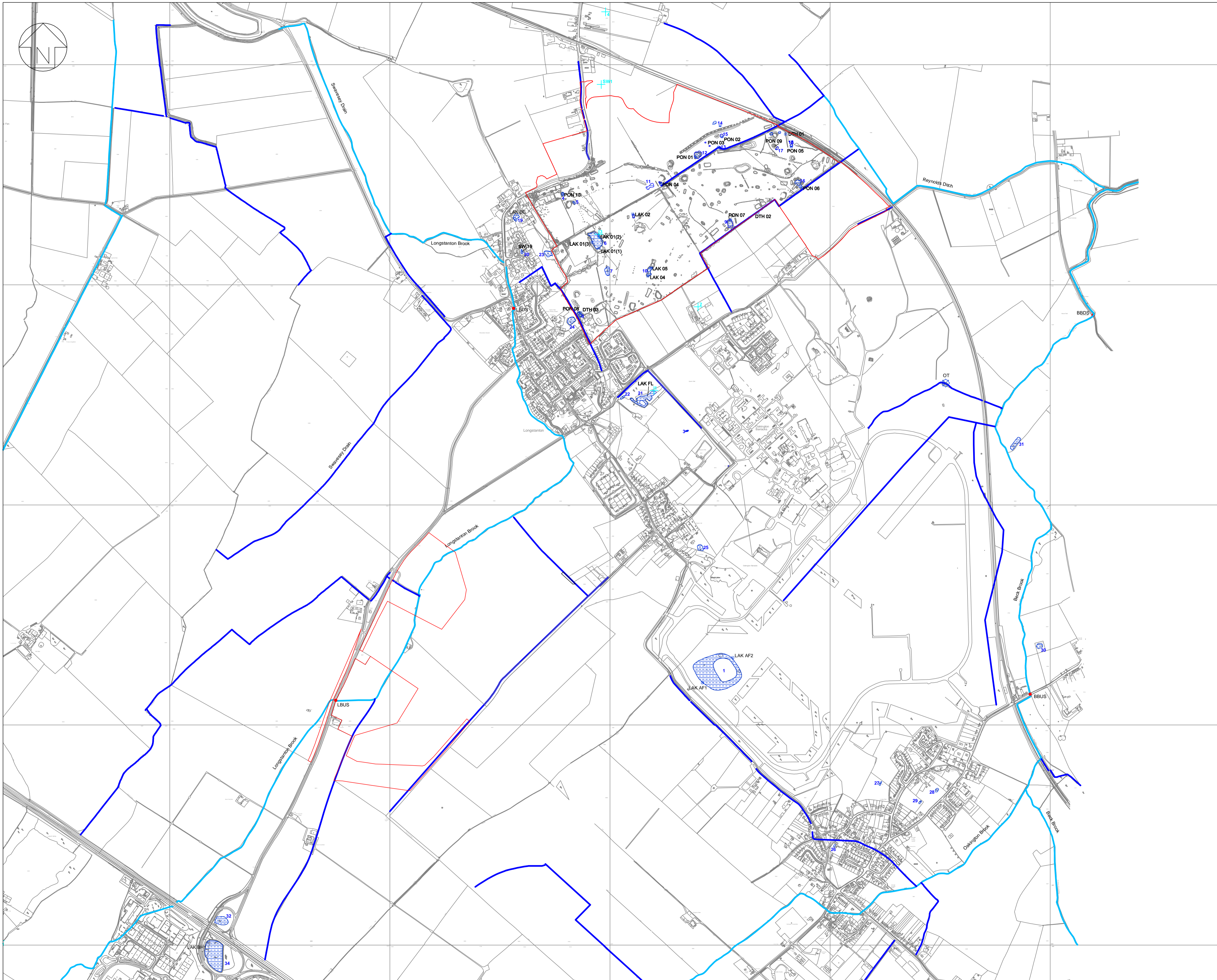
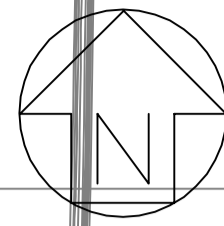
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ARCHITECT:					
PROJECT: NORTHSTOWE - PHASE 1					
TITLE: EXPLORATORY HOLE LOCATION PLAN PHASE 1 - HATTON'S ROAD AREA					
SCALE/SIZE: 1:5000 @ A3		CHECKED: JMC		APPROVED: EA	
CAD FILE:		DESIGN/DRAWN: JMC		DATE: FEBRUARY 2012	
PROJECT No: 22881-001			DRAWING No: FIGURE 4		REV: A









REV	DATE	BY	DESCRIPTION	CHK	APP
DRAWING STATUS: FINAL					

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DO NOT SCALE

-  Development Boundary
-  Surface Water Abstractions
-  Groundwater Abstractions
-  Pond or Lake
-  Minor Brook, Ditch or Drain
-  Major Brook or Drain
-  Surface Water Sample Location (pond/lake)
-  Surface Water Sample Location (brook)
- LB Longstanton Brook
- OB Oakington Brook
- BB Beck Brook
- US Upstream
- DS Downstream

REV	DATE	BY	DESCRIPTION	CHK	APD

DRAWING STATUS: **FINAL**



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CLIENT: **GALLAGHER**

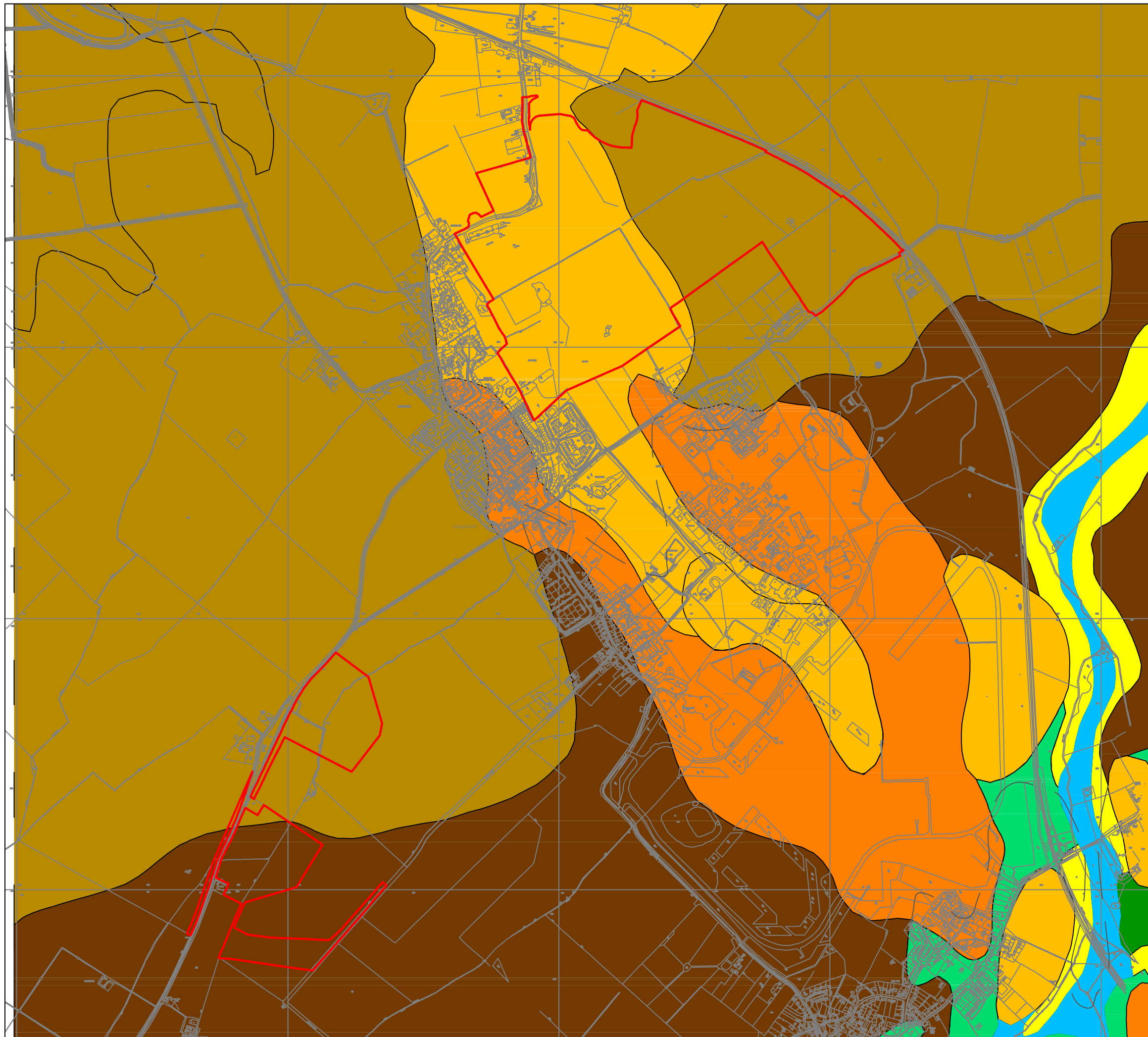
ARCHITECT: **GALLAGHER**

PROJECT: **NORTHSTOWE - PHASE 1**

TITLE: **SURFACE WATER FEATURES AND SURFACE WATER AND GROUNDWATER ABSTRACTIONS**

SCALE@SIZE: NTS	CHECKED: CW	APPROVED: EA
CAD FILE:	DESIGN/DRAWN: JMC	DATE: FEB 2012

PROJECT No: 22881-001	DRAWING No: FIGURE 5	REV: A
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DO NOT SCALE

- Alluvium
- Alluvium on 2nd River Terrace Gravels
- 2nd River Terrace Gravels
- 3rd River Terrace Gravels
- 4th River Terrace Gravels
- Boulder Clay
- Gault
- Lower Greensand
- Kimmeridge Clay
- Ampthill Clay
- Inferred boundary of solid geology beneath drift
- Site Boundary

REV	DATE	BY	DESCRIPTION	CHK	APD

DRAWING STATUS: FINAL



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CLIENT: GALLAGHER

ARCHITECT:

PROJECT: NORTHSTOWE  
PHASE 1

TITLE: INFERRED SITE GEOLOGY

SCALE@SIZE: NTS @ A3	CHECKED: EA	APPROVED: EA
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CAD FILE:	DESIGN/DRAWN: JMC	DATE: FEBRUARY 2012
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PROJECT No: 22881-001	DRAWING No: FIGURE 6	REV: A
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