

A stylized, layered illustration of a park scene. In the background, there are large, dark green trees with brown trunks. A light blue river flows through the center. On the left, a person in a brown tank top and white shorts is running. On the right, a person in a yellow shirt and brown hat is riding a bicycle. In the middle right, a person is sitting on a bench, fishing. Several white swans are in the water. In the foreground, there are tall, dark green reeds and grasses. Several bees are flying around. The overall style is modern and graphic, with a muted color palette of greens, blues, and browns.

Barnham Eastergate & Westergate (BEW)

Parcel SC1
Phase 1 Land Contamination
Desk Study

January 2022

Pell Frischmann



P e l l F r i s c h m a n n

Barnham Eastergate Westergate

Phase 1 Land Contamination Desk Study Preliminary Risk Assessment

Date: 12 October 2021

Report Ref: A13394-PF-C-ZZ-XX-RPT-0002

Revision Record

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Executive Summary

Site name	Barnham-Eastergate-Westergate, West Sussex. BEW Parcel SC1 for this application.
Location	The Site primarily comprises agricultural land located to the east, south and west of the existing residential neighbourhoods of Westergate, Eastergate and Barnham and is located at National Grid Reference (NGR) 494693E, 104110N
Development proposals	This LCDS report was prepared in October 2020 to support planning applications within the wider BEW site allocation boundary. This will ultimately comprise up to 4,300 homes, re-alignment of the new A29 route, a bridge over the railway, a new local centre with retail, commercial and community facilities. To include: library, health centre, public open space, two primary schools, nursery facilities and new sports pitches. This report accompanies the BEW Parcel DC1 application of the wider allocation.
Land use history	The majority of the on-site area has remained as arable agricultural land since the earliest records. The railway lines are known to have been constructed around 1840's and are present prior to the earliest mapping. In addition, the earliest maps show two farms to the south, namely New Barn and Headhone Farm. Several footpaths, railway crossings and water features, such as Lidsey Rife are also present. In 1899, the Headhone Farm appears to re-locate from the centre of the site west, to a closer to the road outside the site boundary. The site has remained without changes up to 1912-13 when the north-westernmost part of the site show two new nurseries namely "The Warwick" and "The Brooks". Around 1960's Highground Barn Nursery to the south east extends beyond the Bognor Branch line towards the centre of the site A small sewage works is identified within the north of the site between 1979 and 1993. Lindsey Oil works, located just outside the southern boundary of the site are known to be built in 1987. By 2020 a new surface water feature is shown immediately north of Lidsey Oil Works.
Published geology	The Site is predominantly underlain by superficial deposits of Alluvium, head deposits, raised beach deposits and River Terrace Deposits which cover most of the site and wider area, and which are underlain by solid 'bedrock' geology of London Clay Lambeth Group and Lewes Nodular Chalk
Hydrogeology & hydrology	Superficial Deposits – Secondary A Aquifer London Clay Formation – unproductive strata. Chalk – Principal Aquifer
Unexploded ordnance	Low risk (based on preliminary Zetica UXO mapping)
Geotechnical risks	This study has identified the following potential geotechnical risks associated with any development of the site; ➤ Unknown ground conditions; ➤ Shrink/swell clays; ➤ Shallow groundwater
Land contamination Preliminary Risk Assessment (PRA) conclusions	The PRA has identified five potential contaminant linkages for the Site. Of which one has been assigned a 'moderate' initial risk rating, associated with the following: ➤ Moderate risk of inhalation of ground gas by end users on the southern area of the Site.
Recommendations for further work	A flood risk assessment is required as the site is over 1 hectare in size. This assessment should include a scoping study of the risks from groundwater flooding. A detailed site investigation is required to inform on geotechnical and geoenvironmental design and engineering design parameters for the proposed works. It should comprise of: ➤ Window samples and trial pits to allow collection of samples for geochemical analysis and allow installation of ground gas and water monitoring wells; ➤ Boreholes to delineate the geological conditions on site and allow in-situ testing to be undertaken to assess soil and groundwater beneath the site; ➤ Ground gas monitoring in areas identified within the south of the site. ➤ Geotechnical and geoenvironmental testing of soil samples;

1 Commission

1.1 Introduction

Pell Frischmann has been commissioned by CC Projects, Ashmarden Ltd and Hanbury (PM) Ltd (promoting the site together as 'The Southern Consortium') to prepare a Phase 1 Land Contamination Desk Study (LCDS) for the site at Barnham/ Eastergate/ Westergate, (BEW), West Sussex as allocated in the Arun Local Plan Policy H SP2c SD5 (Allocation Boundary).

This LCDS includes a review of site specific and readily available desk-based geoenvironmental information to provide an initial assessment of the likely ground and geoenvironmental conditions at the Site and to identify potential land contamination risks and /or geoenvironmental constraints which may impact upon and/or restrict the proposed development.

The LCDS includes a Tier 1: Preliminary Risk Assessment (PRA) for land contamination, which includes the development of an outline Conceptual Site Model (CSM) for the proposed development.

This LCDS report was prepared in October 2020 (reported March 2021) to support planning applications within the Allocation Boundary, which includes plans for up to 4,300 dwellings, a Community Hub to include retail, commercial and community facilities, a new A29 route through the allocation, primary schools and nursey facilities, transport infrastructure, public open space amenity and sports pitches.

In October 2021 this report has received minor revisions to communicate the intention for it to accompany the planning application for BEW Parcel SC1 which wholly lies within the wider Allocation Boundary that this report was originally prepared for. On this basis, the report remains largely unchanged from the original document with the exception of a change to Section 1.3 and the addition of the BEW Parcel SC1 application boundary to Figures 1, 2 and 10. With the exception of these changes, all content, quantities, measurements and assessment included within this report relate to the wider Allocation Boundary that the BEW Parcel SC1 application wholly lies within.

This LCDS has been prepared to satisfy the requirements of a Tier 1: Preliminary risk assessment (PRA) in line with current Environment Agency guidance on Land Contamination: Risk Management (updated May 2020) detailed on GOV.UK. which aligns with stated Arun District Council requirements to meet (the now replaced) PPS 23 for planning applications.

1.2 Land Contamination Risk Management

The Environment Agency (EA) Land Contamination: Risk Management (LCRM)¹ guidance (published in October 2020) sets out a 'staged risk-based approach' of land contamination risk management. There are three stages and each stage is broken down into tiers or steps, as outlined in **Table 1**.

Table 1: Land Contamination Risk Management Stages

LCRM	Tier 1	Tier 2	Tier 3
Stage 1 Risk Assessment	Land Contamination Desk Study & Preliminary Risk Assessment (PRA)	LCRA - Generic Quantitative Risk Assessment (GQRA)	LCRA - Detailed Quantitative Risk Assessment (DQRA)
Stage 2 Options Appraisal	Identify reasonable remediation options remediation	Detailed evaluation of options	Select final remediation options
Stage 3 Remediation	Develop Remediation Strategy	Remediation and Verification	Long term monitoring and maintenance, if required

The guidance and the associated risk management stages set out how to assess whether there are likely to be unacceptable land contamination risks associated with a site or proposed development; then how

¹ www.gov.uk (published 8 October 2020)

to select remediation options that are suitable to manage unacceptable risks; how to plan and carry out remediation and how to verify the remediation has been undertaken effectively.

This LCDS has been prepared in line with a Stage 1 Risk Assessment: Tier 1 Preliminary Risk Assessment (PRA), as shown in **Table 1** above.

1.3 Proposed Development

BEW Parcel SC1 forms part of the wider BEW site allocation.

Outline planning permission (with all matters reserved except for the A29 realignment) for the demolition of existing structures and mixed use development to provide residential dwellings (Use Class C3), care home/senior living accommodation (Use Classes C2/C3), flexible retail and community floorspace (Use Classes E/F2/sui generis), a primary school, plus associated open space, landscaping, drainage and all other associated ancillary works; and realignment of the A29 and early connection to existing A29, including construction of a new road carriageway, junctions and associated infrastructure.

Extracts of the proposed development plans are included as **Figure 1**.

Figure 1: Proposed Development

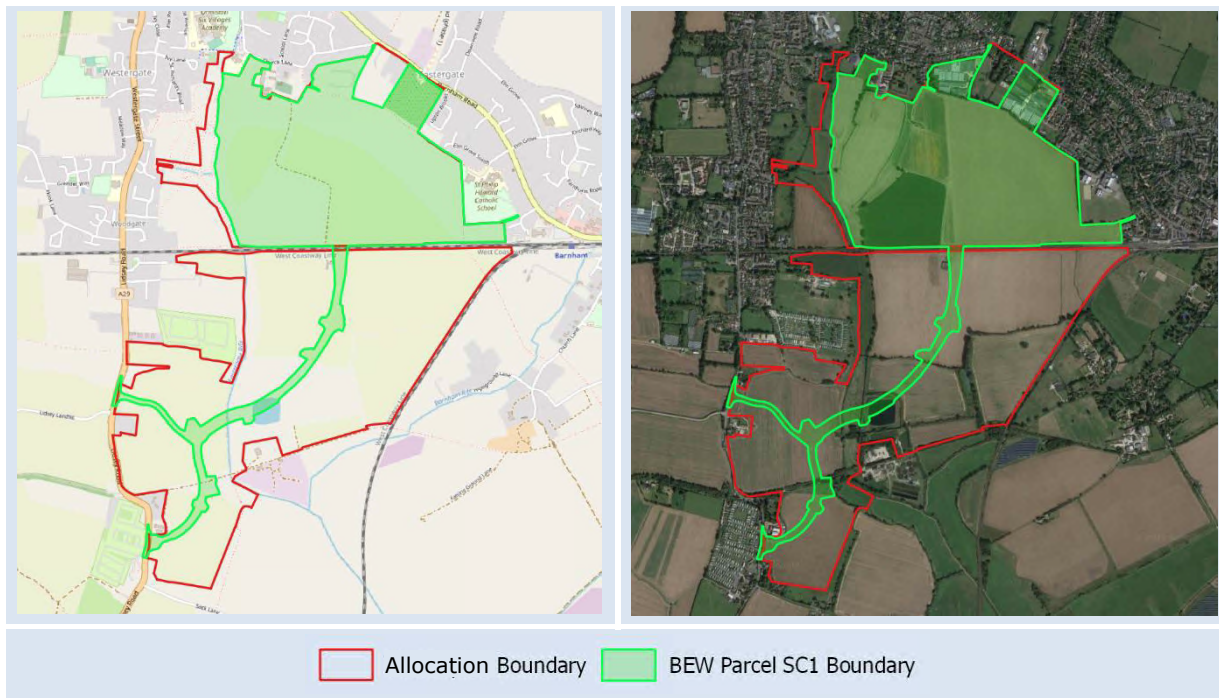


2 The Site

2.1 Site Location

The Site primarily comprises agricultural land located between the existing residential neighbourhoods of Westergate, Eastergate and Barnham. The approximate centre of the Site is located at National Grid Reference 494537E,103739N. The site location is shown in **Figure 2**.

Figure 2: Site Location Plan



2.2 Site Description

The Site occupies an area of 225 ha, has an irregular shape and is bisected east-west by the West Coastway rail line. To the north of the rail line it is both directly and indirectly bound by predominantly residential properties of Woodgate and Westergate to the west, Eastergate to the north and Barnham to the east. To the south of the West Coastway rail line the Site is predominantly bound by agricultural land with more occasional residential, commercial and agricultural premises situated to the west and south and the Bognor Regis branch line which runs along the far eastern site boundary.

The Site is relatively level with the majority of the site elevation ranging from 11m to 5m AOD and falling to as low as 2m AOD at the watercourse of the Lidsey Rife which flows north south through the site near the western site boundary. Topographic gradients are very gentle and broadly fall towards the south and west with less noticeable influences towards other local watercourses.

The Site has multiple access points including via Church Lane, Barham Road, Lidsey Road and Gospond Road.

The majority of the site comprises undeveloped agricultural land. Within the north-eastern most part of the site, the site boundary encompasses land currently occupied by Fleurie Nurseries which includes glass houses, polytunnels and horticultural infrastructure including tanks, cabins and ponds. Two farms to the north and south currently utilise the majority of the fields for arable farming with some of the western land used for equine pasture. A number of farms (Ryefield Farm, Headhone Farm, Lidsey Farm), houses and a dog kennel are present off-site but lie adjacent to the western site boundary.

2.3 Walkover survey

A limited geo environmental walkover survey was carried out as part of the scheme and a selection of site photographs taken during this visit are included alongside Google Earth imagery for each of the development areas as shown in **Figure 3**. Within the figures below, colour coded arrows match each image with the respective location marked on the Google Earth mapping extracts.

Figure 3: Walkover Survey Photographs



North of railway – View to south.

Imagery indicates the site to mostly comprise agricultural land and which is surrounded by limited wooded areas and rough vegetation.

The image shown by the blue arrow relates to the agricultural land bound by a footpath and Fleurie Nursery to the north-east and the railway line in the south. New Barn is distantly visible on the other side of the railway line on the right.

The image captured shown by the yellow arrow relates to a green field between the Eastergate Primary School and Manor Farm.

Although not captured due to restricted access in these pictures, the Lidsey rife is known to flow along a vegetated channel within a private housing area behind Eastergate Primary School.

No significant potential sources or signs of contamination were identified.



South of the Railway – View to north and north west

The imagery relates to the area bound by Lidsey Road to the west, by the railway line to the north, the Bognor Regis Branch line to the east and by a footpath and Lidsey Oil Field to the south. The site area is clearly dominated by agricultural land with the exception of a surface water feature located approximately in the centre of the site.

The image shown by the yellow arrow shows bare agricultural land adjacent to the lower land area of the disused Arundel Canal. It is possible to identify Willows Caravan Park and adjacent housing to the north. No significant potential sources or signs of contamination were identified.

The dark blue arrow is image of the Lidsey Oil Field site. From external view the site was visually noted as clean and tidy with no obvious signs of oil spillages, however the site walkover did



Figure 3: Walkover Survey Photographs

not include access to the oil site. No significant signs of contamination were identified.

The light blue arrow points at the recent surface water reservoir feature constructed on-site to the north of the Lidsey Oil field. The purpose of the reservoir is not known however due to its elevation above the surrounding land it must receive recharge through pumping or solely from precipitation. No significant potential sources or signs of contamination have been identified.

The orange arrow direction points to another agricultural field adjacent to the east of the reservoir. More substantial vegetation including trees are present along the western and eastern peripheries. No significant potential sources or signs of contamination were identified.



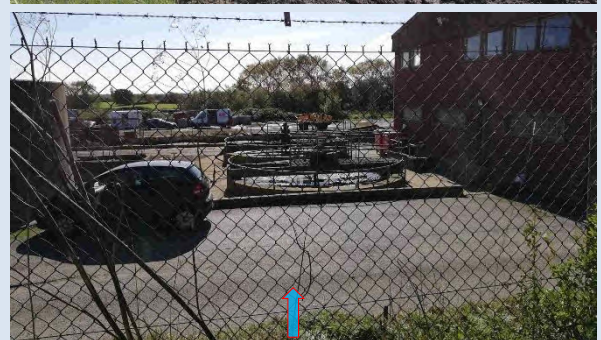
South of the Railway – View to South and south west

The imagery relates to the same area as described above with views to the south.

The image shown by the yellow arrow relates to an agricultural field to the south of the disused Arundel Canal. Trees are shown in the peripheries. No significant potential sources or signs of contamination were identified.

The light blue arrow is relevant to the Southern Water - Wastewater Treatment works. This picture was collected from an external side of the Wastewater Treatment works site but gives an indication of the site operations.

The Bognor Branch Railway line is identified by the arrow orange. No sidings or other evidences of potential contamination sources were identified.



3 Environmental Data Search

3.1 Sources

The following 'desk-based' data sources have selectively been reviewed with respect to the geo-environmental status and setting of the Site and its surroundings:

- Historic Ordnance Survey maps,
- Historic and current aerial photographs (Google Earth and Envirocheck),
- British Geological Survey (BGS) maps and records,
- Environment Agency (EA) data,
- EA River Basin Management Plans (RBMPs),
- Commission specific environmental database search results (Envirocheck), and
- Relevant internet-based data sources.

Relevant information is presented in the following sections and sub-sections of this report.

3.2 Environmental Database

As part of the data search an Envirocheck (Site Sensitivity) Report, Geology Datasheet and a set of historic maps have been procured from Landmark Information Group (Landmark). Copies of the Landmark products (in the form of datasheets and maps) are included in [Appendix A](#). Selected map extracts and relevant datasheet information summaries are included within the report text below.

The key information topics included within the Envirocheck Report and Geology Datasheet are summarised in [Table 2](#).

Table 2: Landmark Reports

Envirocheck Report incl. Site Sensitivity Maps	Geology Datasheet
• Environment Agency records, • Hydrology and hydrogeology, • Waste, • Hazardous substances, • Geological, • Industrial land uses, and • Sensitive land uses.	• Artificial ground and landslip map, • Superficial geology map, • Bedrock and faults map, and • Combined geology map.

Pertinent information from the Landmark products has been considered in conjunction with the findings of the other desk study data sources and the collated findings are presented in the following sub-sections of this report chapter. Where Landmark information is referenced, the distances quoted to the identified features are from the nearest point on the subject site boundary, unless stated otherwise. The on-line Envirocheck Analysis tool has also been used to review, combine and extract relevant information from the Landmark products.

3.3 Pre-Existing Reports

Table 3 summarises the pre-existing reports which have been made available and reviewed as part of this desk-based review.

Table 3: Pre-existing Reports

Report Title & Reference	Reference	Source	Date
Phase 1 Geotechnical & Geo-environmental Desktop Study	A13394-PF-C-ZZ-XX-RTP-0001	Pell Frischmann	March 2019
Hydrogeology and Hydrology Report	A076162-3	WYG Group	November 2017

3.4 Summary of Pre-Existing Reports

This section provides further information on the geo-environmental content of the reports detailed in **Section 3.3**.

Phase I Geotechnical and Geo-environmental Desk Study (Pell Frischmann, 2019) with reference A13394-PF-C-ZZ-XX-RTP-0001

This report provides a preliminary quantitative geotechnical and geo-environmental assessment for an area within the site, relevant to part of the proposed A29 layout (1.2km only) that connects Barnham Road to Westergate Street.

Much of the information within this study is included within the present report and therefore will not be reviewed further.

Hydrogeology and Hydrology Report (WYG, 2017) with reference A076162-3

This report outlines the findings of an intrusive investigation and continuous groundwater and surface water monitoring for one year. The work undertaken in 2016 involved drilling 17no. boreholes and the installation of groundwater monitoring wells to a maximum depth of 5m bgl. These were subject to continuous groundwater monitoring between June 2016 until June 2017. The report can be found in Appendix B.

During the ground investigation detailed exploratory borehole logs were produced. The encountered bedrock conditions were considered to be in line with BGS mapping. With regards to the superficial deposits, it was reported to be technically difficult to distinguish between the variety of the superficial deposits expected and even though Raised Marine Deposits and River Terrace Deposits were identified, much of the superficial strata were recorded as alluvial material, given the proximity of the surrounding stream channels.

Groundwater was recorded at shallow depths close to the surface (often less than 1m below existing ground level with the exception of two monitoring locations in the south). The report concluded that ground conditions play an important role in the groundwater levels given that wells located on the northern London Clay have a significantly higher (~3m) groundwater level than wells located over the Chalk in the southern part of the site. Superficial deposits also play an important factor in the control of groundwater levels, particularly in slower drainage through silty material or more rapid drainage through more sandy, gravelly material. The thickness of superficial deposits is also a relevant factor.

It was concluded that the topographic level of a location has an important factor in groundwater levels, with lower levels being far more likely to be waterlogged or influenced by water levels in streams.

During the monitoring period it was noted that some wells to the east of the site became waterlogged. It was concluded that it was likely due to the low hydraulic conductivity of the London Clay and the lack effective drainage around the site. It was also concluded that soakaway drainage to ground was unlikely to be feasible across most of the site due to the shallow groundwater conditions observed.

Tidal influence was investigated but not observed.

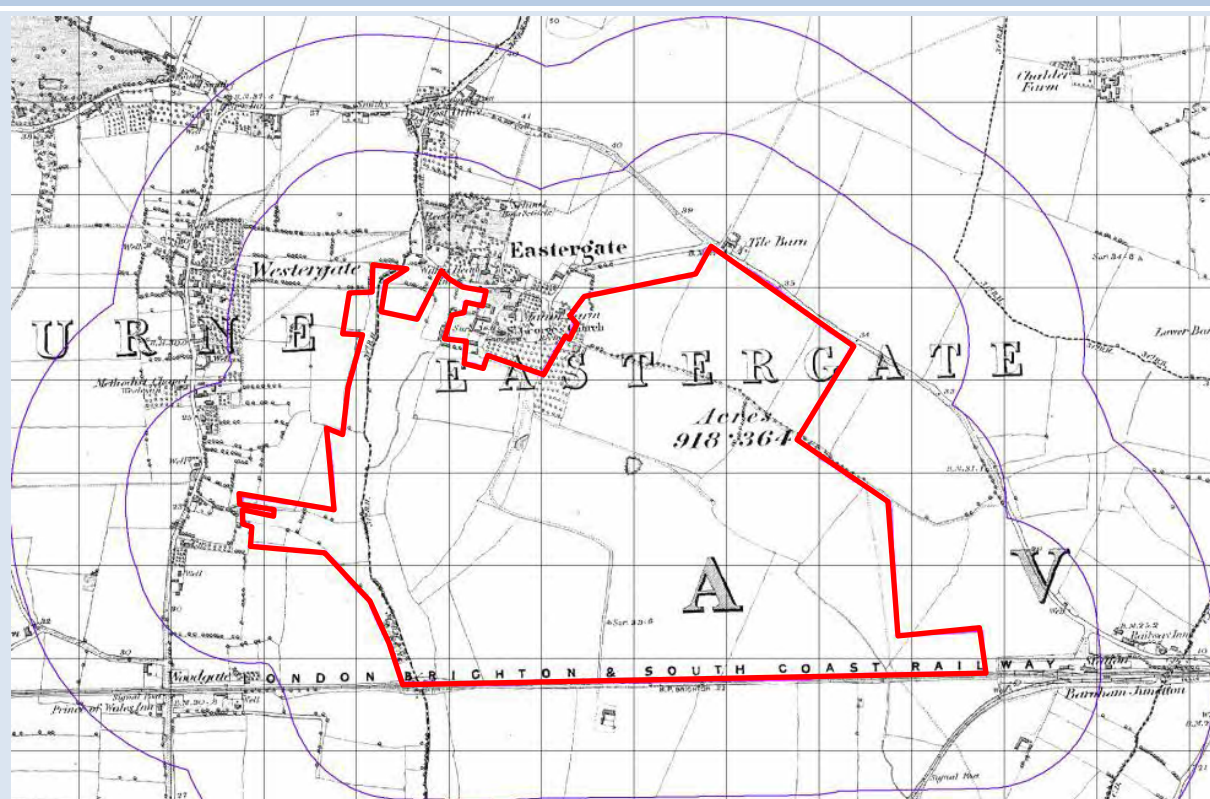
3.5 Site History

In order to provide an overview of the Site's history and to help identify potentially contaminative historic land uses both on-site and in the immediately surrounding area, the following historic records have been reviewed:

- Historic County Series and Ordnance Survey (OS) map editions (source: Landmark) and
- Historic and recent aerial photographs (source: Google & Landmark).

Given the dimensions of the site and the presence of the London Brighton and South Coast Railway line which bisects the site north - south, the site has been split into North and South for reporting of the historical mapping. A summary of the North sites history is presented in **Table 4** and of the South Site is presented in **Table 5**. These tables include a selection of map extracts at scale 1:10,000. These maps show a 500m buffer in all directions except towards the London and Brighton & South Coast railway which bisects the Site and the 250m buffer is retained for the purpose of continuity only. In some cases, the text in the table describes features from more than one map edition, in that case the time range is shown, and the year of the map extract presented. (Note: all distances quoted in these tables are approximate).

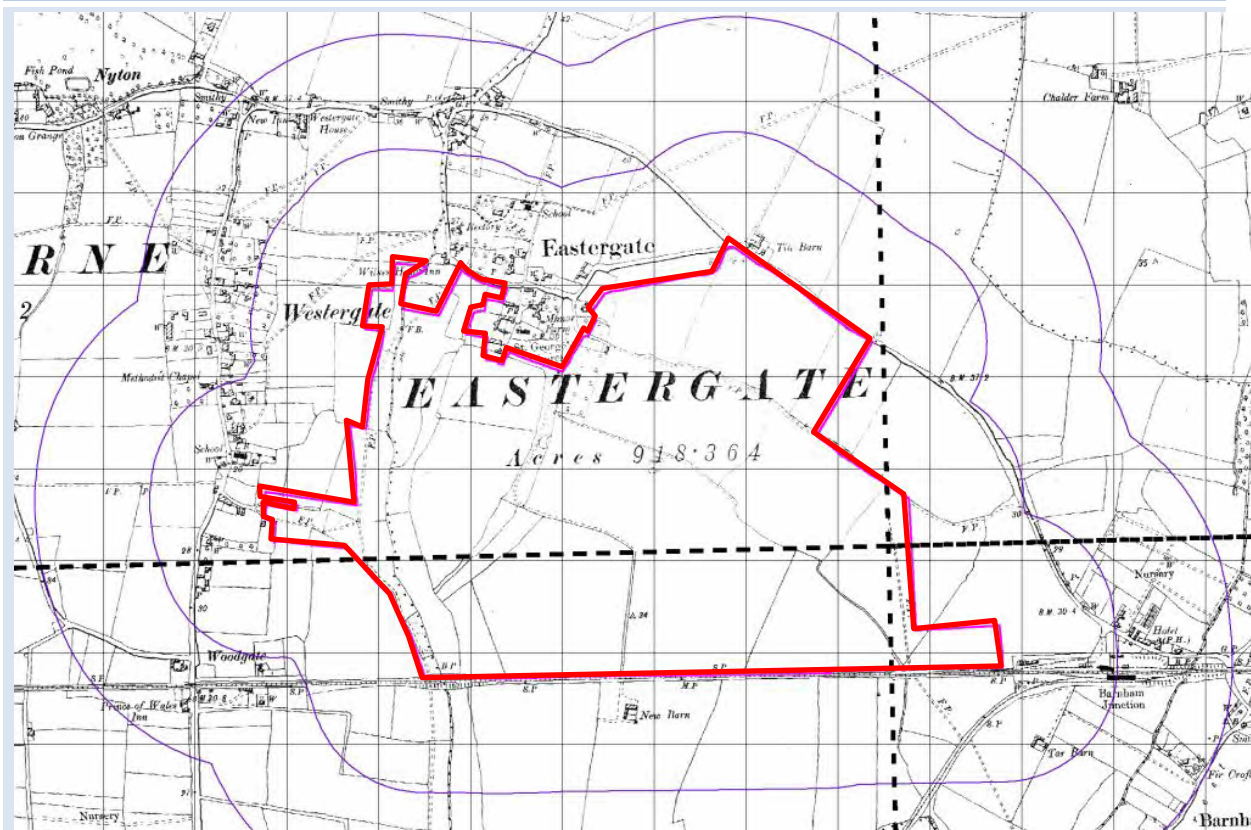
Table 4: North of the London Brighton Railway Line History



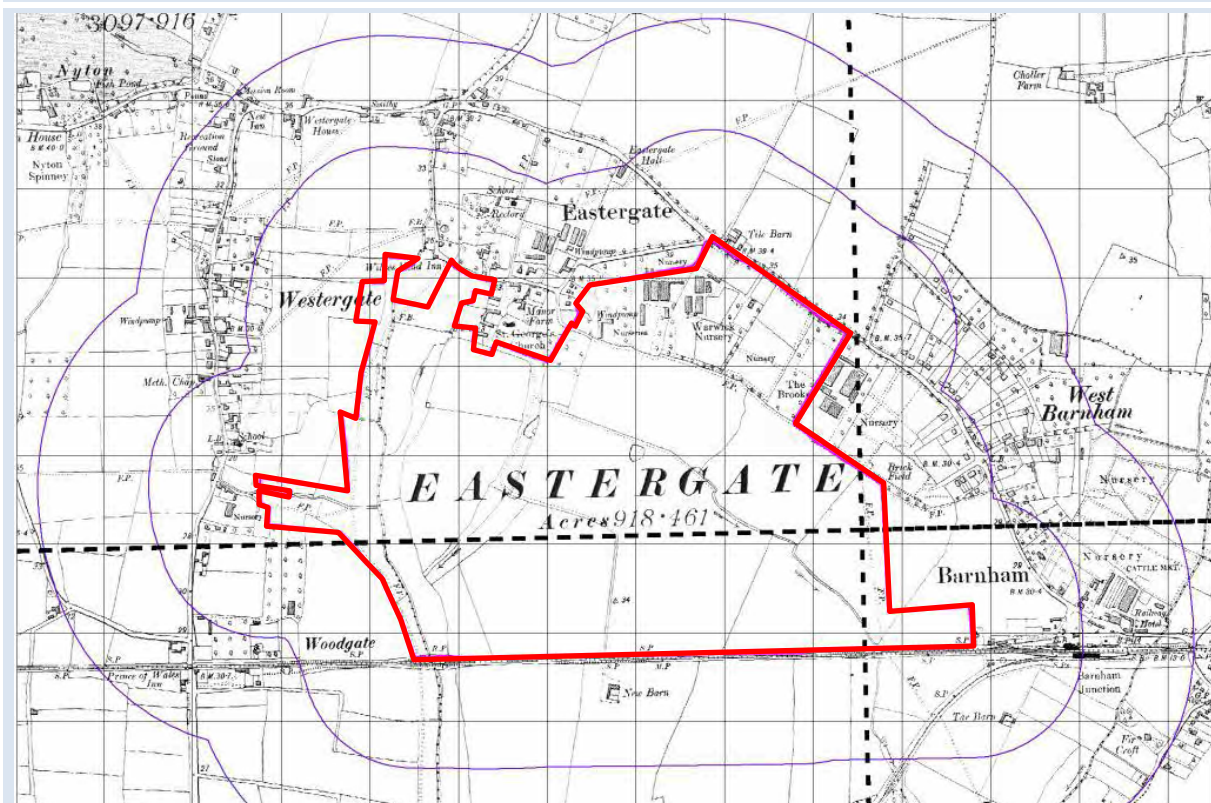
1875-1880 - on Site: in general, most of the Site is undeveloped agricultural land with several footpaths and unfenced roads. Two ponds are identified approximately in the centre parcel of the site. Several streams are also identified within the site boundary. The longest is Lidsey Rife and runs from north to south, crossing under the railway embankment and is located close to the western boundary. An Orchard is identified within the boundary as part of Warner Farm - St George Church sitting adjacent to the site boundary;

Off Site: The communities of Westergate and Eastergate are located to the north, Woodgate and Barnham to the south are identified on the map. These parishes are mainly occupied by rectories and farms with connecting roads. Several wells are identified along them. The London and Brighton & South Coast Railway is also visible on the map. The map dated 1876 scale (1:2,500) shows a railway crossing in Woodgate 1km (SW) of the centre of the site. The railway embankments and the railway crossing to the new barn are also visible. The maps 1875-1887 (1:2,500) show the Barnham Inn - hotel, the station and junction approximately 1km (SE). The map dated 1876 (1:2,500) shows the Westergate area mainly comprises houses with private orchards and several wells. No other features of relevance are identified in this location. The 1897 map (1:2,500) map shows the Eastergate area mainly occupied by Manor Farm, St George's church Rectory, a graveyard and a School 1km (N). No other significant features have been identified.

Table 4: North of the London Brighton Railway Line History

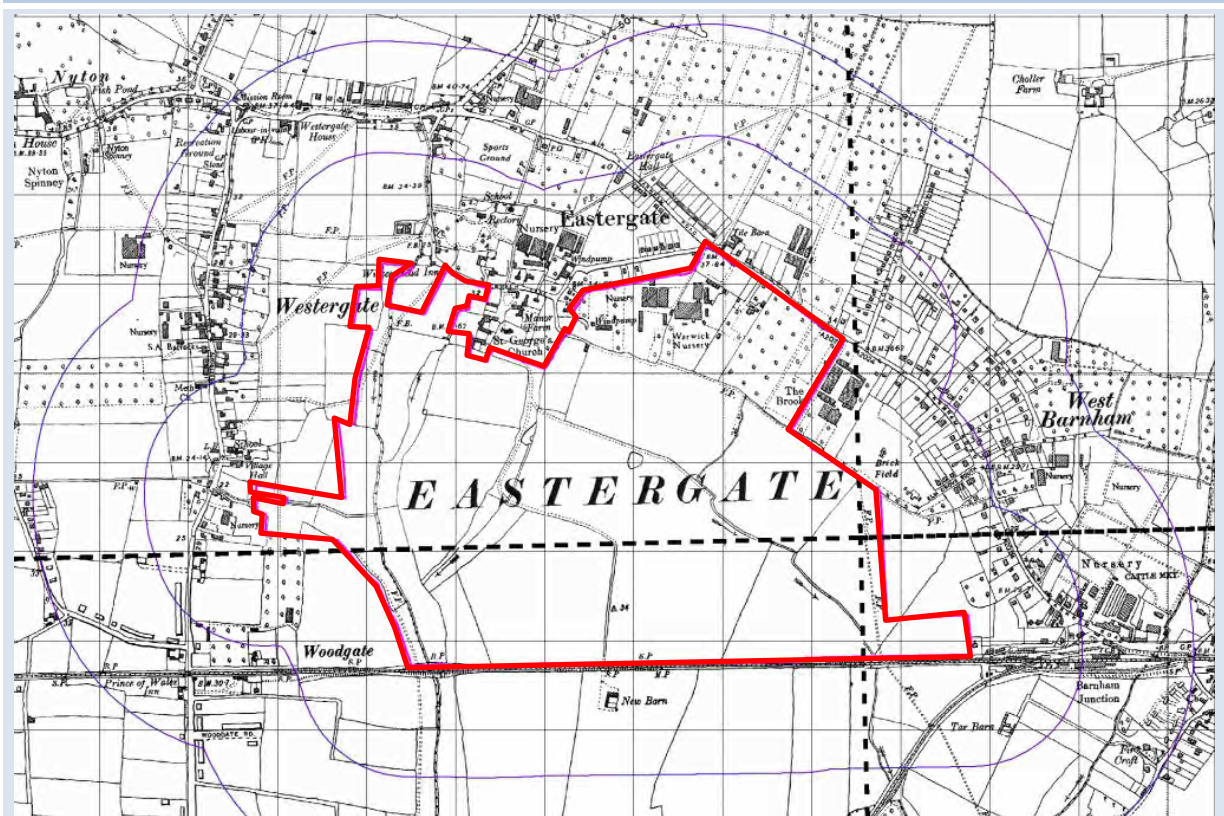


1887 -1899 On Site: No significant changes have been identified; **Off Site:** Nyton parish (NW) is now identified on the map. A new school is identified in Westergate 950m (W) to the centre of the site. A new nursery is also identified to the north of the Railway next to Barnham Station. No significant changes have been identified in the 1:2,500 maps between these dates.

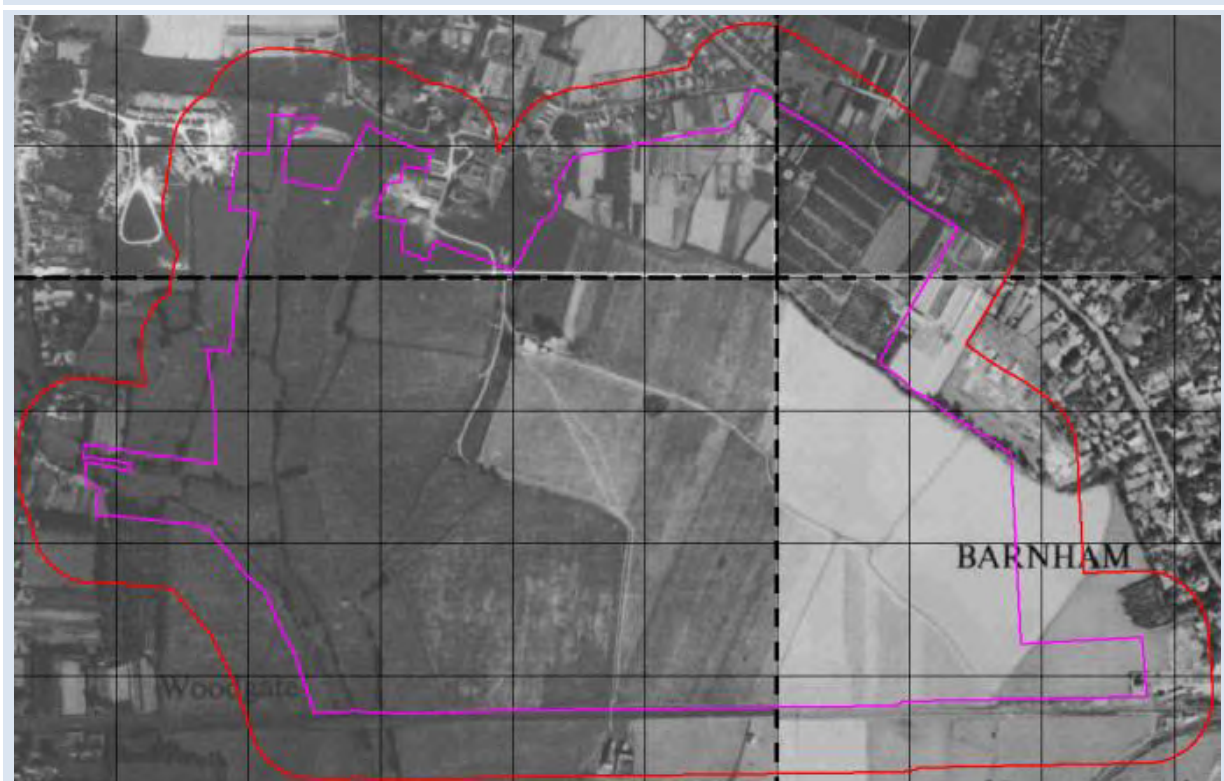


1913(SE) - 1914 On Site: Within the northernmost part of the Site to the east of Eastergate is occupied with several Nurseries, namely the Brooks and Warwick Nursery. The presence of buildings (likely glasshouses) and Windpumps are noted in this area. **Off Site:** Extensive development of residential houses with private gardens within Barnham to the east. The road of Elm Grove is visible. A Brickfield adjacent to the Site boundary is identified and the Cattle Market in West Barnham are visible on the maps.

Table 4: North of the London Brighton Railway Line History



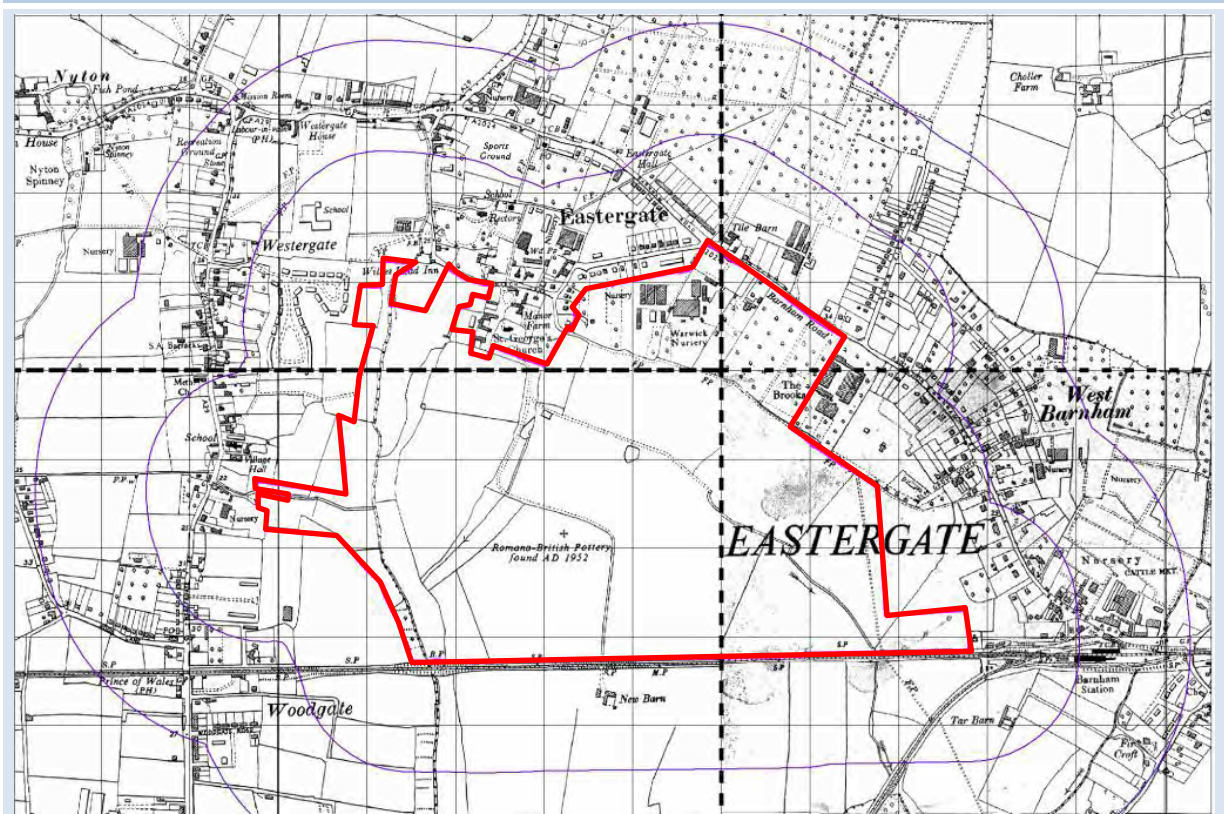
1938 (NE)-1951 On Site: No significant changes identified; **Off Site:** Barnham Road (NW and W), Church Lane (N), Fontwell Avenue (N) and Westergate Street (W) are identified on the map. Eastergate and West Barnham become increasingly occupied by residential development. By 1950, virtually the whole area between Fontwell Avenue, Wandleys Lane, and Barnham Road were orchards and glasshouses.²



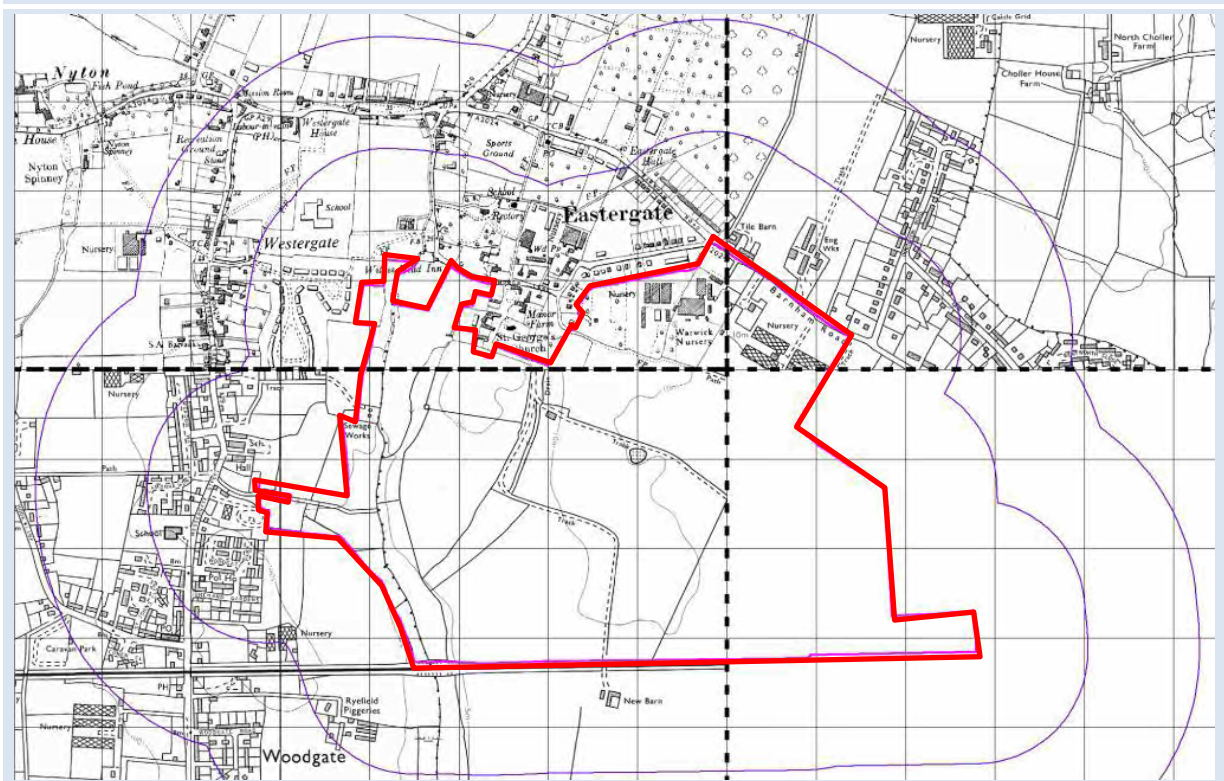
1947-1949(NW) on Site: A house/farm/barn is shown in the northern corner of the centre L shaped parcel of land. No other significant changes have been identified; **Off Site:** Additional residential streets are visible in Westergate.

² <https://www.british-history.ac.uk>

Table 4: North of the London Brighton Railway Line History

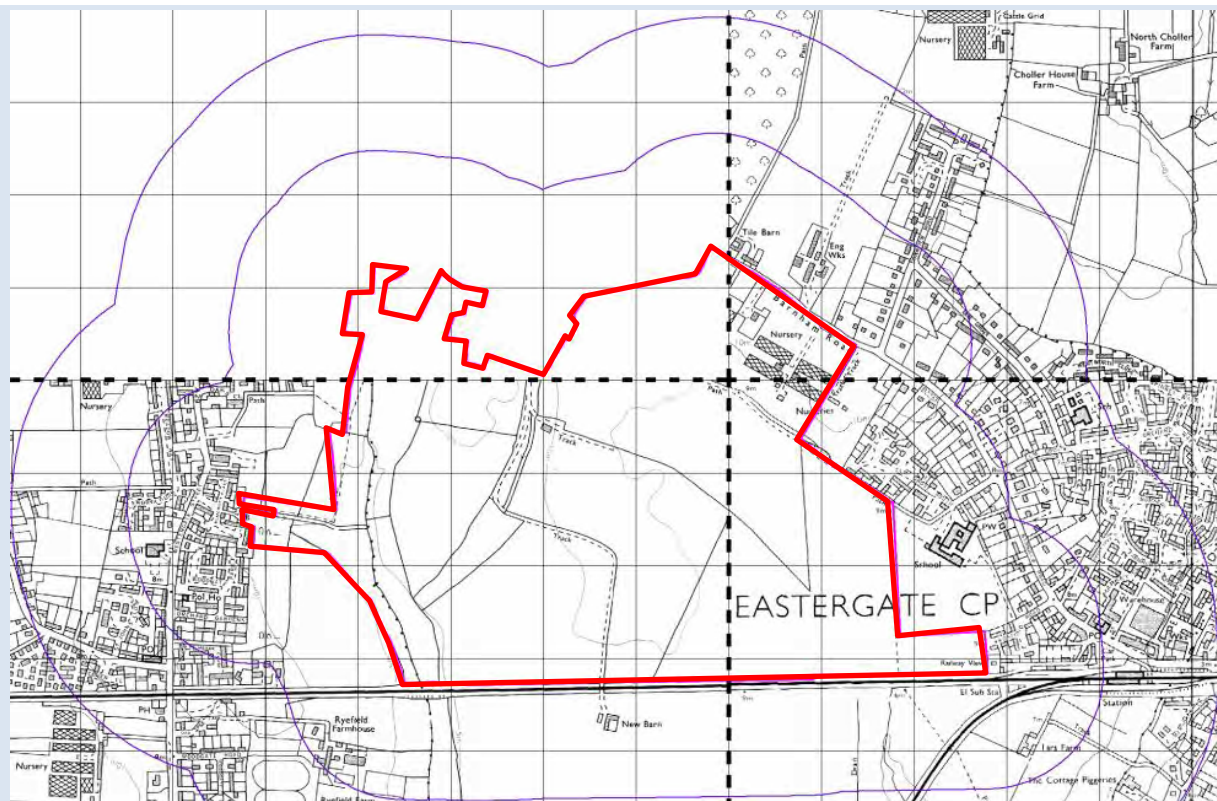


1961-1962(SE) On Site: A Romano British Pottery is found in 1952; **Off Site:** A school and new residential development is marked within Westergate immediately west of the Site no other significant changes have been identified.

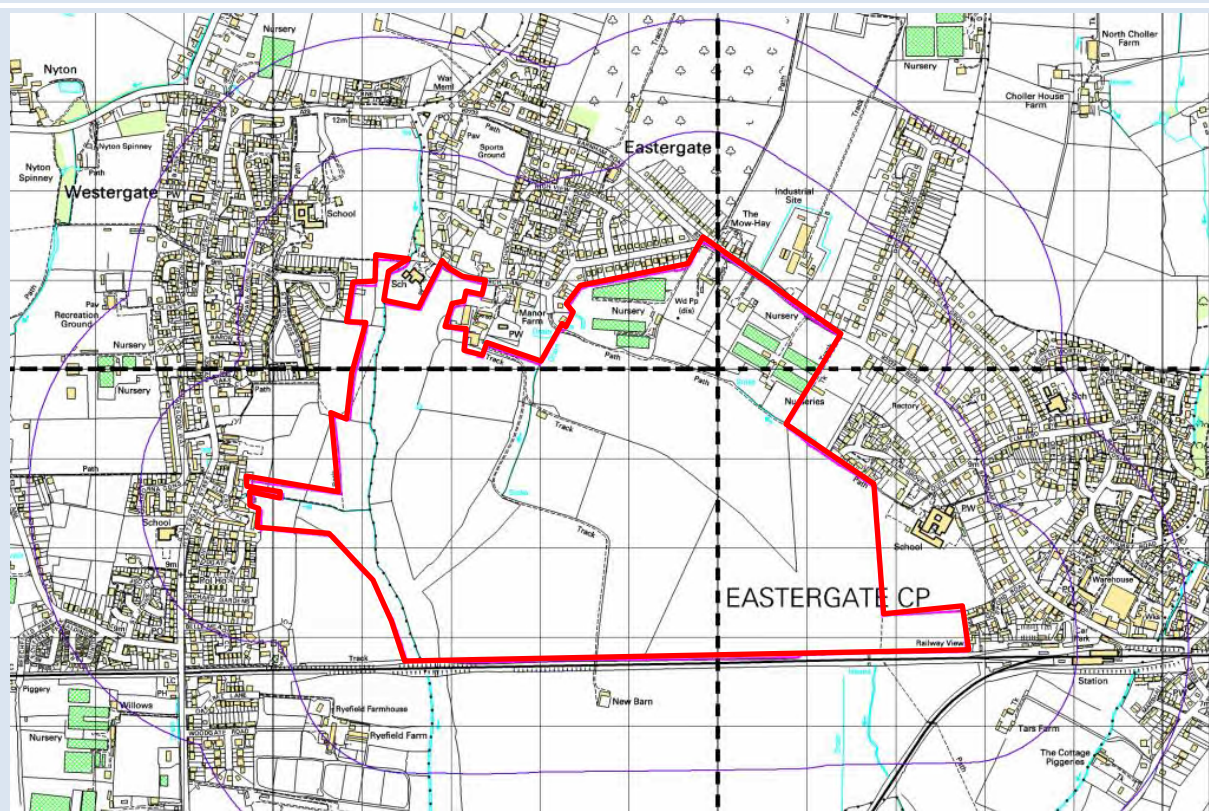


1970(NW) – 1979(SW and NE) On Site: The map is incomplete. The presence of sewage works is noted adjacent to the western boundary in the 1979 map (marked by blue circle). Drains are now mapped as crossing the central areas of the site; **Off Site:** Barnham Nurseries' Station was closed between 1955 and 1965 and was later built over as well as the nursery facing Manor Farm (noted in the map dated 1980-1984 at a scale 1:2,500. The market-garden site in Barnham village has been redeveloped as residential housing 1980's. The Industrial site facing Barnham Road is identified (NE).

Table 4: North of the London Brighton Railway Line History



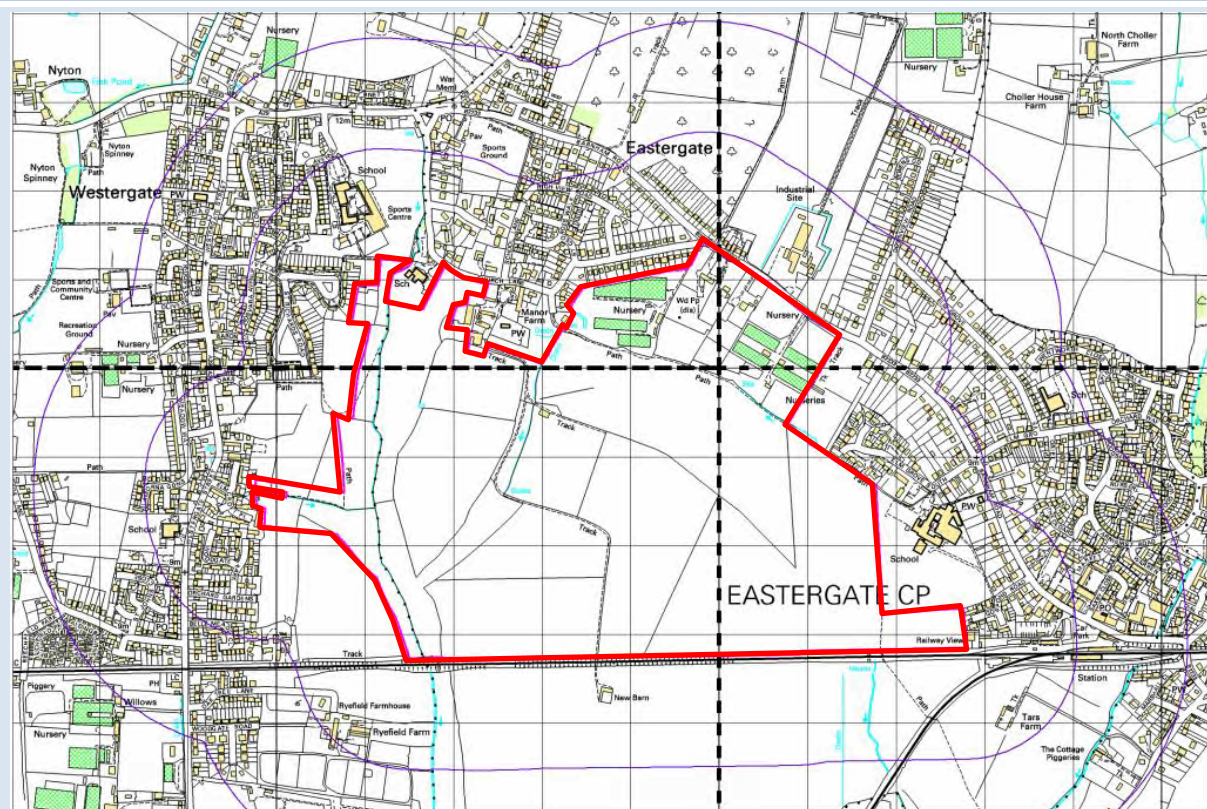
1992-1993(SW). On Site: The map shown is incomplete. Sewage Works is no longer identified on the map. Surface water features appear to have been infilled; Off Site: No significant changes identified.



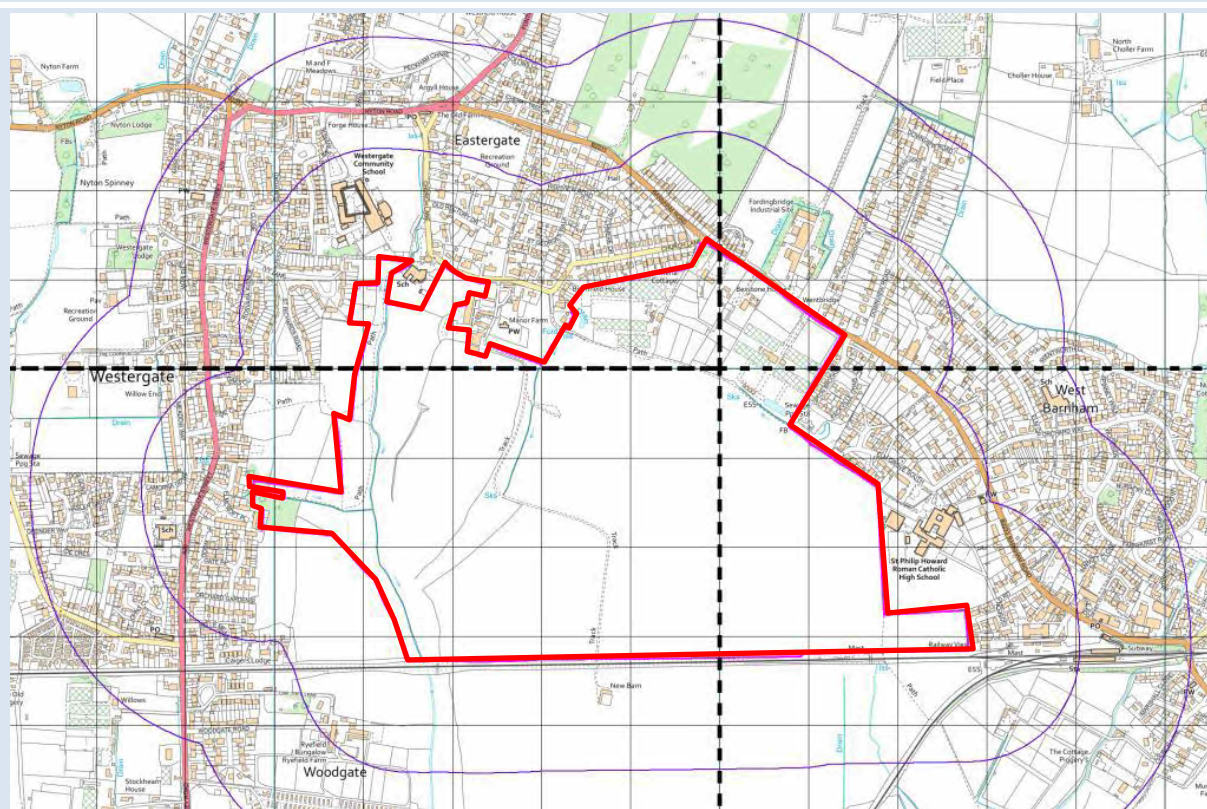
2000 On Site : Warwick/Eastergate Nurseries were bought in 1999 and the land parcels have since been occupied by Fleurie Nursery³; Off Site: Substantial residential development to the both sides of Westergate Street in the west.

³ <https://www.tristramplants.co.uk/home/fleuries-history>

Table 4: North of the London Brighton Railway Line History



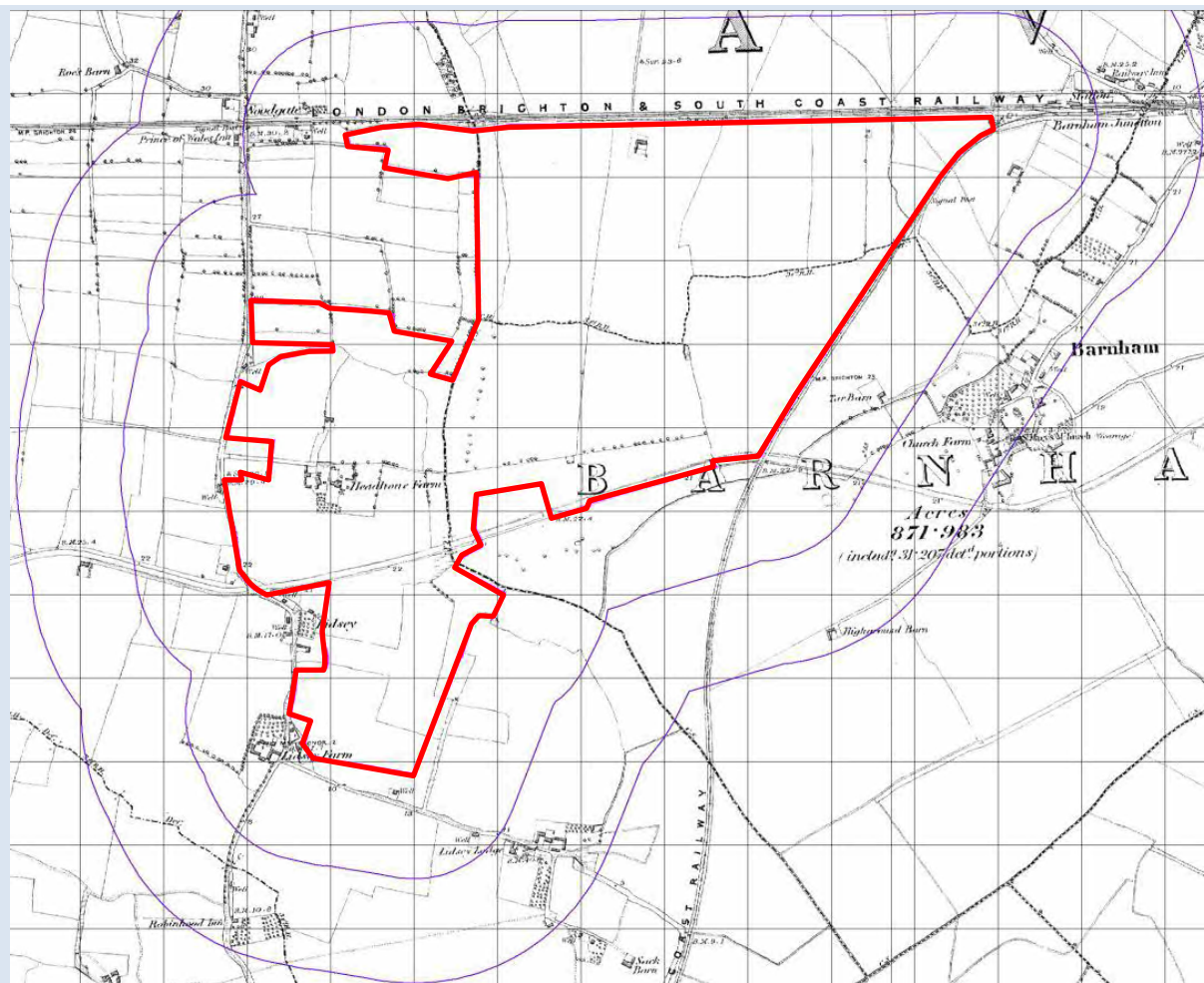
2006 on Site: No significant changes identified; **Off site:** No significant changes identified.



2020 on Site: No significant changes identified; **off site:** No significant changes identified.

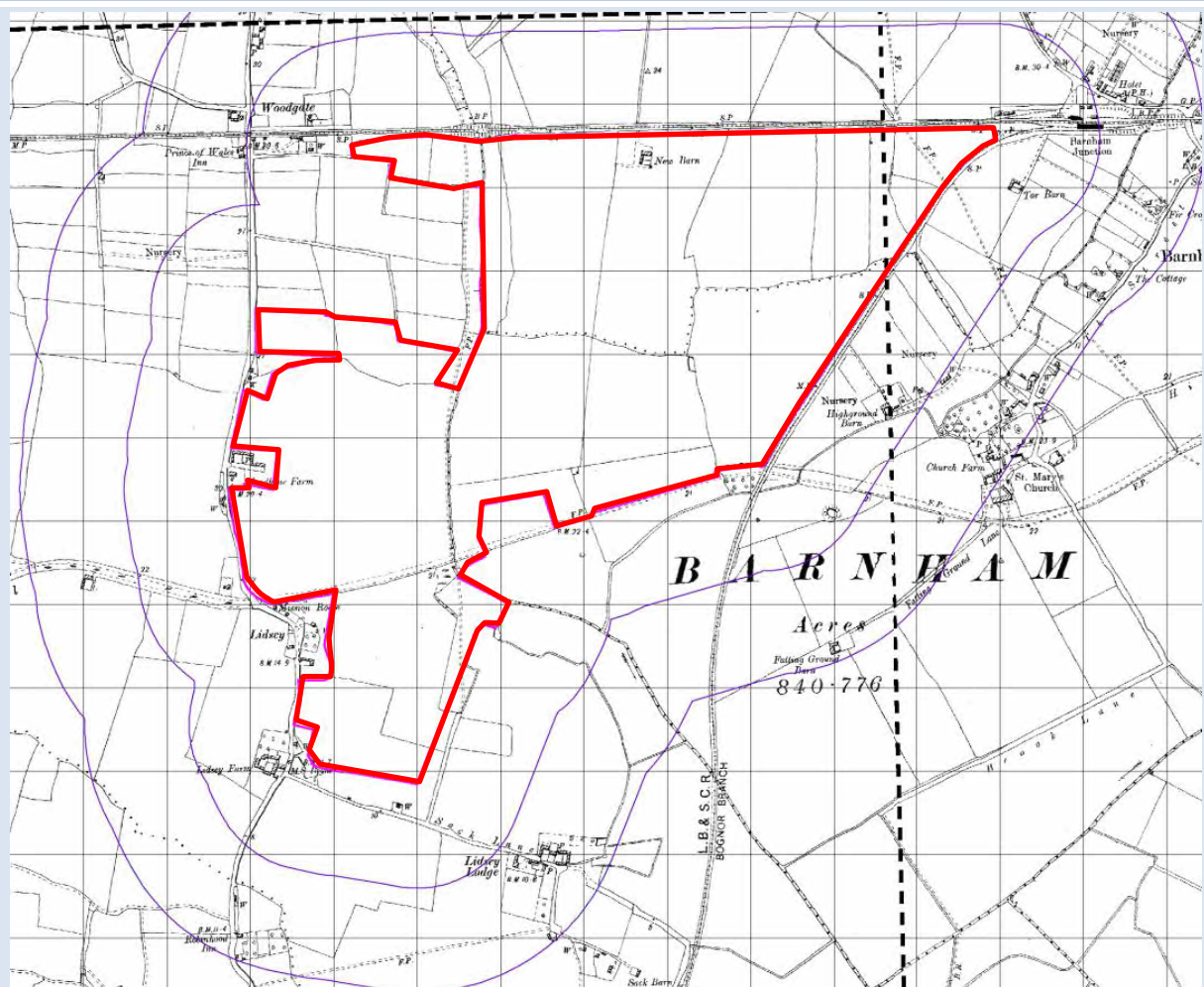
Key: N north, E east, S south, W west, NE north east, NNE north north east etc.

Table 5: North of the London Brighton Railway Line History



1880 on Site: The Site is mainly occupied by agricultural land. Immediately facing the south of the London Brighton and South Coast Railway line a Barn identified as 'New Barn'. Lidsey Rife and other minor streams are also identified. Lidsey Rife (this feature continues from the north site) flows south and crosses most of the site. Headhone Farm is identified within the central west of the Site boundary to the west of the Lidsey Rife. A canal (Chichester and Arundel Canal) bisects the site to the south of Headhone Farm. The same canal lies within and along the southern site boundary to the east. **Offsite:** Woodgate is marked to the west, Barnham to the east and Lidsey to the south are visible on the map. The named parishes are mainly occupied by rectories and farms. Some hotels and other commercial services areas are also noticeable along the main routes. It is possible to identify Barnham Junction. The station and the hotel Railway Inn are immediately facing the eastern boundary of the site. Several wells are identified on the routes connecting these parishes, including Eastergate and Westergate to the north. Earlier maps dated 1886 (1:2,500) show a gravel pit located 180m (SW) , near where Towing Path crosses Bognor Railway Branch. No other significant features have been identified.

Table 5: North of the London Brighton Railway Line History



1899 on Site: Headhorne farm is no longer recorded within the site boundary and is now marked as a new farm development to the west of the site boundary; **Off Site:** A few nurseries are noted on the map, in Woodgate 200m (W), and in Barnham immediately facing the Bognor Branch line.

Table 5: North of the London Brighton Railway Line History

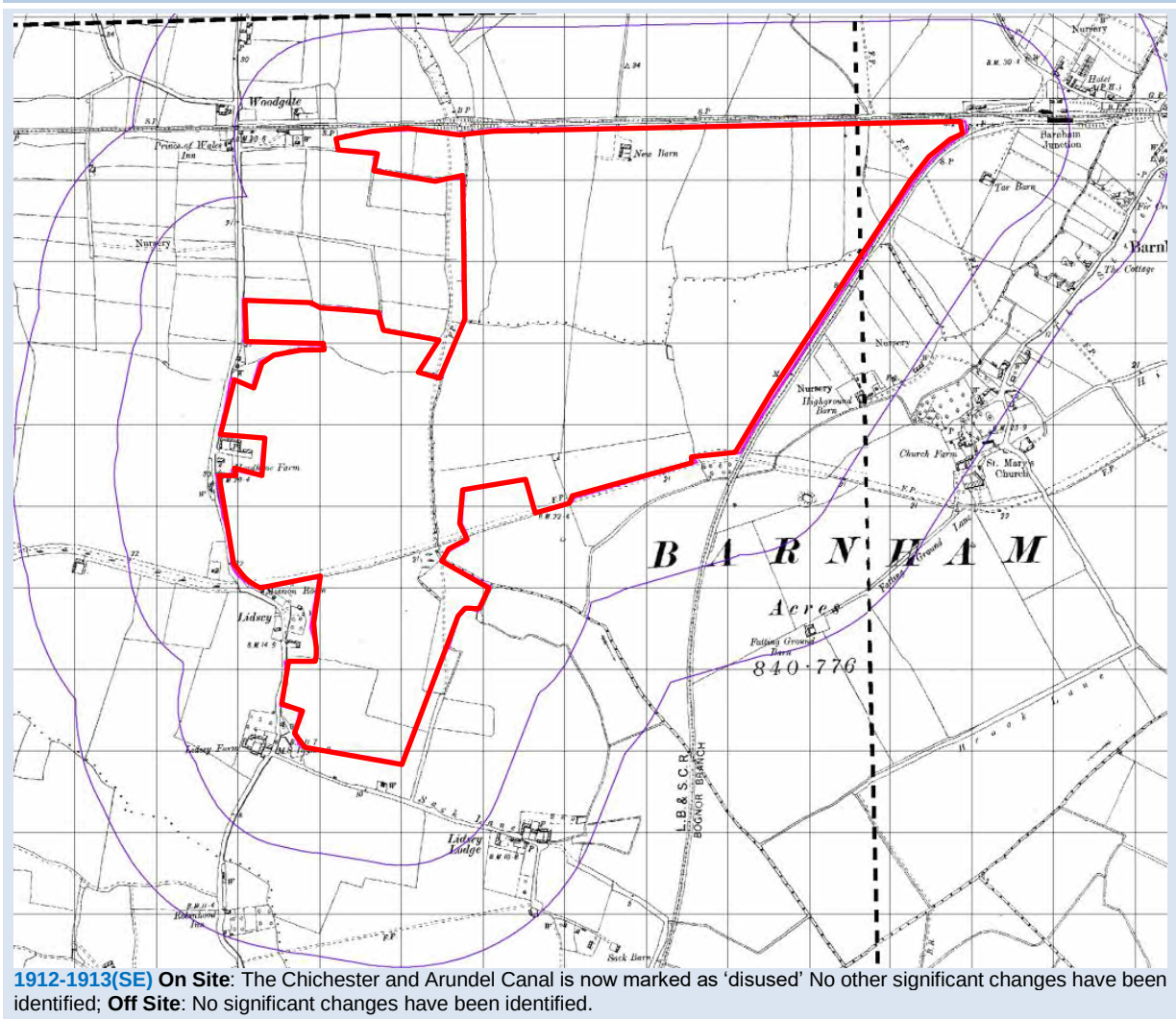


Table 5: North of the London Brighton Railway Line History

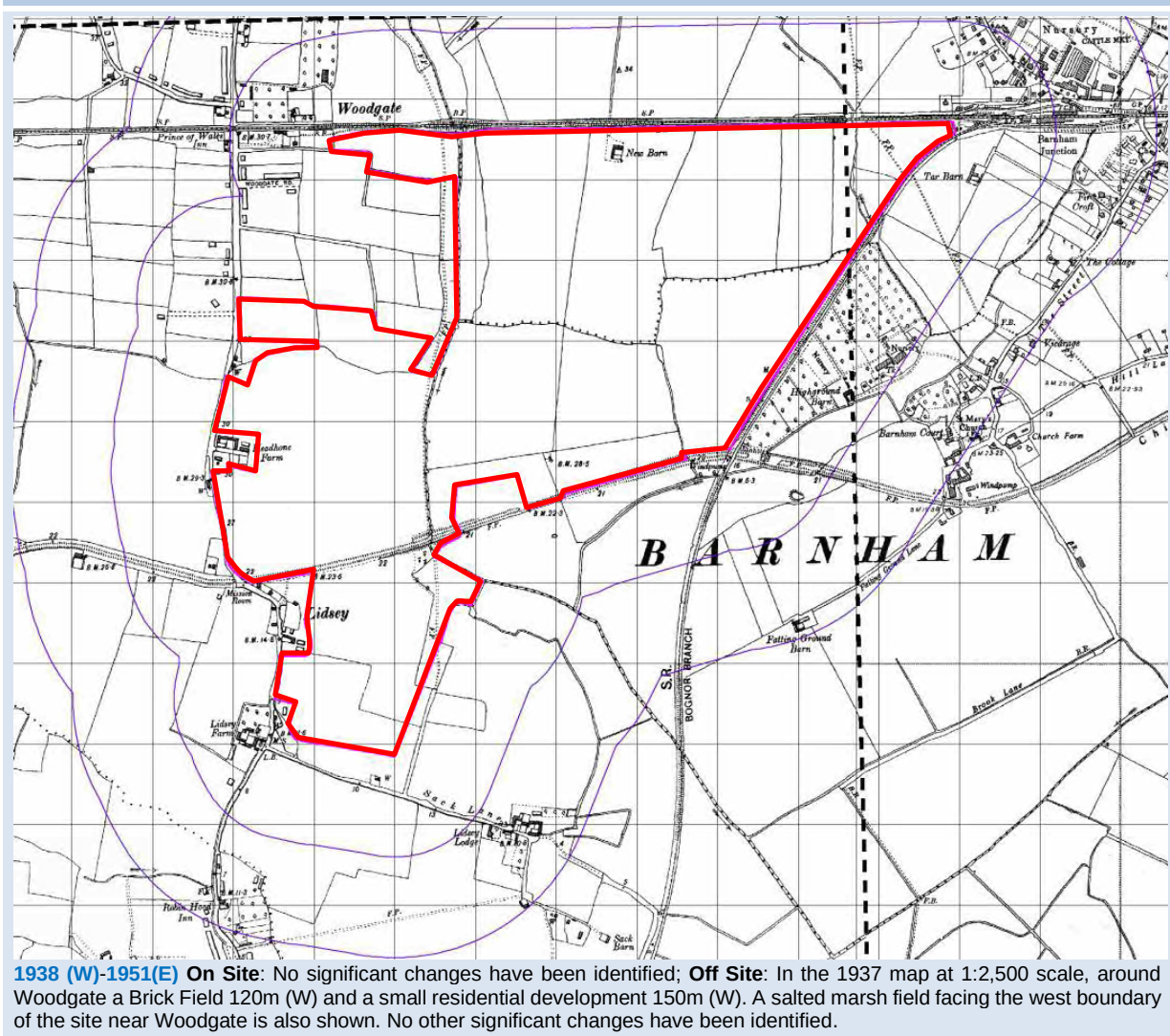
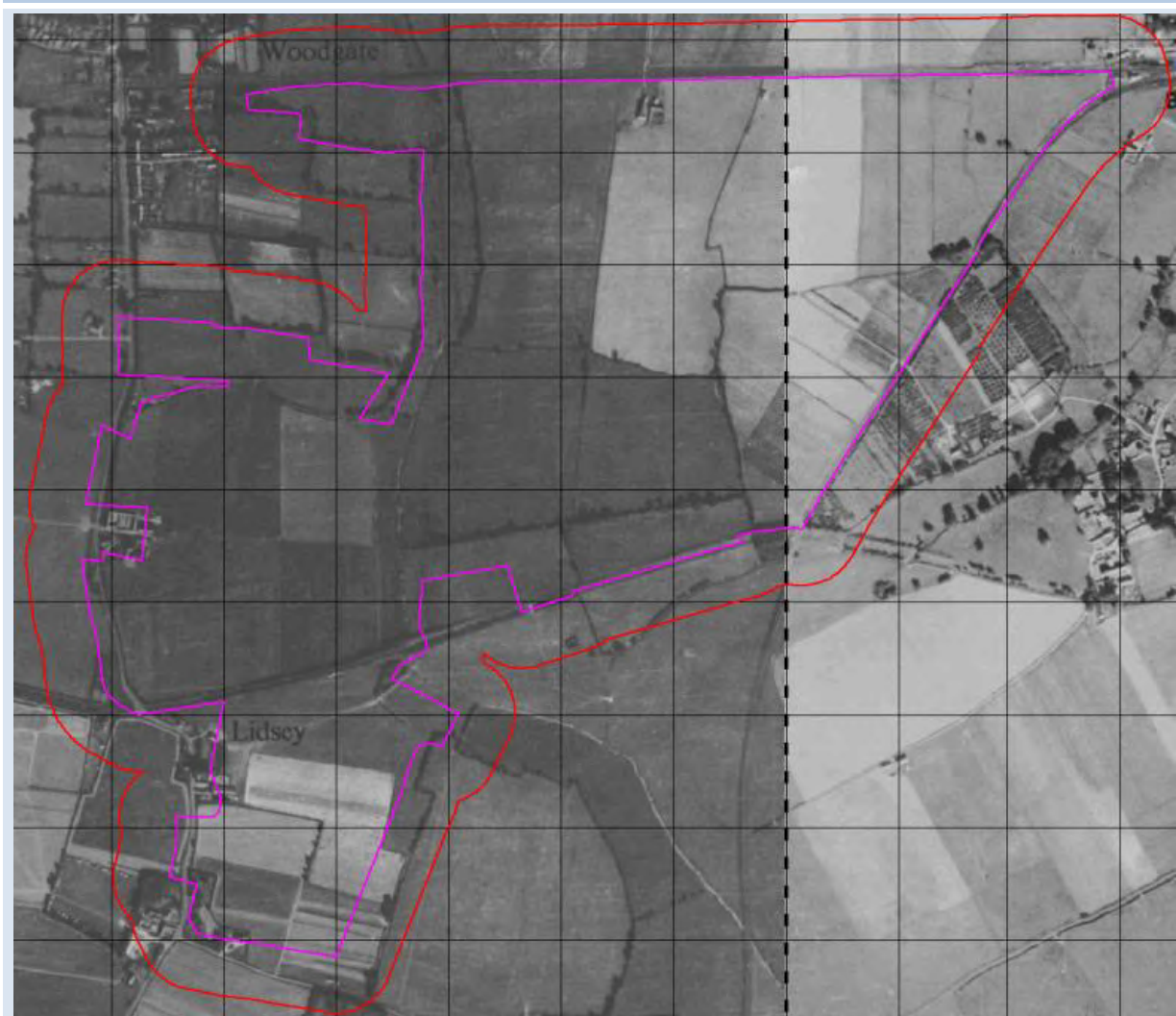
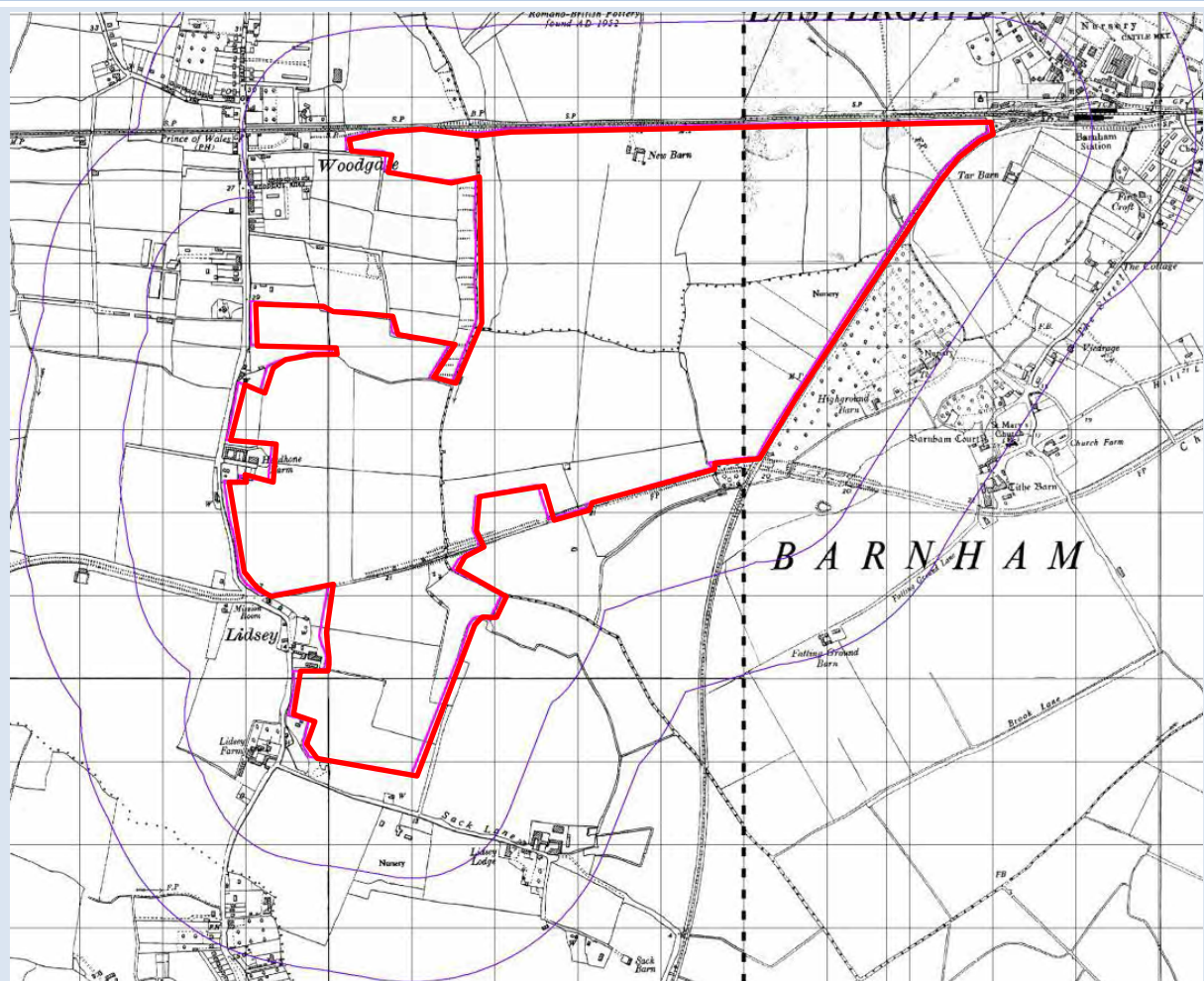


Table 5: North of the London Brighton Railway Line History



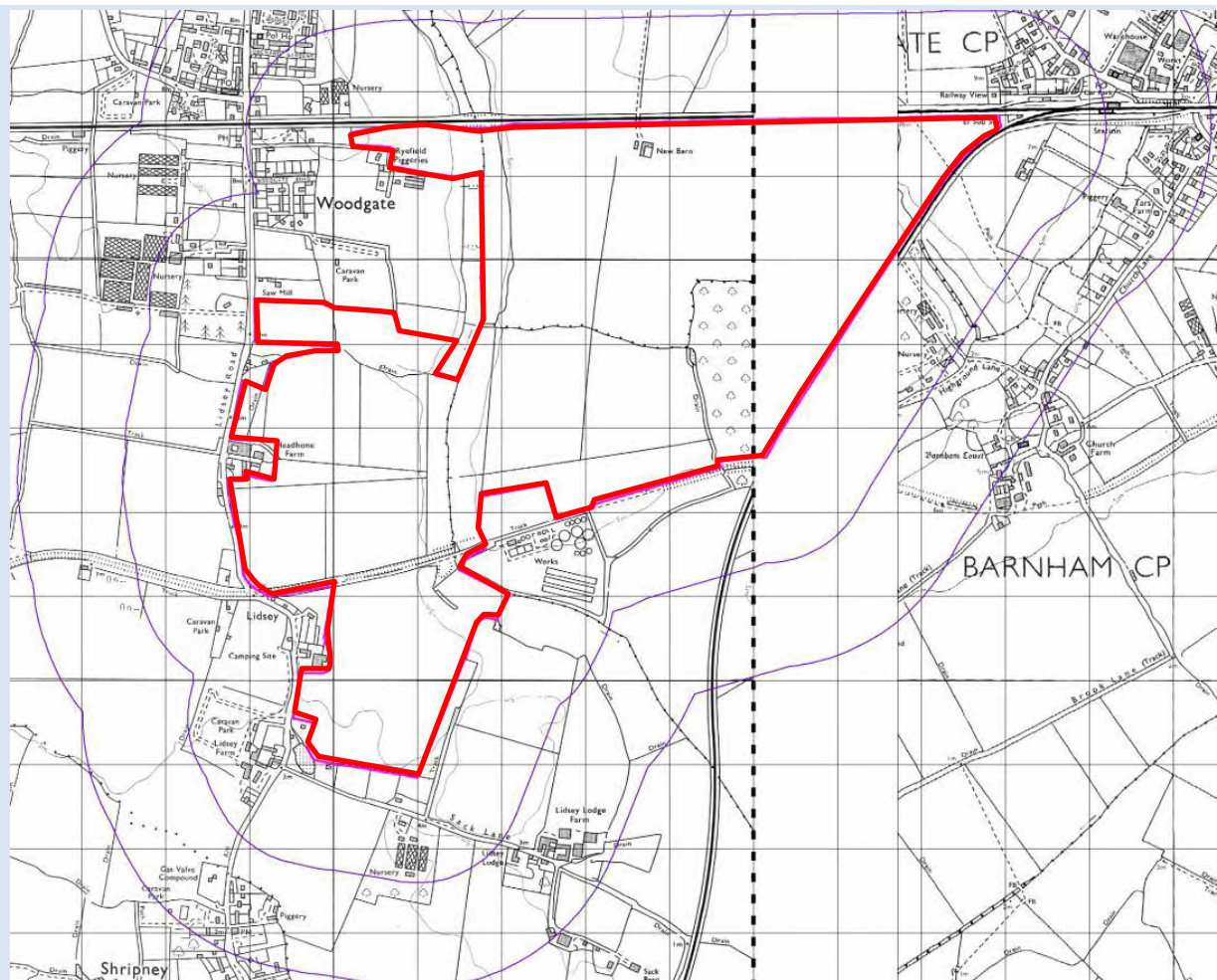
1947 (Aerial Photograph) **On Site:** The photograph confirms the site as being predominantly occupied by agricultural land, In this picture it is possible to distinguish the extension of the Barnham nurseries within the site boundary to the east. No other significant changes have been identified; **Off Site:** No significant changes have been identified.

Table 5: North of the London Brighton Railway Line History



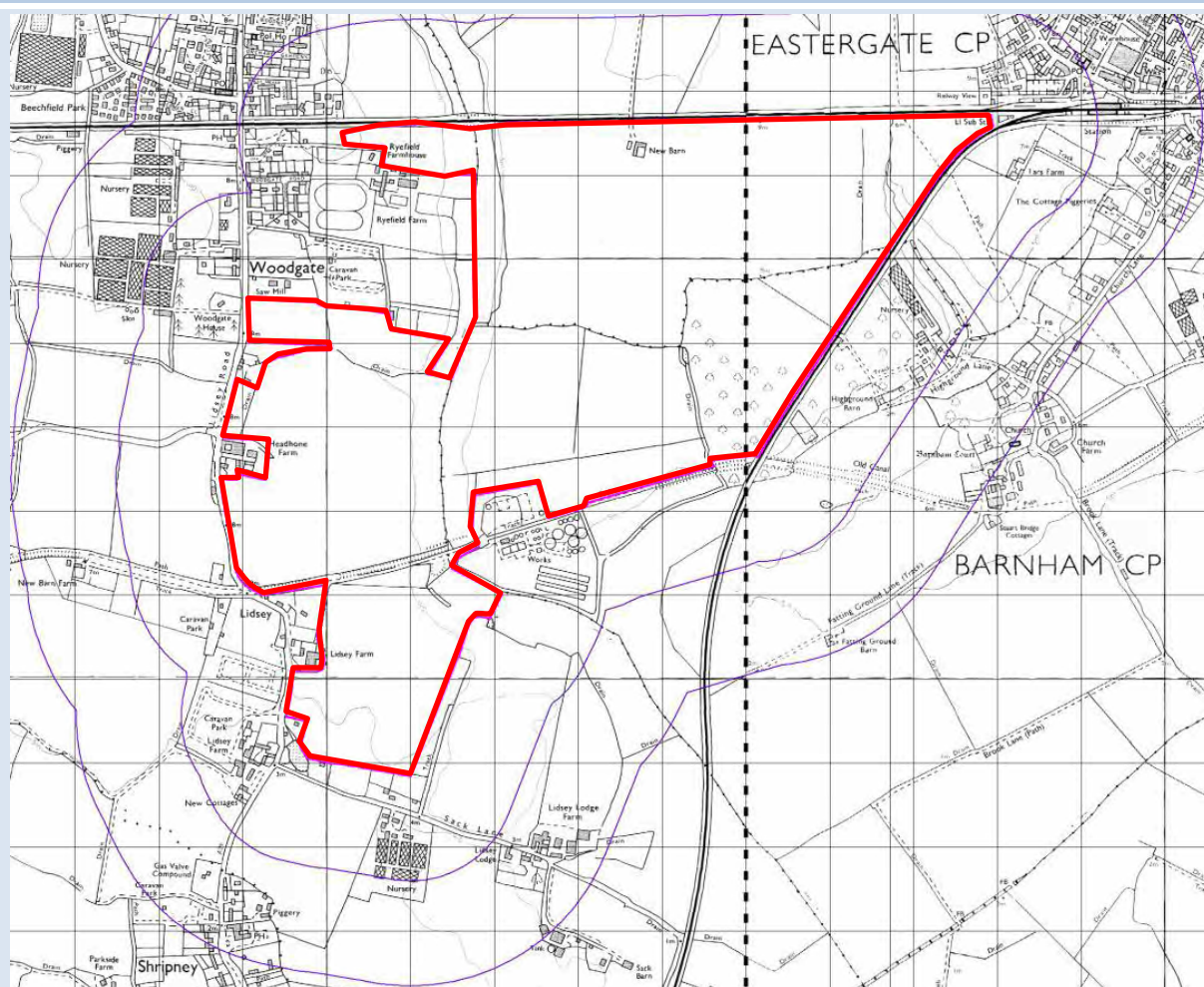
1961(W)-1962(E) on Site: No significant changes have been identified; **off Site:** Some new residential houses are shown in the area of Woodgate. No other significant changes have been identified.

Table 5: North of the London Brighton Railway Line History



1979(W)-1980 (E) On Site: The former Chichester and Arundel Canal shows significant evidence of infilling. An Orchard now shown as occupying the area referred in previous mapping as the nursery extension. A new drain is marked on the map in line with the edge of the orchard field; **Off Site:** By 1979 Lidsey, Woodgate and Barnham have undergone substantial residential and industrial development and a number of manufacturing works are now shown. These include Piggeries just adjacent (W) and 380m (E), Nurseries 190m (S) 500(W), Sawmill 50m (N), Gas Valve Compound 350m (SW) and Sewage treatment Works (S). Lidsey Road is now identified on the map. A caravan site in Lidsey is located to the west of Lidsey Road.

Table 5: North of the London Brighton Railway Line History



1992-1993 On Site: The Nursery extension area is used as an Orchard; **Off Site:** The marsh field is no longer shown on the map. The Lidsey Oil Field was discovered in 1987⁴. This is located immediately S of the site boundary. The Lidsey Landfill opened in 1988⁵ and is located 470m west of the site, although is not recorded in the historical maps scaled 1:10,000 but is identified on the later 1:2,500 mapping and Site Sensitivity maps. This landfill accepted non-hazardous household, industrial and commercial waste. No other significant changes are identified.



(source: geograph.org.uk)

Lidsey Oil Field³

A photographic record from google imagery of the Lidsey Oil field and a summary of data available for the exploration of the oil wells.

Production License: PL241

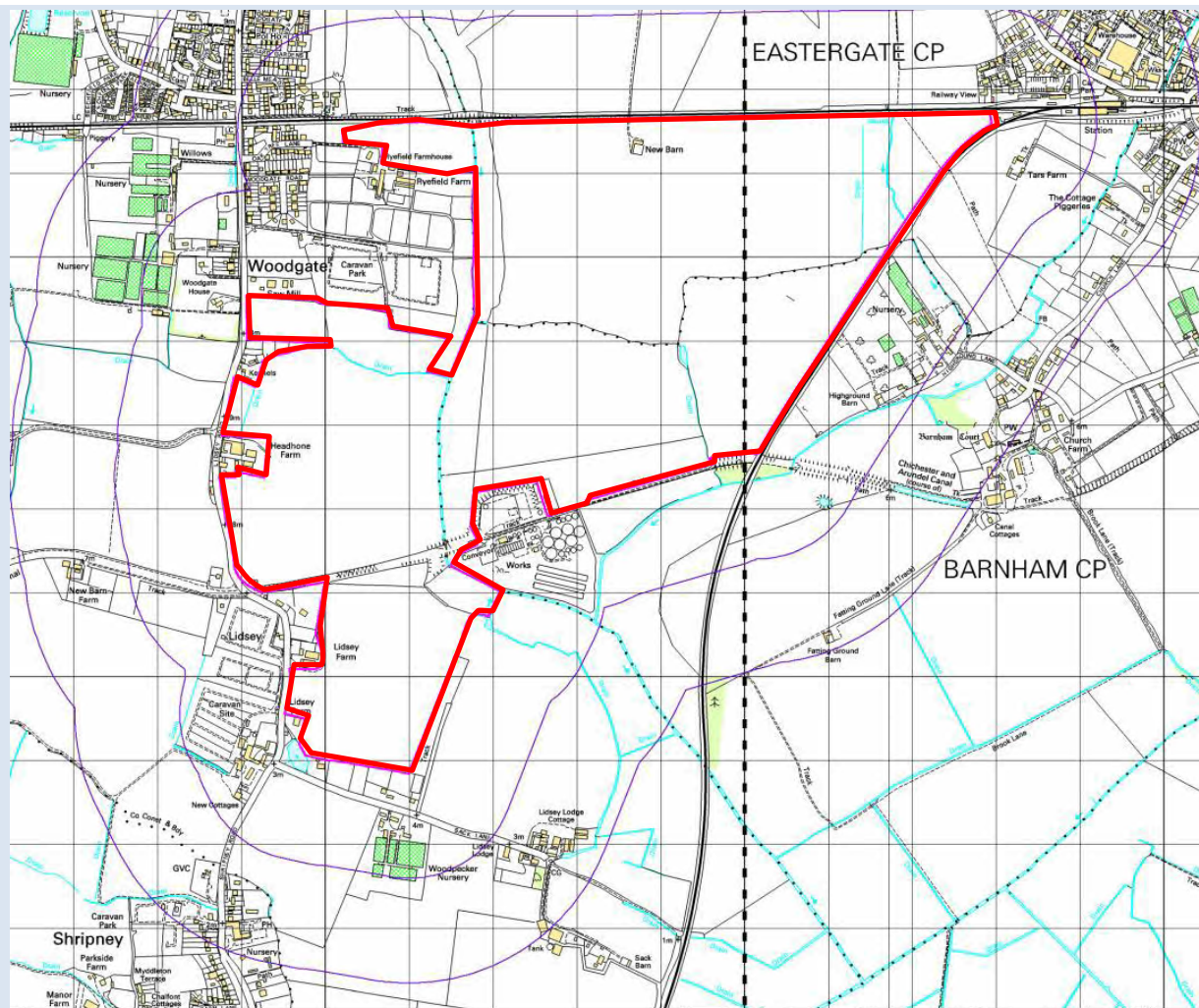
Licence area: 5.3km²

Operator: Angus Energy

⁴ <http://www.angusenergy.co.uk>

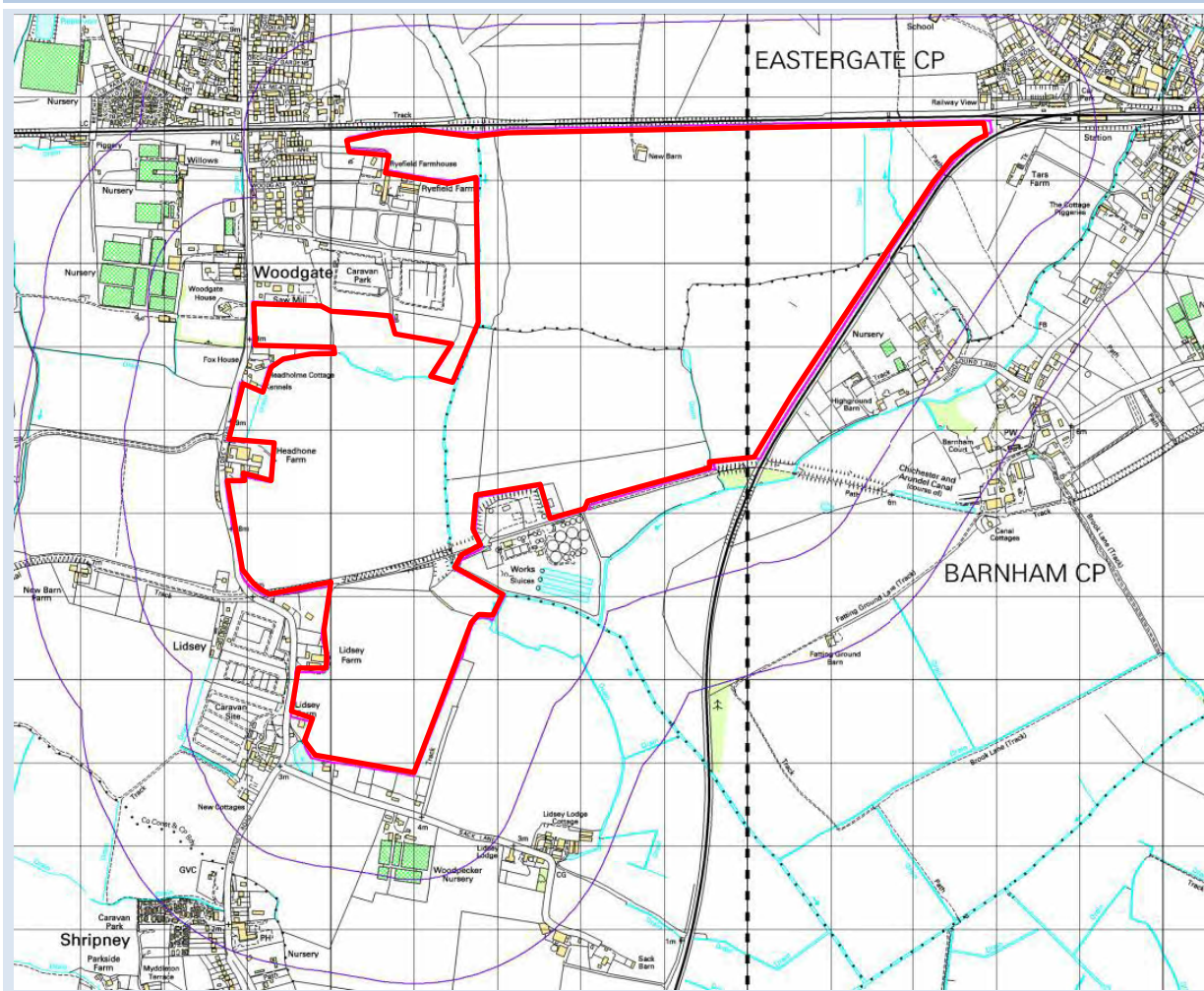
⁵ <https://beta.companieshouse.gov.uk>

Table 5: North of the London Brighton Railway Line History



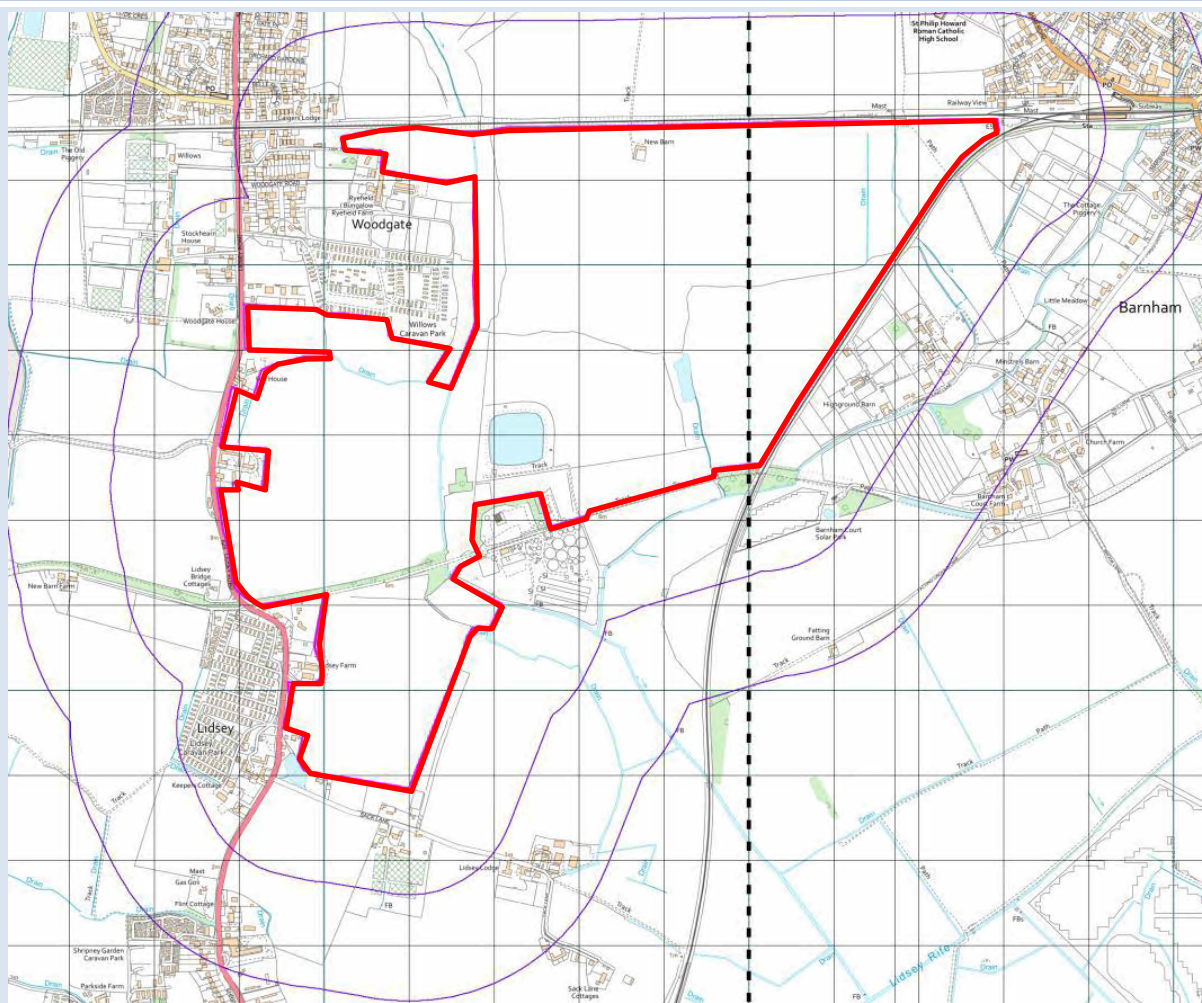
2000 On Site: No significant changes are identified. The Highground nursery extension is now shown as arable site; **Off Site:** No significant changes have been identified.

Table 5: North of the London Brighton Railway Line History



2006 On Site: No significant changes have been identified; **Off Site:** No significant changes have been identified.

Table 5: North of the London Brighton Railway Line History



2020 On Site: A new surface water feature likely to represent a reservoir is shown some 50m north of the site boundary. No other changes are identified; **Off Site:** Barnham Court Solar Park is identified 150m (SW) .

Key: N north, E east, S south, W west, NE north east, NNE north north east etc.

In summary, the North and South historic maps and images indicate the following:

- The railway lines are known to have been constructed around the 1840's and are present prior to the earliest mapping.
- The Site is mostly occupied by arable agricultural land. The earliest maps show two farms to the south: New Barn and Headhone Farm. Several footpaths, railway crossings and water features, such as Lidsey Rife, other minor relevant streams/drains, and ponds are present. Arundel Canal is already shown as disused within early mapping.
- In 1899, the Headhone Farm appears to move west and falls outside the site boundary.
- The site has remained without changes up to 1912-13 when the northernmost part of the site gave place to two new nurseries in church lane and Barnham road: "The Warwick" and "The Brooks".
- In 1952 a Romano Pottery is identified to the north of the London Brighton & South Coast Railway line.
- Around the 1960's Highground Barn Nursery extends beyond the Bognor Branch line towards the centre of the site with a triangular shape and with an approximate area of 13Ha.
- By 1979 Lidsey, Woodgate and Barnham have undergone substantial residential and commercial development. They are dominated by residential developments and streets. A number of manufacturing 'works' are also present such as piggeries, nurseries, engineering works, a sawmill and sewage works. The presence of sewage works is identified adjacent to the western boundary of the site between the period up to 1993, however no data within the Envirocheck reporting provides information that confirms its presence.

- By the end of the 1980's the Lidsey Landfill Waste Site is present 500m (W) from the Site and the Lidsey Oil Works has been developed on the southern site boundary.
- In the early 1990's several surface water features on the northern area of the site appear to have been infilled.
- By 2020 a new surface water feature is shown immediately north of Lidsey Oil Works.

3.6 Published Geology

The published geology of the area is shown on the geological map for Chichester and Bognor (Sheet 317/322, scale 1:50,000), published by the BGS. Derivatives of the BGS mapping are included in the Geology Report (Landmark) and further geological information has been also obtained from the BGS website. The published geology is shown in **Figure 4** and **Figure 5**.

The maps indicate that the Site is predominantly underlain by superficial deposits of Alluvium, Raised beach and marine deposits, River Terrace Deposits which cover most of the site and wider areas, and Head deposits from the quaternary period mainly related to current/historical surface water channels. The site is directly underlain by solid 'bedrock' geology of the London Clay formation under the majority of the Site and the Lambeth Group and Lewes Nodular Chalk within the south of the site only.

The BGS describes the underlying geological strata as follows:

- Alluvium - Generally unconsolidated clay, silt, sand and gravel deposits deposited in a fluvial setting.
- Head Deposits - Generally poorly sorted and poorly stratified, rock and soil debris, typically deposited by solifluction and gelifluction processes.
- Raised Beach Deposits - Shingle, sand, silt and clay
- Raised Marine Deposits - Variable lithology. Gravel (shingle), sand, silt and clay; commonly charged with organic debris (plant and shell).
- River Terrace Deposits (Undifferentiated) - Sand and gravel, locally with lenses of silt, clay or peat.
- London Clay - Clay, Silt and Sand. Sedimentary Bedrock formed approximately 48 to 56 million years ago in the Palaeogene Period. Local environment previously dominated by deep seas.
- Lambeth Group - Vertically and laterally variable sequences mainly of clay, some silty or sandy, with some sands and gravels, minor limestones and lignite and occasional sandstone and conglomerate.
- Lewes Nodular Chalk - Chalk with flints. With discrete marl seams, nodular chalk, sponge-rich and flint seams throughout.

No artificial ground is recorded by the BGS within the site boundary. The centre line of the Chichester Syncline bisects the site and aligns from West Barnham in the east, to the south of Woodgate in the west.

Figure 4: Published Surface Geology

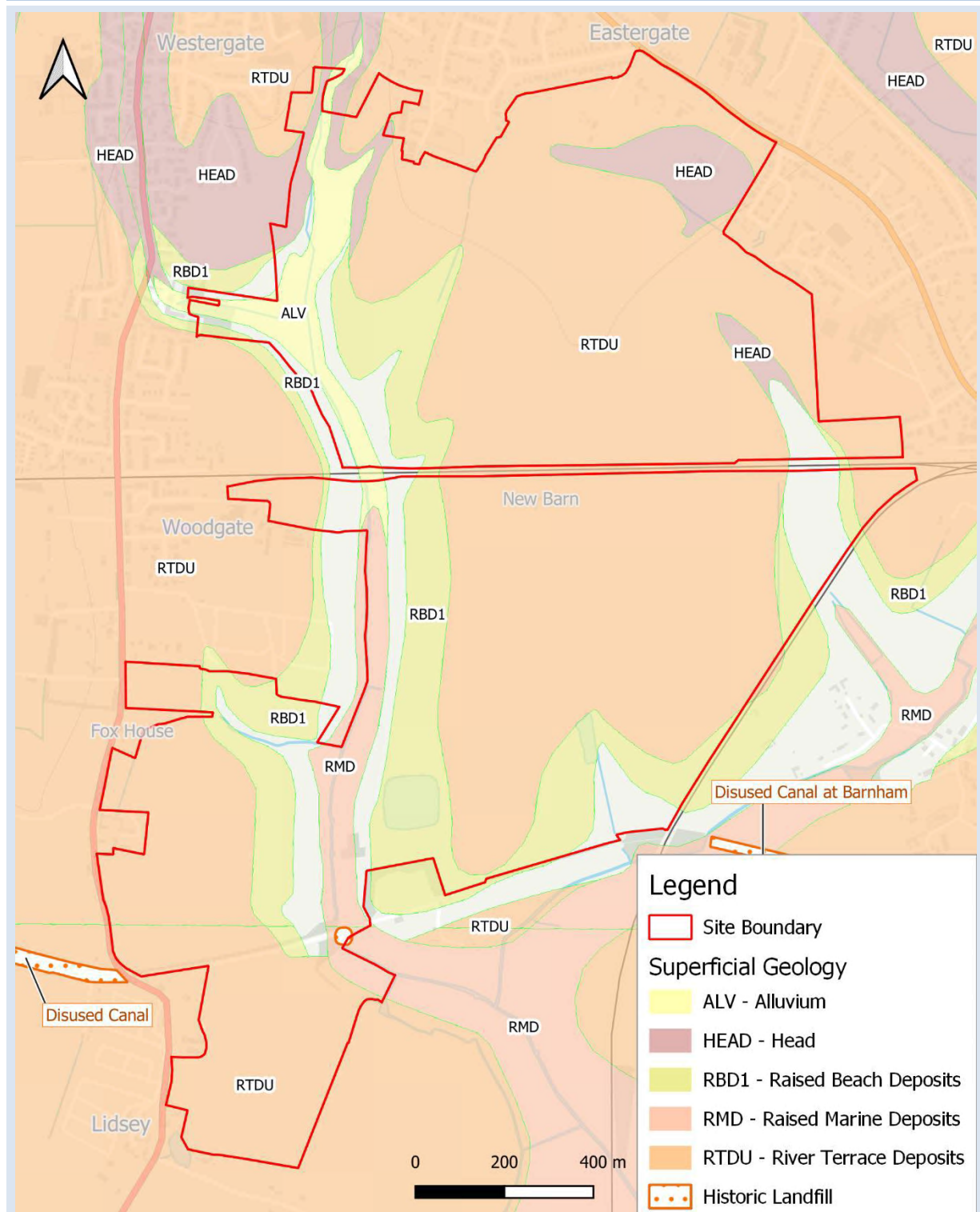
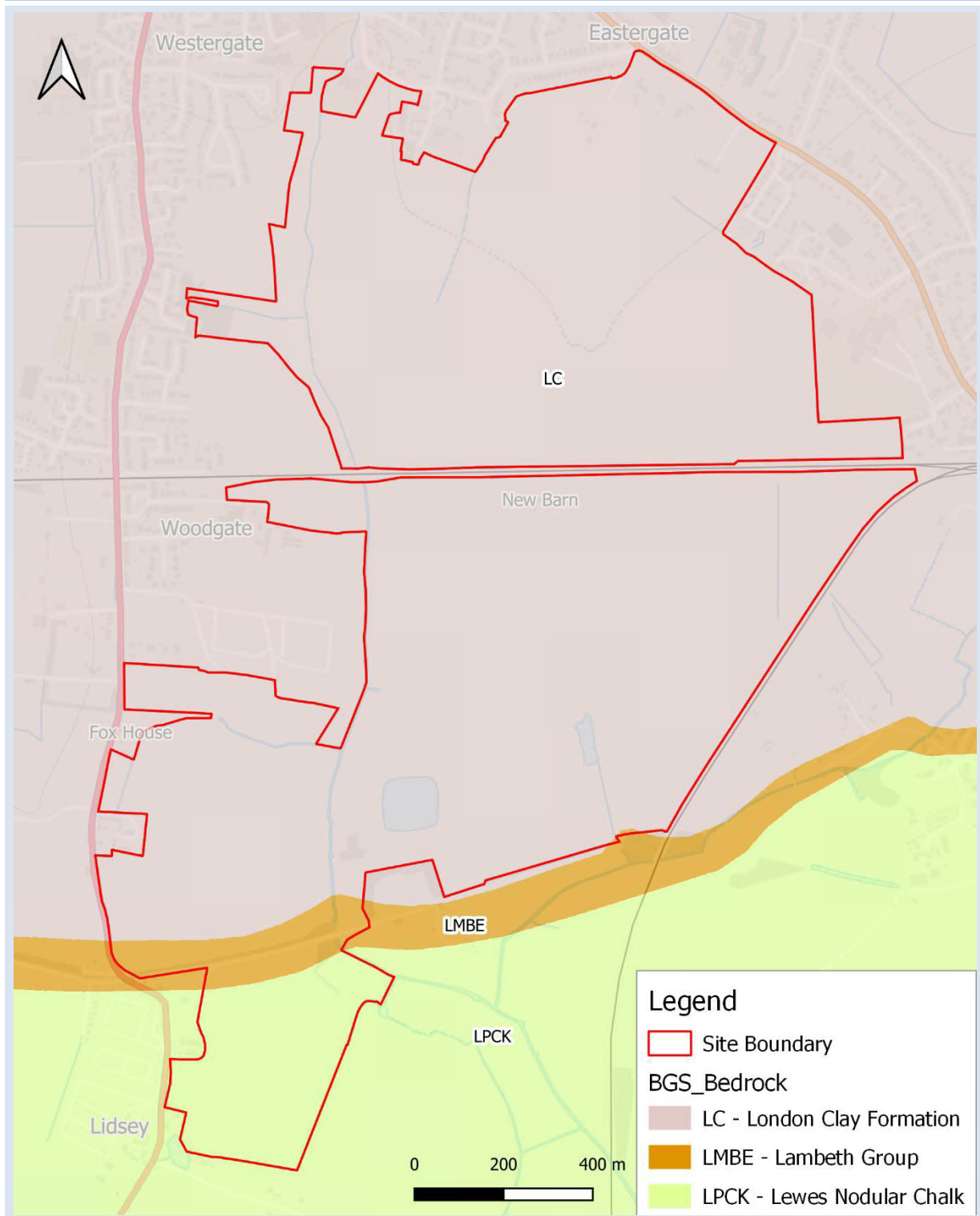


Figure 5: Published Bedrock Geology

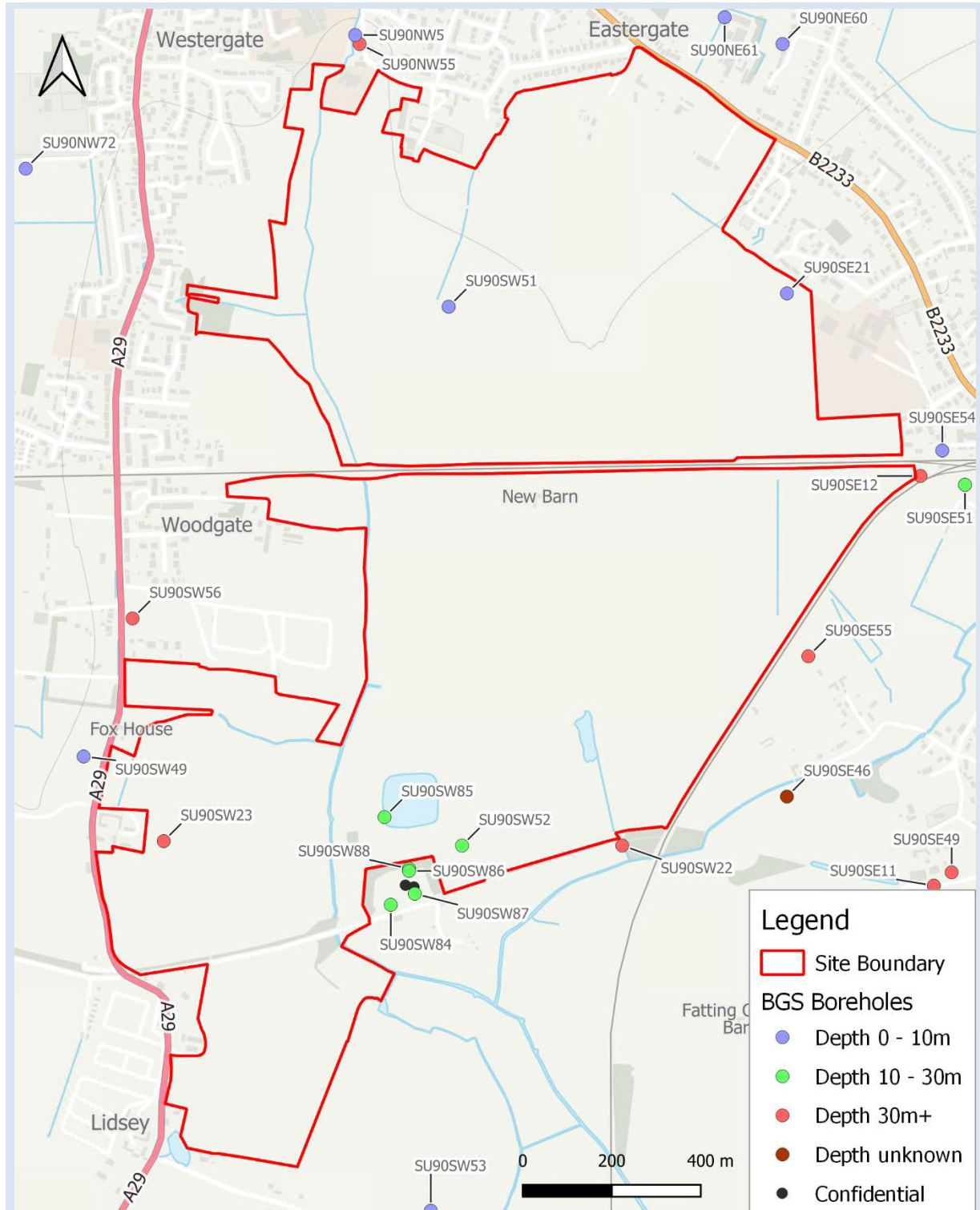


The BGS maintains an archive of historic boreholes. The locations of the available borehole records are shown in [Figure 6](#). Across the site only 5no. borehole logs are available within the site boundary however, the quality and detail within these exploratory records is generally limited.

The two boreholes to the north of the railway line, [SE90SE51](#) and [SE90SE21](#) describe a sequence of superficial strata comprising up to 0.5m of Topsoil, 1.5m of silty CLAY (Brickearth), over 1.4 to 3m of gravelly SAND and sandy GRAVEL described as Raised Beach Deposits and Head Gravel. Both are underlain by London Clay at 2.9 and 4.6m bgl respectively.

In the southern area of the site the deeper borehole [SU90SW23](#) located closer to the site western boundary extends down to 102m below ground level, showing 71m of London Clay underlain by 30m of Reading Beds (part of the Lambeth Group). To the south of the Site, the boreholes [SU90SW52](#) and [SU90SW85](#) located close to the manmade reservoir prove depths of 15m and 30m respectively. These indicate the top of the London Clay at 3.4m and 6m depth with the top of the Chalk only confirmed by the deeper borehole at 27m bgl. Given the limited detail provided within the drilling log from [SU90SW85](#) the description of a 6m thickness of Made Ground should be treated with caution.

Figure 6: BGS Borehole Records



A summary of the ground conditions is presented in **Table 6** based on the available BGS information and on the recorded information from the previous intrusive investigation by WYG in 2017.

Table 6: General Sucession of Strata Anticipated

Strata	Top of the stratum (m bgl)	Thickness (m)
Topsoil	0.0	Up to 0.5
Made Ground	0*	6*
Superficial Deposits	0.5	2.55-4 (varies)
London Clay	1.3-7.6 (varies)*	Up to 71 (varies)
Lambeth Group	4- 71(varies)*	Not proven
Chalk	1.9- 27m and not proven	Not proven

*Described in one location only where the quality of the exploratory hole record is considered to be poor, this value should be treated with caution until confirmed by additional investigation.

3.6.1 Geological Records

The Landmark Envirocheck Report and Geology Datasheet includes a series of natural ground stability hazards records, these are summarised in **Table 7**.

Table 7: Natural Ground Stability Hazards (North)

Natural Ground Stability Hazard	Hazard rating
Collapsible deposits	Low to Very Low
Compressible deposits	No Hazard
Ground Dissolution	No Hazard
Landslide	Very Low
Running sand	Low
Shrinking or swelling clay	Low
Coal mining affected areas	'In an area that might not be affected by coal mining'
Mining instability	No hazard

3.7 Hydrogeology

The hydrogeological classifications for the underlying superficial deposits and solid geology (bedrock), taken from the Envirocheck Report are summarised in **Table 8**.

Table 8: Aquifer Designations and Hydrogeological Characteristics

Stratum	Aquifer Designation	Hydraulic Characteristics (EA Descriptions)
All superficial deposits (Superficial)	Secondary A	"Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers."
London Clay (Bedrock)	Unproductive strata	"These are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow."

Table 8: Aquifer Designations and Hydrogeological Characteristics

Stratum	Aquifer Designation	Hydraulic Characteristics (EA Descriptions)
Lambeth Group (Bedrock)	Secondary A	"Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers."
Chalk (Bedrock)	Principal Aquifer	"Layers of rock or drift deposits that have high intergranular and/or fracture permeability – meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale."

Superficial Aquifer

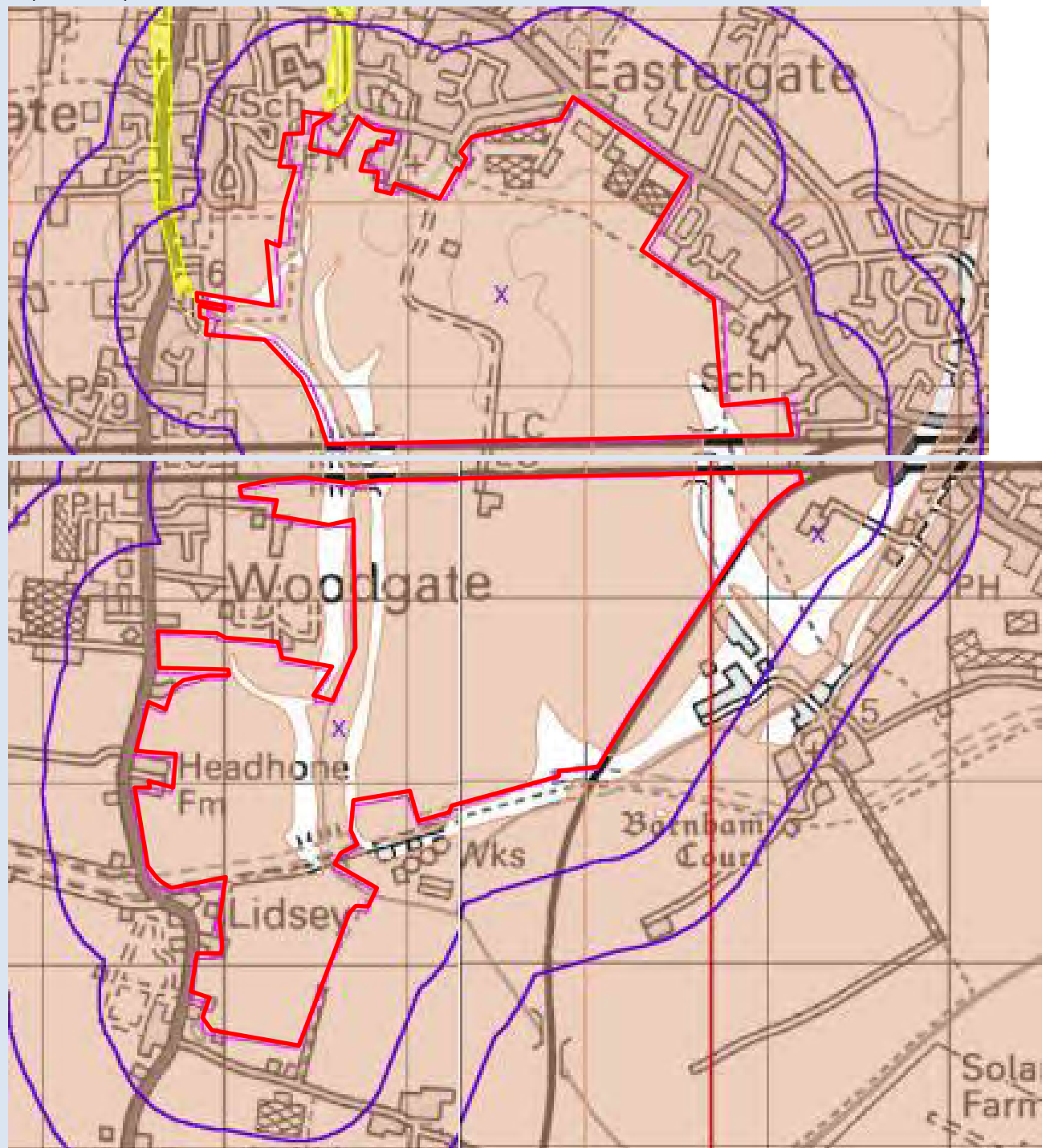
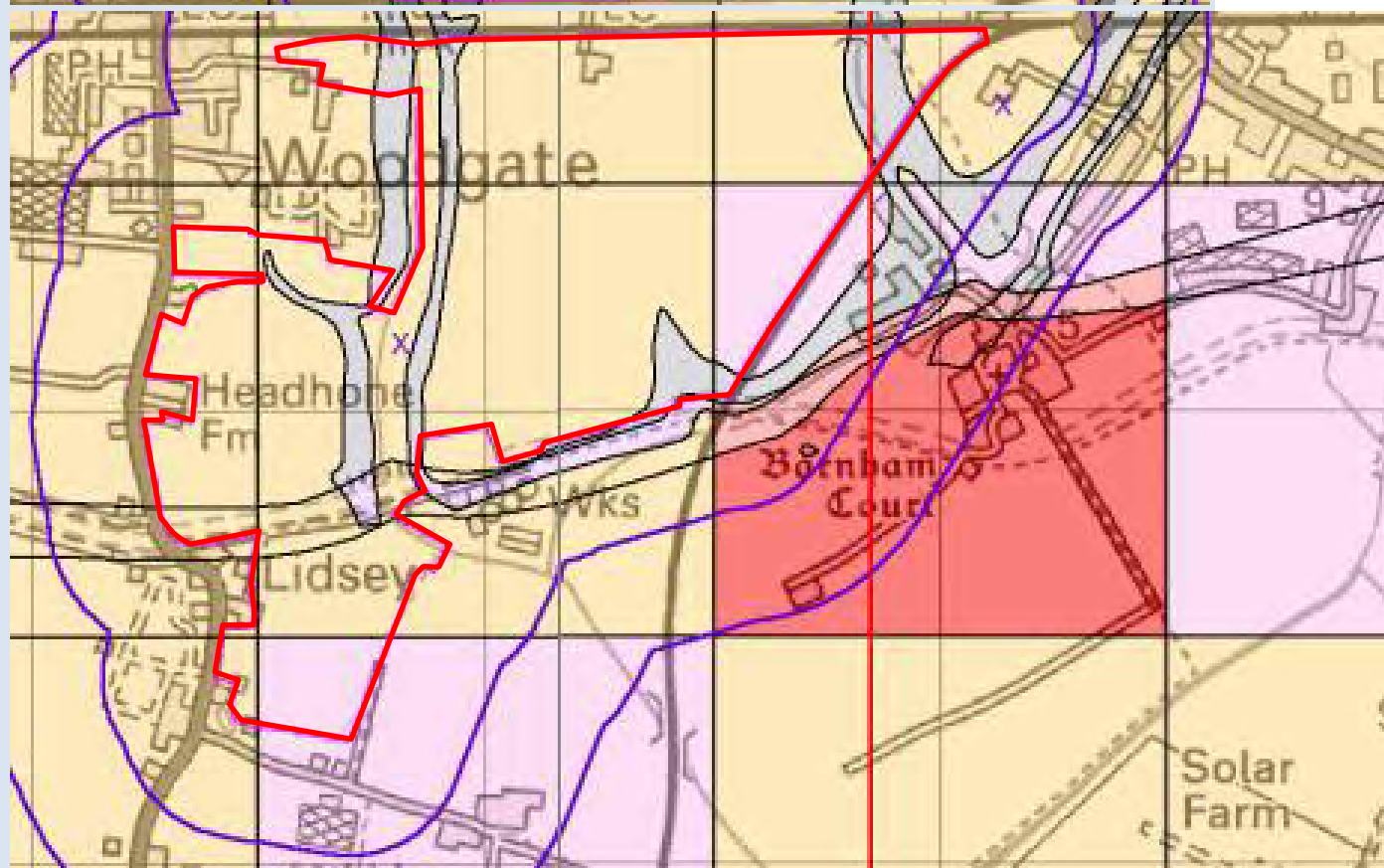
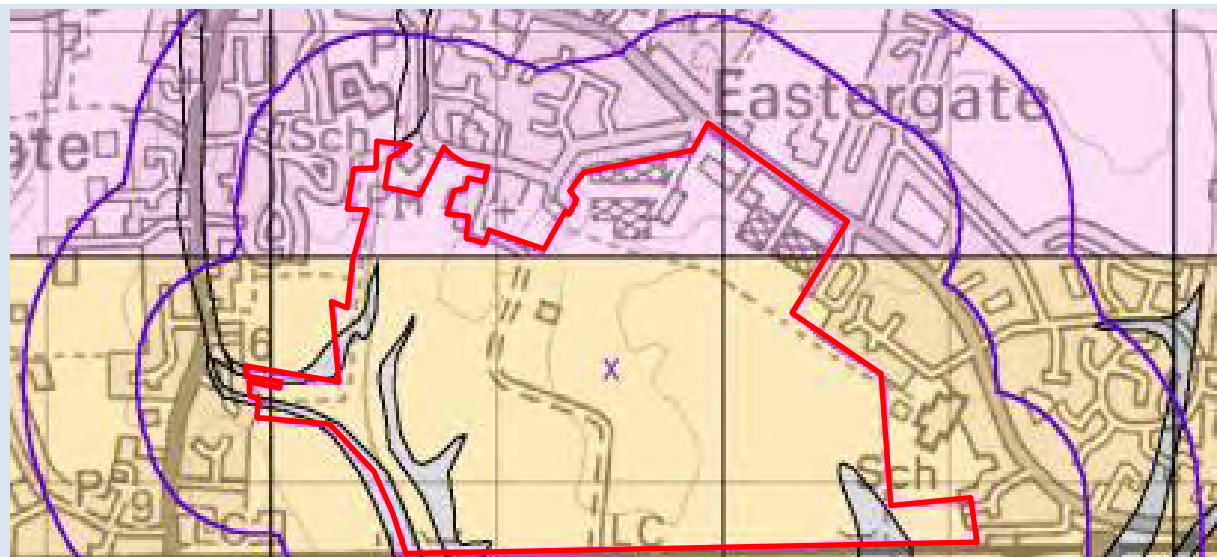


Table 8: Aquifer Designations and Hydrogeological Characteristics		
Stratum	Aquifer Designation	Hydraulic Characteristics (EA Descriptions)
Bedrock Aquifer		
Superficial aquifer classifications		Bedrock aquifer classifications
Principal Aquifer	Secondary A	Secondary undifferentiated
Unproductive	Secondary B	Unknown

Table 9 summarises the groundwater vulnerability information for the superficial and bedrock aquifers identified above.

Table 9: Groundwater Vulnerability

Stratum	Aquifer Designation	Groundwater Vulnerability
All Superficial Deposits	Secondary A	High Risk
Chalk (Bedrock)	Principal Aquifer	High Risk
London Clay (Bedrock)	Unproductive strata	Medium Risk



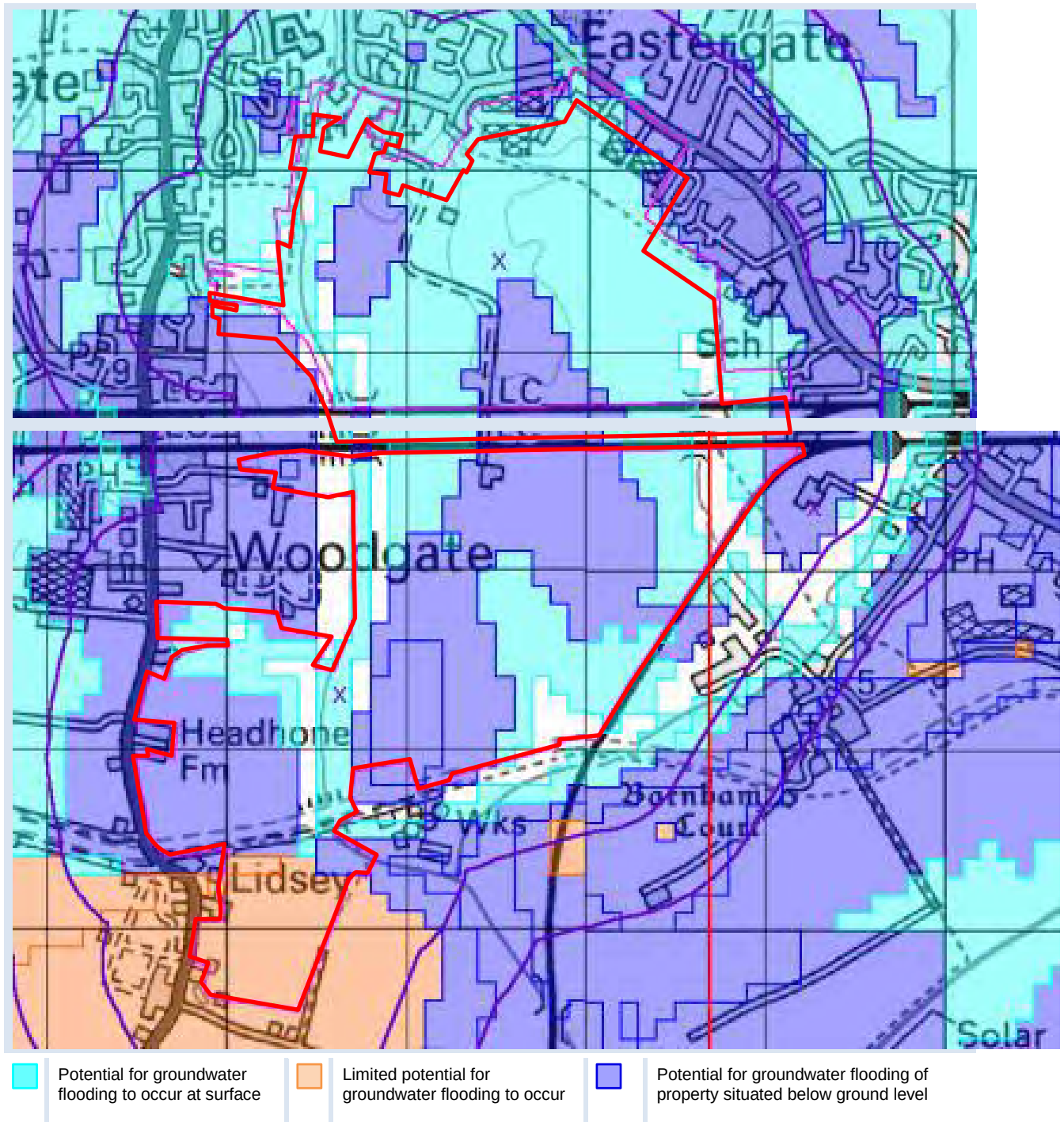
Key	Bedrock Aquifers Vulnerability			Superficial Aquifers Vulnerability		
Principal Aquifer	High	Medium	Low	High	Medium	Low
Secondary Aquifer	High	Medium	Low	High	Medium	Low

The groundwater monitoring undertaken by WYG in 2017 recorded groundwater close to the surface (often <1m below ground level) across the majority of the site, except in the southernmost area where groundwater levels were typically 3-4m bgl. Groundwater flow direction is shown to be flowing from northwest to south east, diverging towards the Lidsey Rife in the west and the Barnham Rife to the east.

The EA records within the Envirocheck Report indicate the following:

- The Site is not within a Source Protection Zone (SPZ); The closest SPZ is 1.7km to the north.
- There are records of 3no. groundwater abstraction licences within 1km, the closest is at 666m (NW) operated by JR Robinson (Private) for general agriculture: Spray Irrigation
- The majority of the Site is located where groundwater flooding may occur at surface or in an area at risk of groundwater flooding 'for properties situated below ground level'; as shown in **Figure 7**.

Figure 7: Groundwater Flooding Risk - North (Envirocheck)



3.8 Hydrology

The surface water features identified within the site boundary are described below:

- Lidsey Rife, small calcareous watercourse runs from north to south through the western side of the site and is fed by two tributaries which flow into the Rife in the north-western part of the site. The Lidsey Rife combines with the Barnham Rife just south of the site, immediately south of Lidsey Water Treatment Works
- Ditches and streams across the site with some culverted sections (mainly associated with the railway). In the east of the site, just to the south of the railway which bisects the site, the Ordnance Survey map identifies a watercourse, School Stream, which flows into Barnham Rife to the east of the site. The biological and chemical status of the stream are unknown. To the north of the railway it is understood to be culverted.
- The route of the disused and partially infilled Arundel Canal, which runs east to west, located on the southern boundary of the site.

The Envirocheck Report and EA data indicate the following:

- There are records of 24 surface water abstraction licences within 1km, 13 of which are within/or very close to the site boundary. The closest are 4no. Operated by Ashmarden Ltd and 9 no. operated by Lidsey Farm for general agriculture and Spray Irrigation
- A number of active water discharge consents have been identified, the majority of which relate to treated sewage effluent from commercial and private residential properties discharging to soakaways or surface water drains.

Extracts from the Environment Agency Flood Zones and DEFRA surface water flood risk mapping are included in **Figure 8** and indicates some flood risk in low-lying areas, primarily in lower lying areas along the shallow valley features within the site and in limited low lying areas – predominantly near existing surface waters. The highest risk of flooding is indicated along the stream corridor of the Lidsey Rife through the western side of the Site and the associated tributaries which are within Flood Zone 2 and 3. No areas within 1km of the Site are identified to benefit from flood defences.

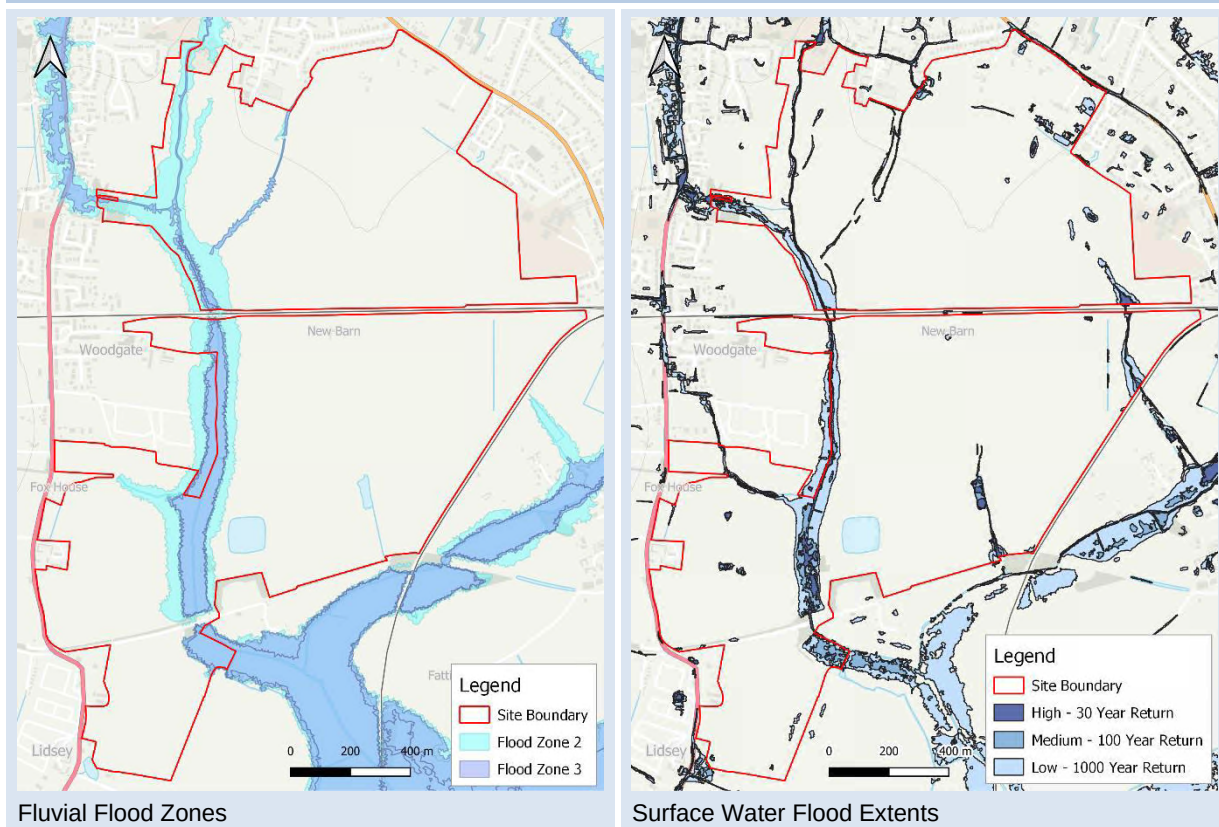
Definitions of Flood Zone according with the National Planning Policy Guidance:

Flood Zone 1 - land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1%)

Flood Zone 2 - land assessed as having a less than 1 in 100 annual probability of river flooding (1%-0.1%), or between 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5%-0.1%) in any year.

Flood Zone 3 - land assessed as having a less than 1 in 100 annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of sea flooding (>0.5%) in any year

Figure 8: Risk of Flooding



Further consideration of flood risk is presented in the Flood Risk Assessment prepared by Pell Frischmann (report ref: 100148-PEF-ZZ-XX-RP-YE-000020). Winter Groundwater Monitoring has been carried out in line with WSCC local policy from October 2019 – January 2021, which shows groundwater to be relatively shallow across most of the site.

3.9 Radon

Reference to the UK Radon maps (www.ukradon.org) (and the Envirocheck Report) indicates that the northern 95% of the Site is within an Intermediate probability radon area, where 1% and 3% of the homes are at or above the radon Action Level and the southern 5% of the site is within the lowest radon area where less than 1% of homes are at or above the radon Action Level. Subsequent reference to BR211 on Radon⁶ indicates that the Site is within an area where 'no radon protection measures are necessary in the construction of new dwellings or extensions'.

3.10 Environmental Data Searches

3.10.1 On-Site

Review of the Envirocheck Report did not identify any additional records of geoenvironmental significance on-site. In particular, the report indicates that there are no records of 'Contaminated Land Register Entries on-site.

The following additional records of geoenvironmental significance on-site have been identified from the review of the Envirocheck Report (ID on Sensitivity Maps is included in square brackets for future reference):

- Several areas of relatively limited infilled land associated with historical water features (e.g. ponds) have been identified. Most notably land to the west of Lidsey, Wastewater

⁶ BR211 Radon. Guidance on protective measures for new buildings, 2015 edition. Building Research Establishment.

Treatment Works is marked on the historic landfill layer as 'Disused Canal East of A27' The former canal is similarly described, immediately off-site to the west.

- A Generic Tank is identified within the area correspondent to Fleurie Nurseries (N)
- Railway land bisecting the Site
- Slurry Bed adjacent to the site boundary (N) associated with Manor Farm.

Four minor pollution incidents to controlled waters have been identified within the site boundary involving crude sewage and oils, however no pollution incidents of significance have been identified within the site boundary.

3.10.2 Off-Site

Based on a review of the Envirocheck Report the following potentially contaminative land-uses are noted within proximity of the Site:

- Barnham Station and two Railway line branches. London Branch dissecting the site and Bognor Brach adjacent to southwestern boundary.
- Historical landfills recorded in the location of the former Canal to the south, both on and off-site.
- A former Licenced Waste Management Facility, namely Lindsey Landfill Site and Extension located approximately 500m west of the Site.
- Mining Waste operations associated with the licensed Lidsey Well Site and operated by Angus Energy, where crude oil is extracted from the ground and stored on site prior to collection.
- Potential infill of land within the historical West Barnham and Woodgate and Brick Fields less than 10m (NE).
- Engineering works including several Vehicle Cleaning/Diagnostic/Repair/Testing/ Servicing and Garage Services
- Sewage pumping station adjacent to Site boundary (NE)

Refer to the map shown in **Figure 10** of **Section 5.5** which identifies the potential contaminative land uses listed in **Section 3.10.1** and **3.10.2** above.

3.11 Unexploded Ordnance (UXO)

The United Kingdom was targeted in terms of bombing during World War II. The presence of unexploded bombs presents a risk for construction workers and residents of the surrounding areas.

A UXO desk study for the site has not been carried out. However, as an initial step towards a preliminary UXO risk assessment (in line with the CIRIA report C681, 2009), a non-specialist UXO screening exercise has been carried out for the Site.

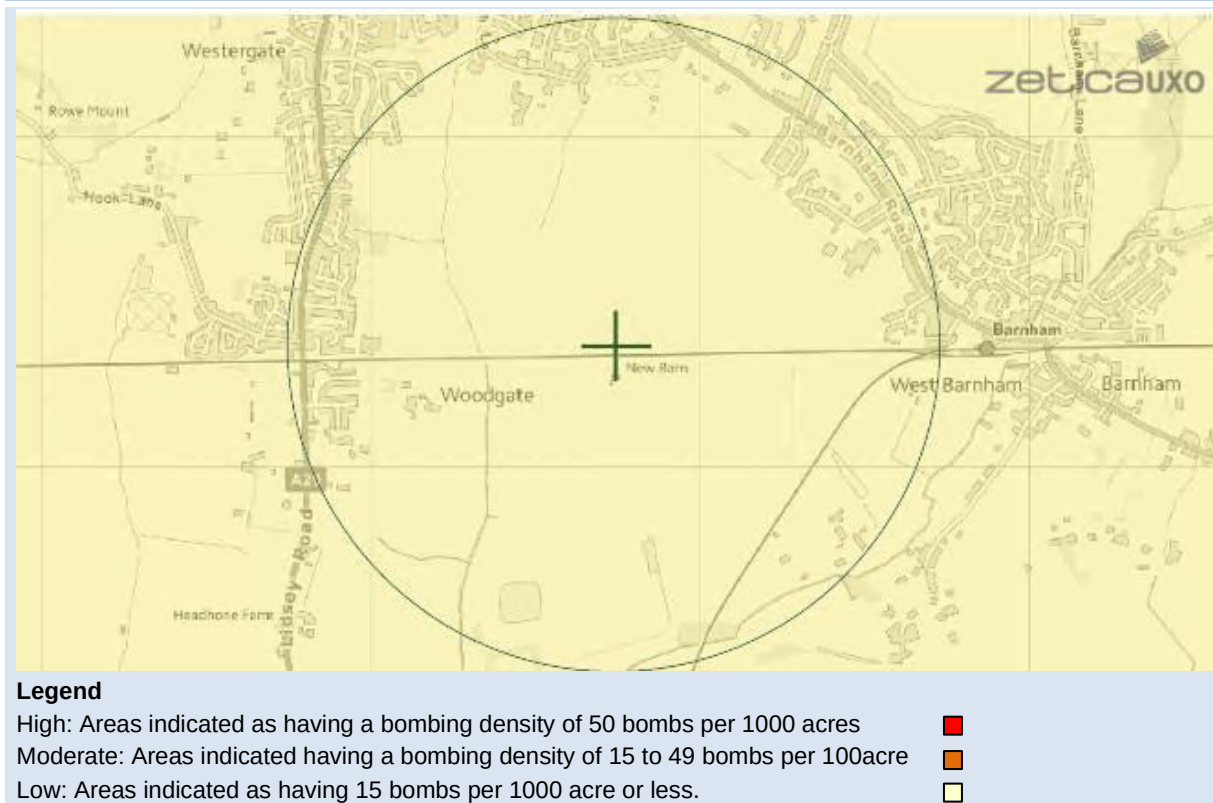
As an initial part of the screening exercise, no historic military land-uses have been identified in proximity to the area from the historic maps and aerial photographs reviewed and described in **Section 3.5**

An UXB risk map for the site has been downloaded from Zetica⁷. The map indicates a low risk. A copy of the map, key and supplementary notes is included in **Figure 9**.

A qualitative assessment of the UXO risk based using the historical land use in conjunction with the bombing records is presented here. The following scores are assigned to re assessable variable which depends on the potential risk for the aerial delivered UXO stated in CIRIA C681. From the list of probability and consequence factors assessable variable in bold which affect the risk and their respective scores are presented in the tables below:

⁷ Zetica are a UK provider of services for managing the risk of UXO on land assets <https://zeticauxo.com>

Figure 9: Zetica Unexploded Bomb Risk Map



3.12 Environmentally Sensitive Designations

The Envirocheck Report records the site being within a Nitrate Vulnerable Zone and the presence of a Local Nature Reserve is noted 2.5km to the south. No other environmentally sensitive designations have been recorded within 1km of the Site.

4 Geotechnical Considerations

The proposed development involves construction of a new road alignment, railway bridge and several low rise commercial and residential structures on an area currently used as arable agricultural land. The history of the site indicates that there has been little or no substantial development within the site boundary. Nevertheless, there will always be some inherent risk from a geotechnical perspective due to the very nature of the ground. These risks are generically identified and summarised in **Table 10** together with consideration and possible mitigation options which may be considered.

Table 10: Preliminary Geotechnical Hazards

Item	Hazard	Impact on the Proposed Development	Mitigation Measures
General Ground Conditions	Unknown Ground Materials Strength Profile, Physical and Chemical Properties: Unknown load carrying capacity of ground for foundations. Poorly compacted and variable thickness Made Ground in areas of potential infill may result in settlement of external areas. The ground may contain potentially sulphate bearing soils and fill materials.	Conservative Design Solutions: Inability to appraise a wide range of design solutions due to lack of information. An over-conservative design may arise. Impact to Cost and Programme: Unforeseen ground conditions may cost delays and cost implications to the programme. Potential Concrete Damage: Aggressivity of the ground may damage the foundation materials.	Ground Investigation: Undertake a detailed site-specific ground investigation where boreholes of appropriate depth are advanced with associated in-situ and laboratory geotechnical and chemical testing in order to determine the strata profile on site, parameters for design and soil aggressivity to buried concrete and quantify any contamination present.
Groundwater	Shallow Groundwater Conditions: This will impact on the potential design solutions for the development. Excavations including foundation trenches may require dewatering measures. Softening at the base of shallow footings can occur. Unknown Chemical Properties The aggressivity of groundwater needs to be determined and thus testing needs to be carried during a ground investigation.	Road Construction: Deeper subsoil drainage may be required to protect road subgrade material Settlement: High water table may result in longer settlement times for fill areas. Earthworks/Excavation and construction: Dewatering may be required during construction. High water levels may affect the reusability of the site material if its deemed to be too wet to reuse effectively.	Ground Investigation: Carry out testing to characterise the aggressivity of the groundwater. Design: Groundwater conditions to be considered for foundation constructability and stability of excavations. Effective site drainage: may be used to reduce water levels in surface water bodies and in superficial deposits that overlay London Clay (WYG 2017).
Flooding	Risk of groundwater and surface water flooding: This will impact on the potential design solutions for the development.	Potential structural damage: Uplift forces induced by high water tables at the site from groundwater flooding has the potential to affect the bearing capacity of buried structures and foundations if this is not considered in the design.	Flooding Risk Assessment (FRA): Understand the actual risk of the flooding and determination of the minimum ground floor levels Design: Water levels and associated uplift pressures to be considered based on FRA. Mitigation measures may be required in the design to prevent structures from flooding.
Services	Risk to Workers and End Users and 3rd Party Assets: Damage to existing and proposed utilities and services.	Health and Safety: Health and safety implications for construction workers and general public if a service strike were to occur during construction. Impact to Cost and Programme: Unexpected services can cause delays and cost implications to the programme especially if damage to third party assets occurs.	Services Location: Obtain all the latest existing service drawings and liaise with service providers to understand constraints and requirements from service providers. Impact Assessment: Undertake an assessment of proposed works (temporary and permanent) on third party assets. Develop monitoring and mitigation proposals as required.
Unexploded Ordnance	Risk to Workers and End Users: Encountering UXO during works. Site is identified as low risk based on initial assessment.	Health and Safety: Health and safety issues during construction. Impact to Cost and Programme: Unforeseen UXO may cause	UXO Assessment: The preliminary assessment considers the site to be of low risk. The Contractor should exercise all reasonable precautions with regard to UXO.

Table 10: Preliminary Geotechnical Hazards

Item	Hazard	Impact on the Proposed Development	Mitigation Measures
		delays and cost implications to the programme.	
Potential for archaeology beneath the site	Risk of heritage damage: A Romano artefact encountered in 1952 on site.	Impact to Cost and Programme: Unforeseen archaeological artefacts/sites may cause delays and cost implications to the programme.	Archaeological Desk study. Client to commission an archaeological desk study.

4.1 Preliminary Geotechnical Design Considerations

It is proposed that the redevelopment of the Site will involve the construction of a new road, the building of predominantly low-rise dwellings but with some higher structures (up to 5 storeys) and a bridge over the railway. Consequently, the selection of the suitable foundations will be dependent on the size and type of the structure and the actual geotechnical and groundwater conditions present.

Part of the proposed development is anticipated to comprise of low-rise dwellings and therefore likely to be founded on conventional spread foundations bearing on the natural ground. Such foundations are particularly well suited for low to moderately loaded structures. However, the presence of high-water table and elevated risk of groundwater flooding pose at risk the reduction of the bearing capacity on granular soils. Small diameter piling may be preferred.

In respect to the railway bridge foundations, the loads are expected to be significantly higher and a piling solution is the most likely foundation. Piles would extend into the competent strata at depth.

The highway section is anticipated to require minimal cut and fill works to reach the design levels subject to confirmation of the Flood Risk Assessment.

Table 11 presents the geotechnical design considerations and mitigation which may be considered, dependent on the final proposed development and associated ground conditions.

Table 11: Geotechnical Design Considerations

Factor	Structure	Description	Mitigation Measures
Settlement	Re-alignment of A29	In areas of fill beneath cohesive soils differential settlements and hydrodynamic consolidation may occur	Along the A29 a detailed settlement analysis will be required in areas where significant fill needs to be placed. Areas underlain by normally consolidated cohesive material (fill or natural) may require settlement hold period prior to highway paving to mitigate the risk of differential settlement.
	Bridge over railway		
	Low Rise buildings		
Subgrade	Re-alignment of A29	Strength of subgrade beneath highway pavement	In areas where the underlain material does not meet strength requirements, over excavation and replacement with imported fill, treated and compacted site won fill, or a ground improvement technique might be required.
Material re-use	Re-alignment of A29	Re-use of site won materials	Geotechnical testing to confirm suitability for re-use as engineered fill.
	Bridge over railway		
Slope Stability	Re-alignment of A29	Assessment of the new slopes originated by cut and fill	A slope stability analysis will be required in areas of significant cut and fill to confirm the permanent

Table 11: Geotechnical Design Considerations

Factor	Structure	Description	Mitigation Measures
	Bridge over railway		batter angles and to meet the required factors of safety against instability according with design specification.
Excavation	Re-alignment of A29	Removal of overburden for foundation construction	Earthworks may be required to level the site. Dewatering may be required during the excavation and placing fill where high groundwater is present above formation level.
	Bridge over railway		
	Low Rise buildings		
Piles	Bridge over railway	Load transfer to competent strata	Piles may be required to support structures underlain by soft, loose ground conditions or transference of significant loads.
	Low Rise buildings		

The different type of proposed structures will require a bespoke foundation solution for the housing areas, for the road re-alignment and for the over railway bridge. **Table 12** summarises the suitable foundation options for the different loading condition having in consideration the geotechnical risks and the expected works of excavation on site.

Table 12: Foundation Options

Determining Factors		Spread Footing / Raft Foundation	Piled Foundation Scheme/ Assisted Piled Raft	Improved ground / compaction
Risks	Description			
Geology/ Groundwater	The geology of the site is variable however in its majority comprises of a thin layer of topsoil overlying by granular superficial deposits and London Clay Formation.	A raft, pad or strip foundation may be suitable where the founding level is within the granular superficial deposits.	Piled foundations will be suitable for all structures and likely ground conditions.	Treated and compacted site won fill, or a ground improvement are suitable in areas where the underlain material does not meet strength requirements required for shallow foundations and pavement design.
	There are areas where the superficial deposits are of cohesive nature, namely around the Lidsey and Barnham Rife.	It is also possible that the top of the London Clay will also provide a suitable bearing stratum, however this may be dependent on the degree of weathering.		
	Groundwater levels are identified to be shallow.	Hydrostatic uplift can be accommodated with under slab drainage or enough building loads. The presence of water in the excavations might soften the soil or make it unstable. Dewatering may be required during the excavation of shallow foundations, and placing fill where water is present above formation level.	Tension piles can be designed to resist hydrostatic uplift and soil heave pressure.	

Table 12: Foundation Options

Determining Factors		Spread Footing / Raft Foundation	Piled Foundation Scheme/ Assisted Piled Raft	Improved ground / compaction
Risks	Description			
Shrink and Swell Clays	The London Clay Formation present on site is known to be of high plasticity. Brickearth deposits are generally classified as low to medium volume change. A high plasticity stratum gives rise to the swelling and shrinking of clays, as the result of seasonal moisture changes.	Discrete bearing pads/footing of sufficient depth can be used with a suspended slab to accommodate potential volume change of the underlying soils.	Pile foundations with a suspended slab would negate any effect of volume change in the underlying soils.	Chemical treatment with lime can be considered to reduce the of the expansibility of clays.
Excavation/ Cut and fill works	Removal of overburden for foundation. Cut and fill works may be required to level the site, around the road realignment for the access to the bridge.	Removal of unsuitable overburden is required to ensure bearing on firm strata. Where ground heave will occur due to unloading movement can be accommodated with void former or suitable bearing pressure.	Piles can be designed to resist soil heave movements or combined with suspended slabs to accommodate soil heave.	This usually the cheaper solution to use in extensive open site areas of cut and fill, considering all the construction stages. Areas underlain by normally consolidated cohesive material (fill or natural ground) may require pre-loading to mitigate the risk of differential settlement.

5 Preliminary Land Contamination Risk Assessment

5.1 Introduction

A Preliminary Risk Assessment (PRA)⁸ has been undertaken to identify potential land contamination and/or geoenvironmental constraints which could impact upon and/or restrict the proposed redevelopment.

A Preliminary Risk Assessment (PRA)⁸ has been undertaken to identify potential land contamination and/or geoenvironmental constraints, which may impact upon and/or restrict the future redevelopment of the Site. Therefore, the risk assessment that follows focuses on potential development constraints only.

The main part of the PRA involves the development of a Conceptual Site Model (CSM). The CSM is a 'representation of the characteristics of the site in diagrammatic or written form that shows the possible relationships between contaminants, pathways and receptors'⁸; (see definitions in **Table 13**).

Table 13: Contaminant-Pathway-Receptor Definitions⁹

Term	Definition
Contaminant	A substance in, on or under the land and which has the potential to cause significant harm to a relevant receptor, or to cause significant pollution to controlled waters.
Receptor	Something that could be adversely affected by a contaminant, for example a person, an organism, an ecosystem, property or controlled waters.
Pathway	A route or routes by which a receptor is or might be affected by a contaminant.

The term 'contaminant linkage' (CL) is used to describe the relationship between a particular 'contaminant-pathway-receptor' combination. All three elements of a CL would need to be present for a land contamination risk to exist.

The contaminant linkages from the desk-based review are compiled to form an 'outline' or 'initial' CSM. The CSM can then be used to inform the overall land contamination risk assessment process and to identify requirements for more detailed investigation. The CSM is subsequently refined or revised as more information and understanding is obtained.

5.2 Potential Contaminant Sources

Table 14 summarises the potential contaminant sources and/or potentially contaminative land-uses that have been identified on-site and/or in proximity to the Site, as part of the desk-based review.

Table 14: Potentially Contaminative Land-Uses

On-site	Off-site
- Old Sewage Works (marked on the historical maps of 1979 on the northern side of the railway line adjacent to the west site boundary) - Railway land bisecting the site - Made ground associated with potential infilled land, most notably, areas of the former canal (partially infilled) recorded as historic landfill. - Generic Industrial Tank (NE) and Slurry bed (NW) associated with waste disposal	- Railway line adjacent to southwestern boundary - Waste Landfill, Storage and disposal located to the west. - Made ground associated with infilled Land - Production and storage of Crude oil adjacent to the southern site boundary. - Sewage works proximal to the southern site boundary.

⁸ CLR11, Model Procedures for the Management of Land Contamination, Environment Agency, 2004

⁹ Environmental Protection Act 1990: Part 2A, Contaminated Land Statutory Guidance, Defra, 2012.

Table 14: Potentially Contaminative Land-Uses

On-site	Off-site
	- Engineering works (vehicle repair, testing and servicing) closest at 14m (W) - Sewage pumping station adjacent to Site boundary (NE)

Based on the potentially contaminative land-uses summarised above the following contaminants should be considered when compiling future geochemical laboratory analysis suites:

Heavy metals/metalloids (including but not limited to arsenic, cadmium, chromium vi, copper, lead, mercury, nickel, selenium, vanadium and zinc), asbestos, sulphate/sulphide, and hydrocarbons (including total petroleum hydrocarbons and polycyclic aromatic hydrocarbons). Analysis suites should also include supporting information/determinands including pH, total organic carbon and loss on ignition.

5.3 Potential Receptors

In line with Defra's Contaminated Land Statutory Guidance⁹, the following potential receptors have been identified with respect to the Site and the proposed end-use:

- Human health of the future end users;
- Human health of the site preparation and construction workers; and
- Controlled Waters, including local groundwater.

5.4 CSM and Risk Assessment

An initial CSM for the proposed development is presented as **Table 16**. The status of CLs included in the CSM should only be considered as 'potential' CLs until the possible sources identified can be investigated to establish their presence/absence and/or significance.

As part of this PRA, a qualitative risk assessment has been undertaken for each CL. The assessment considers the product of the 'severity of the consequence' and the 'probability of the likelihood' as detailed in the Risk Matrix below **Table 15**. The Risk Matrix is based on guidance within the CIRIA C552¹⁰ good practice guide. For ease of reference the resulting risk rating has been included in the CSM. The results of the qualitative risk assessment have been integrated into **Table 16**.

Table 15: Risk Matrix Key

Product probability x consequence		Consequence			
		Severe	Medium	Mild	Minor
Probability	High Likelihood	Very high risk	High risk	Moderate risk	Low risk
	Likely	High risk	Moderate risk	Low risk	Very low risk
	Low Likelihood	Moderate risk	Low risk	Low risk	Very low risk
	Unlikely	Low risk	Very low risk	Very low risk	Very low risk
	No Linkage	No risk			

¹⁰ CIRIA C552, Contaminated land risk assessment, A guide to good practice (CIRIA), 2001.

Table 16: Initial Conceptual Site Model and Preliminary Risk Assessment

Source(s)	Possible Pathway(s)	Receptor(s)	Probability	Consequence	Risk Level	Comments
Soil Contamination within the on-site soils. Including from Made ground or former site activities.	Ingestion, inhalation or dermal contact.	End users	Unlikely	Medium	Very low risk	Historical information indicates the presence of limited Made Ground in areas of potential infilled water and non-water features. However, the significant majority of the site has been used for arable agricultural land use with only limited areas formerly used for other activities. The risk from the identified historical land uses is likely to be low. Recommend: ground investigation including near surface soil sampling to enable the geochemical nature of these materials to be established and potential sources to be quantified and risk to be assessed.
		Site preparation workers	Unlikely	Medium	Very low risk	
Asbestos containing soils (ACS) from historical sewage treatment works, infilled areas, railway line in the vicinity	Inhalation	End users	Low likelihood	Medium	Low	Some limited areas of Made Ground may be present on site as a result of former infilling. While historical onsite activities do not suggest a significant likelihood of widespread ACM within the on-site soils, demolition of former structures that may have occupied the site and infilling of certain areas may give rise to potential localised presence of Asbestos within soils. Recommend: ground investigation included near surface soil samples to screen for asbestos in soils.
		Site preparation workers	Low likelihood	Medium	Low	
Ground gas potentially generated from infilled ground on site or from infilled areas and landfill waste sites within 250m of the site boundary.	Migration and accumulation into new buildings and indoor air	End users	Unlikely and Likely*	Medium	Low and Moderate*	All land to the north of the railway line is considered to be at low risk from ground gas as no onsite or offsite sources have been identified. Over 99% of the land to the south of the railway lies >500m from the Lidsey Landfill and none lies within 250m. 80% of this land lies >250m from recorded landfill activity. *20% of the land south of the railway dose however lie within 250m of areas of infilled canal marked on the historic landfill layer. The type of material used to infill the canal are not known and may comprise materials that give rise to elevated ground gas risk. Recommend: Undertake ground investigation to determine the presence of any onsite materials liable to generate ground gas with any significant methane or carbon dioxide. Install ground gas monitoring wells and undertake ground gas monitoring for development areas within 250m of the identified historical landfilled areas.
Soil Contamination Leaching to groundwater	Migration through the unsaturated zone	Underlying groundwater - Secondary A and Principal aquifer	Unlikely	Medium	Very low risk	A Secondary aquifer exists within the superficial deposits across most of the site which is underlain by unproductive strata of London Clay. The southernmost part of the site is underlain the Chalk Principal Aquifer. Given the lack of identified contaminative land uses on the site itself, the risk that the ground conditions could be causing identifiable deterioration in groundwater quality would appear to be low. Recommend: ground investigation to determine the geochemical nature surface soils and to observe the nature of shallow groundwater.
Migration of hydrocarbon contaminants into drinking water supply pipework:	Permeating through drinking water supply pipework and connections	End users	Unlikely	Medium	Very low risk	Significant hydrocarbon contamination is unlikely to be present below the site with the potential exception of very localised areas of unknown fuel or oil spillages. Hydrocarbons can permeate through plastic water main pipes and connectors into drinking water thus impacting the drinking water quality. Recommend: ground investigation to determine the geochemical nature of soils and groundwater below the site to determine the potential presence of organic contaminants and enable suitable water supply pipe material to be selected.

5.5 Preliminary Risk Assessment Summary

The PRA has identified five potential CLs for the Site for which only one has been assigned a 'moderate' initial risk rating, associated with the following:

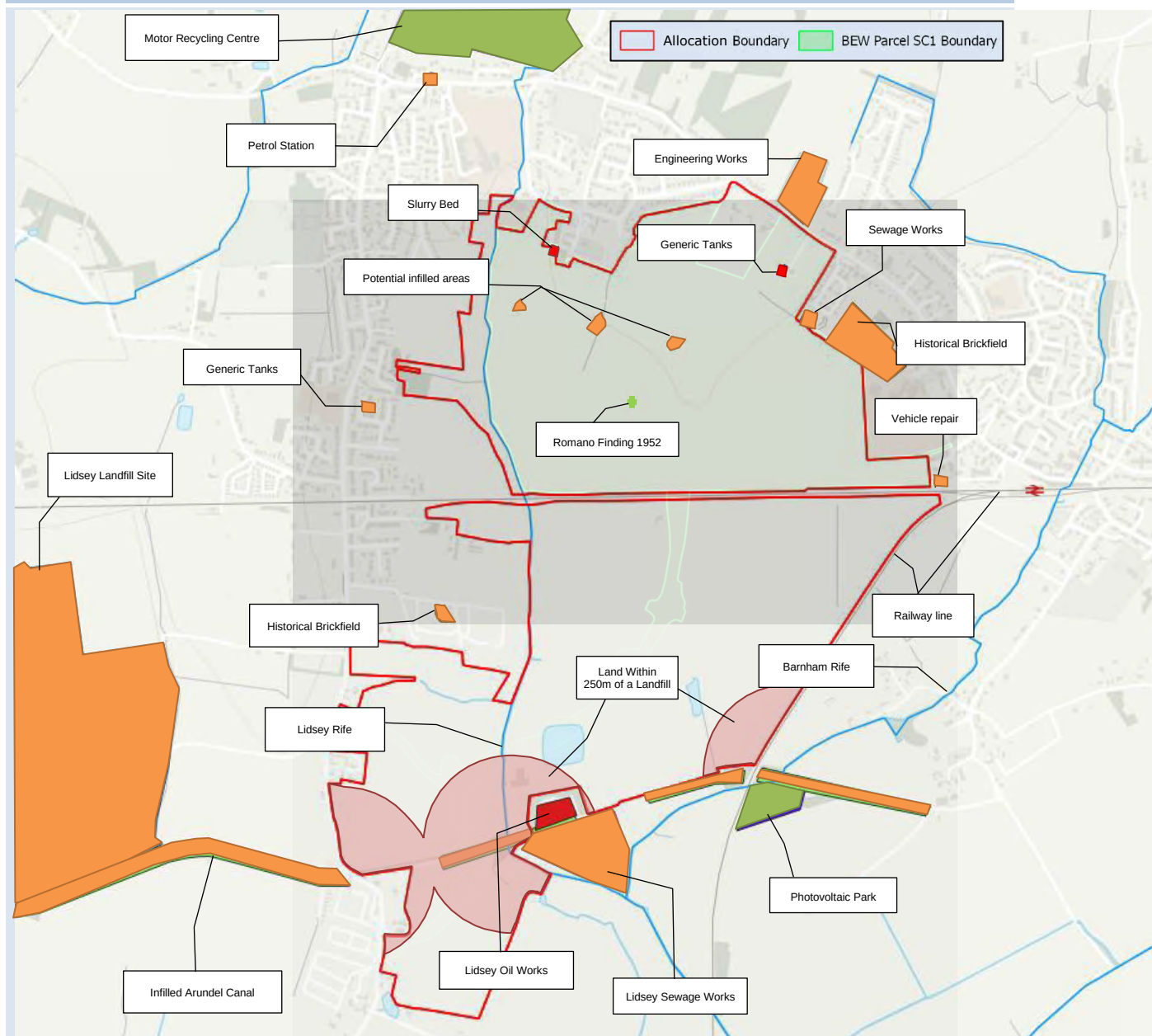
- Moderate risk of ground gas to end users.

The Moderate ground gas risk is only applicable to areas of the site within 250m of identified landfill features and is indicated in more detail within the following figure.

Based on the outcomes of the LCDS and the preliminary risk assessment, the pre-walkover constraints plan has been updated and included as **Figure 10**. The constraints plan uses a Red-Amber-Yellow-Green colour code graded from highest to lowest significant, respectively.

The former tanks located within the site are shown as 'red' land contamination constraints, however their purpose has not yet been determined.

Figure 10: Potential Environmental Constraints Map



Based on the PRA, it is considered highly unlikely that the Site would be classified as Contaminated Land under Part 2A of the Environmental Protection Act (EPA) 1990.

The PRA summarised above is based on the available data presented in this report and progressed using qualitative judgement only. Phase 2 Site Investigation and further risk assessment would be recommended to further evaluate the potential risks, to enable the CSM to be updated and to determine whether mitigation/remedial measure will be required.

6 Conclusions and Recommendations

6.1 Conclusions

In terms of land contamination risk the PRA has identified five *potential* CLs for the proposed development; none have been assigned a 'high' initial risk rating and only one a 'moderate' initial risk rating, associated with the following:

- Moderate risk of ground gas to end users. (specified areas of southern site only)

With respect to site workers (in the construction phase) the PRA has not identified potential CLs that have been assigned with 'high' or 'moderate' risk ratings.

Based on the PRA, it is considered highly unlikely that the Site would be classified as Contaminated Land under Part 2A of the Environmental Protection Act (EPA) 1990. The Council Searches Report (2019) confirms that the property is not on the Council's Contaminated Land Register.

As part of the Land Contamination Desk Study and PRA a land contamination constraints plan has been produced to guide and inform the design of future intrusive site investigation (ground investigation) and subsequent Phase 2 Land Contamination Generic Quantitative Risk Assessment (GQRA).

In terms of geotechnical risk for the Site, the main concerns are risks associated with excessive settlement, hydrostatic and soil heave pressures, aggressive ground and shallow groundwater conditions that have the potential to underlie the Site.

6.2 Recommendations for Further Work

Based on the above the following site investigation activities are recommended:

- Trial pits/window samples (to inspect ground conditions and allow collection of samples for geochemical analysis);
- Boreholes (to establish the strata below the site and determine geotechnical parameters for design derived from in situ and laboratory testing);
- Groundwater sampling and geochemical analysis (to provide data for generic quantitative risk assessment for controlled waters);
- Ground gas monitoring in localised areas of the Site; and
- Laboratory analysis of soil samples (for the purpose for generic human health risk assessment and additional pre-construction Waste Classification Assessment (WCA)).

The findings of a Phase 2 geotechnical and geoenvironmental investigation would generate engineering design parameters for the design of geotechnical elements and enable further land contamination risk assessment to be undertaken to further evaluate potential risks, enable the CSM to be updated and to determine whether mitigation/remedial measures will be required for the proposed redevelopment.

7 Uncertainties and Limitations

This report has been prepared by Pell Frischmann with reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the Client in accordance to the agreed scope of services.

This report has been prepared to provide pre-development geo-environmental recommendations for the BEW site. The report contents should only be used in that context and Pell Frischmann disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of the work.

The report details the findings of work carried out by Pell Frischmann during a study period from June to September 2020. The report has been prepared on the basis of available information obtained during that study period. Information provided by the referenced third parties has been used in good faith and is taken at face value; however, Pell Frischmann cannot guarantee its accuracy or completeness.

Although every reasonable effort has been made to gather all relevant information within the context of the agreed scope of work, all potential environmental constraints or liabilities associated with the site may not have been revealed. Should additional Information become available (including new legislation and changed practices), after the date of the report submission, Pell Frischmann reserves the right to reconsider the recommendations and alter the report accordingly.

Notwithstanding any site observations concerning the presence or otherwise of archaeological sites, asbestos-containing materials or invasive weeds such as Japanese knotweed, this report does not constitute a formal or specific survey of these potential development hazards. Unless otherwise stated, no assessment has been made for the presence of radioactive substances or unexploded ordnance.

Appendix A

Envirocheck Datasheets and Historic Maps