



The Environmental Protection Group Ltd



Piling risk assessment

Land east of Knowle Lane

Fair Oak

Version 1.0

April 2018

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Reference	EPG/8615/2018/PRA/V1	Version	1.0	Issue Date	April 2018
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1. INTRODUCTION

1.1 Purpose

Planning permission has been granted to Parsons Construction Limited (the Client) for a hybrid development on a site in Fair Oak, Eastleigh (planning permission reference F/17/80640). The northern part of the site is intended for combined low rise and high rise residential development, whilst the southern part of the site is intended for commercial development. The planning permission includes a condition relating to piling as follows:

Condition 6: Piling and other penetrative methods shall not be carried out other than with the written consent of the Local Planning Authority. The development shall be carried out in accordance with the approved details. Reason: to ensure that any proposed piling or penetrative method do not harm groundwater resources in line with paragraph 109 of the NPPF.

To contextualise the reason, paragraph 109 of the NPPF states:

'The planning system should contribute to and enhance the natural and local environment by.....preventing both new and existing development from contributing to or being put at unacceptable risk from, or being adversely affected by unacceptable levels of soil, air, water or noise pollution or land instability....'

As a statutory consultee, the Environment Agency commented on an application for discharge of condition 6 as follows:

The west of the site is located on the Whitecliff Sand Member which is designated a Secondary A Aquifer and the eastern part of the site is underlain by the London Clay, which is designated an unproductive aquifer. The site is not within a Source Protection Zone.

The site is located on the Knowle Lane historic landfill and immediately east of the Knowlehill Lane historic landfill. The Fair Oak Authorised Landfill (EPR/BK12441A) lies immediately south of the site. The Planning, Design and Access Statement states that part of the site is on a former licenced sand quarry but that the land has been restored following a agreed remediation scheme.....as this development lies above a former landfill and adjacent to existing and historic landfills there may be contaminated land present beneath the surface which could be mobilised during piling and pose a risk to groundwater during development.

No information has been submitted on the piling method to be used on site and the pollution prevention measures to be implemented to protect controlled waters, therefore we are not able to recommend the discharge of (condition 6).

The Environmental Protection Group Limited (EPG) has been appointed by the Client to produce a piling risk assessment in relation to the proposed development, to be submitted pursuant to discharge of condition 6. Due to its location within an area of widespread historic and recent landfilling activities, this will include a summary of historic uses of the site and its environs and current site conditions.

The piling risk assessment has been undertaken in accordance with guidance produced by the Environment Agency (EA), the Department of Environment, Food and Rural Affairs (DEFRA), and the National House Building Council (NHBC), namely:

- *Piling and penetrative ground improvement methods on land affected by contamination: guidance on pollution prevention* (NC/99/73, EA, 2001);
- *The model procedures for the management of land contamination* (CLR11, EA/DEFRA, 2004); and
- *Guidance for the safe development of housing on land affected by contamination* (R&D66, EA/NHBC, 2008).

The structure of this report is as required by the above guidance, which may be summarised as follows:

- Introduction to the environmental setting of the site;
- Summary of the conceptual ground model;
- Details of the proposed development and the selected foundation methodology;
- Identification of potential adverse environmental impacts;
- Site-specific assessment of the identified risks to the environment;
- Justification of foundation methodology selection and measures required to mitigate any associated risks, including quality assurance (QA) / quality control (QC) requirements.

1.2 Information sources

This report has been informed via the following sources of information:

- Reports provided by the Client and Eastleigh Borough Council as follows:
 - o *Report on site investigation at Knowle Lane, Fair Oak.* Structural Soils Limited, April 1998. Reference 71267 (relating to the BSKyB site);
 - o *Review of archival information, the Fair Oak landfill complex.* Landscan, May 2005;

- o *Environmental audit report.* Geo-Environmental Services Limited, June 2008. Reference GE6388;
 - o *Remediation method statement.* Geo-Environmental Services Limited, June 2008. Reference GE6388;
 - o *Validation report.* Geo-Environmental Services Limited, July 2008. Reference GE6388;
 - o *Exploratory hole logs and gas monitoring records.* Geo-Environmental Services Limited, May and June 2008;
 - o *Contamination assessment strategy.* Geo-Environmental Services Limited, June 2011. Reference GE8053/CAS;
 - o *Fair Oak landfill study – final interpretative report.* Card Geotechnics Limited, June 2012. Reference CG/5515 revision 1;
 - o *Supplementary investigation report.* Geo-Environmental Services Limited, August 2012. Reference GE8053/October12/SIR;
 - o *Ground gas assessment letter report.* Geo-Environmental Services Limited, March 2014. Reference GE8053/GR02/140325;
 - o *Factual report on a site investigation.* Albury S. I. Limited, November 2015. Reference 15/10569/KJC;
 - o *Due diligence site completion report.* Geo-Environmental Services Limited, August 2016. Reference GE15529/DDSCR/AUG16;
 - o *Desk study report for land east of Knowle Lane, Fair Oak.* Geo-Environmental Services Limited, January 2017. Reference GE10117-DSR-JAN17 version 1.0;
 - o *Preliminary gas and vapour risk assessment.* EPG, March 2017. Reference EPG/8615/2017/GRA/V1;
 - o *Ground investigation report.* Geo-Environmental Services Limited, October 2017. Reference GE16117-GIR-OCT17-V1.1
- Information relating to the adjacent closed licensed landfill, including recent boundary monitoring results. Provided by the Environment Agency, April 2017. Enquiry reference 170405 SSD41350;
 - Information relating to the adjacent BSKyB site, including recent boundary monitoring results. Provided by John Stremel, BSKyB Infrastructure Area Manager, July 2017. No document reference;

- Information relating to the burial of Japanese Knotweed on site. Provided by Eco Control Solutions, November 2017;
- Waste Acceptance Criteria analytical results for imported backfill material;
- Word of mouth records from the Client;
- Historic maps obtained from Landmark Information Group;
- British Geological Survey geological map: Southampton, England and Wales Sheet 315;
- Review of available web-based data resources, notably the Environment Agency's 'What's in your backyard?' service, and the British Geological Survey's Geology of Britain viewer and borehole scans;
- Spot and high frequency gas monitoring results, 2017; and
- Results of surface emissions survey, November 2017.

The historic information listed above has been presented in detail in the EPG report ***Detailed quantitative gas risk assessment***, January 2018, reference EPG/8615/2018/DQRA/V1, which has been submitted to the Local Planning Authority pursuant to partial discharge of conditions 11 and 12 of the planning permission. It is recommended that the detailed quantitative gas risk assessment (DQGRA) report is read in conjunction with this piling risk assessment, together with the ground investigation report (GESL, 2017) where details of soil analyses are presented.

2. ENVIRONMENTAL SETTING

The site is located in Fair Oak, approximately four miles to the east of Eastleigh. The location of the site is shown in Figure 1, with the area covered by this report and the planning permission bounded in green. The area intended for residential development is bounded in red.



Figure 1: Site location

The site is an irregular shape, comprising two roughly rectangular areas joined by a dogleg. The northern area comprises a closed and backfilled sand quarry sloping gently to the south. It is bounded to the north by a new residential development, to the east by open fields, to the south by commercial premises owned by the British Sky Broadcasting Group (BSkyB) and a closed engineered landfill, and to the west by Knowle Lane and the BSkyB site. Pedestrian and vehicular access is via a tarmac covered access road which enters the site off Knowle Lane in the southwest corner and extends along the southern boundary of the site before turning southeast at the dogleg. The southern area of the site has been in use as a carpark and office compound since purchase in 2008.

The site extends to approximately 2 Hectares and is approximately centered at National Grid Reference 450600 118520. The proposed hybrid development layout is illustrated in Figure 2, with the residential units represented in orange, and the commercial units in blue.



Figure 2: Proposed hybrid development layout

2.1 Current site layout

An engineer from EPG undertook a site walkover in November 2017 accompanied by the Client. The layout of the site at the time of the walkover is presented in Figure 3.

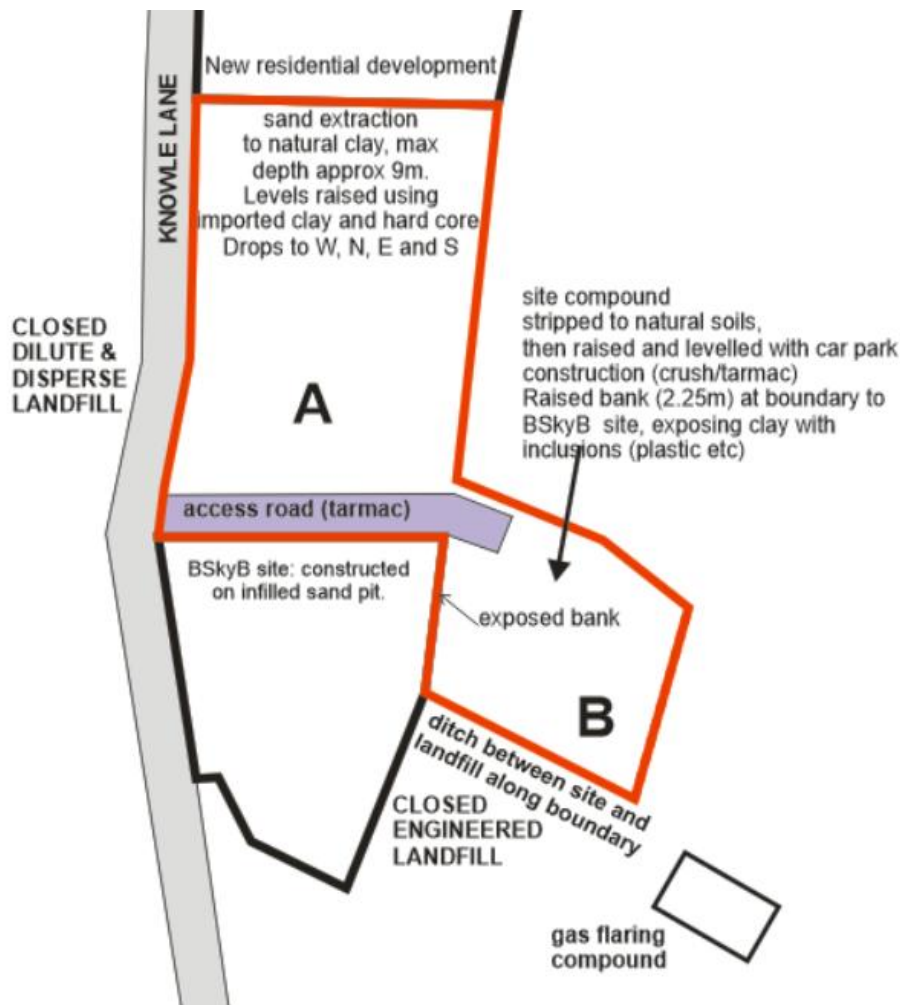


Figure 3: Site layout, November 2017

2.2 Natural geology

The 1:50,000 British Geological Survey geological map for Southampton (*England and Wales Sheet 315 solid and drift edition*, 1987) identifies bedrock comprising the London Clay Formation (LCF) across the site. No superficial deposits are shown in the area, however an element of the LCF in the form of the Whitecliff Sand Member is indicated to be present across the western part of the site. A cross section presented on the map sheet identifies that the overall dip of strata across the site is to the south west. The general distribution of the LCF elements and the cross section local to the site are presented in Figures 4 and 5 below.

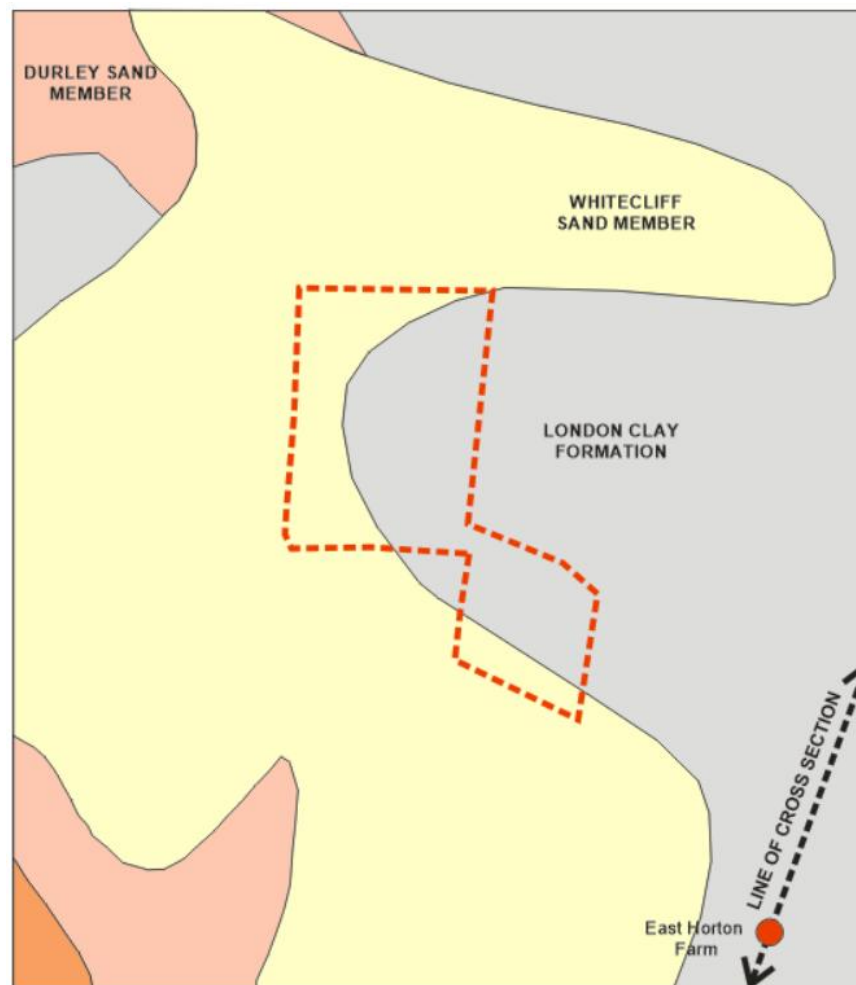


Figure 4: Geology local to the site, after BGS Sheet 315 solid and drift edition

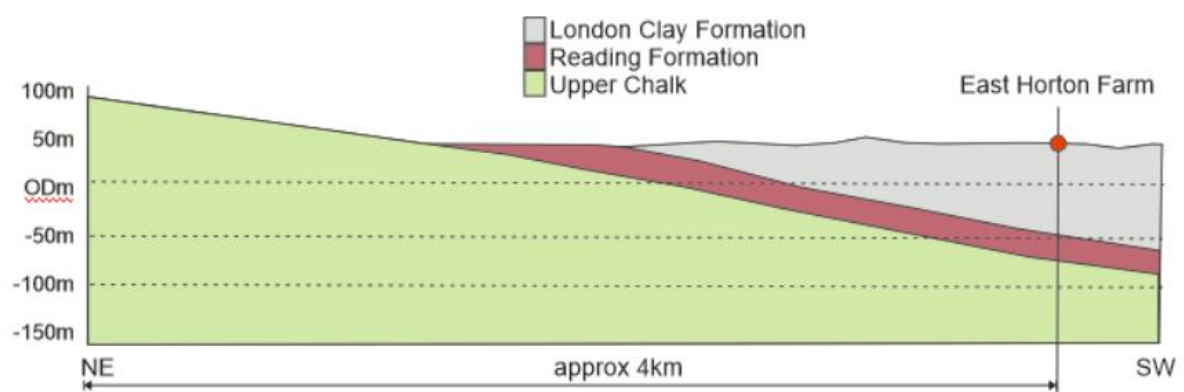


Figure 5: Geological section local to the site, after BGS Sheet 315 solid and drift edition (vertical exaggeration x4)

The Whitecliff Sand Member (WSM) is described as fine-grained sand occurring as lenticular bodies within the upper parts of the London Clay Formation as thin discontinuous beds and channels. Within the Southampton area, the London Clay Formation consists predominantly of interbedded silty sandy clay. Underlying the LCF at depth is the Reading Formation (clay, sand and pebbles) over the Upper Chalk. In the direct vicinity of the site, the Upper Chalk lies at >100m BGL.

2.3 Hydrogeology

The Whitecliff Sand Member is designated as a Secondary A Aquifer, whilst the main body of the London Clay Formation is designated an unproductive aquifer. The overall dip of bedrock strata across the site is to the southwest. Based on natural geology only, it is considered likely that the sandy elements of the LCF (such as the WSM) will contain groundwater perched upon the less- or non-permeable clay elements. The prevalent direction of flow of the perched waters will be locally dependant on the extent and dip of the underlying clay surface.

The history of sand extraction and landfilling across the area will have resulted in the local disruption of the groundwater regime. Groundwater/leachate within the adjacent dilute and disperse landfills will migrate predominantly to the southwest in line with the underlying dip in strata, however it is also likely to 'pool' within the waste.

2.4 Hydrology

The hydrology local to the site is summarised in the 2017 desk study report produced by Geo-Environmental Services Limited as follows:

No surface water features were observed on site. The nearest surface water feature identified was located approximately 68m south east of the site comprising a pond leading into a surface water drain. An issue leading into a surface water drain was also identified 150m west. Notwithstanding this, the site does include some run-off control, with sediment trap and collector ditch located along the eastern boundary (of Site B) and northern boundary (of Site C).

River quality data provided by the Environment Agency demonstrates that the Horton Heath Stream (Hamble Conference to Lower Upham) located 437m to the east was classified as *River Quality B – Good* in 2000.

The desk study identified seven licensed surface water abstractions within a radius of 1km of the site boundary and all associated with East Horton Golf Club used for spray irrigation. The closest was located 350m to the south east of the site.

The desk study identified two discharge consents to surface water within 500m of the site boundary:

- Sewage discharge, final/treated effluent into an unnamed drainage ditch, 198m north; and

- Sewage discharge, final/treated effluent into a freshwater stream/river, 350m south east.

One pollution incident to surface water was recorded within 500m of the site boundary:

- Sewage discharging into stream, category 3 minor incident, 308m south east.

2.5 Natura 2000 Sites and SSSI's

The site is not located in the proximity of a Natura 2000 site (<http://natura2000.eea.europa.eu/#>) or in the proximity of a RAMSAR or SSSI (DEFRA, Magic Map).

2.6 Site history

The history of the site and its environs in the context of this report is presented in detail in the DQGRA report (EPG, 2018), and is summarised below.

Historic records in the form of maps, plans, aerial photographs and regulatory records indicate that the site is located in an area of intensive historic sand extraction and landfilling as illustrated in Figure 6 below.

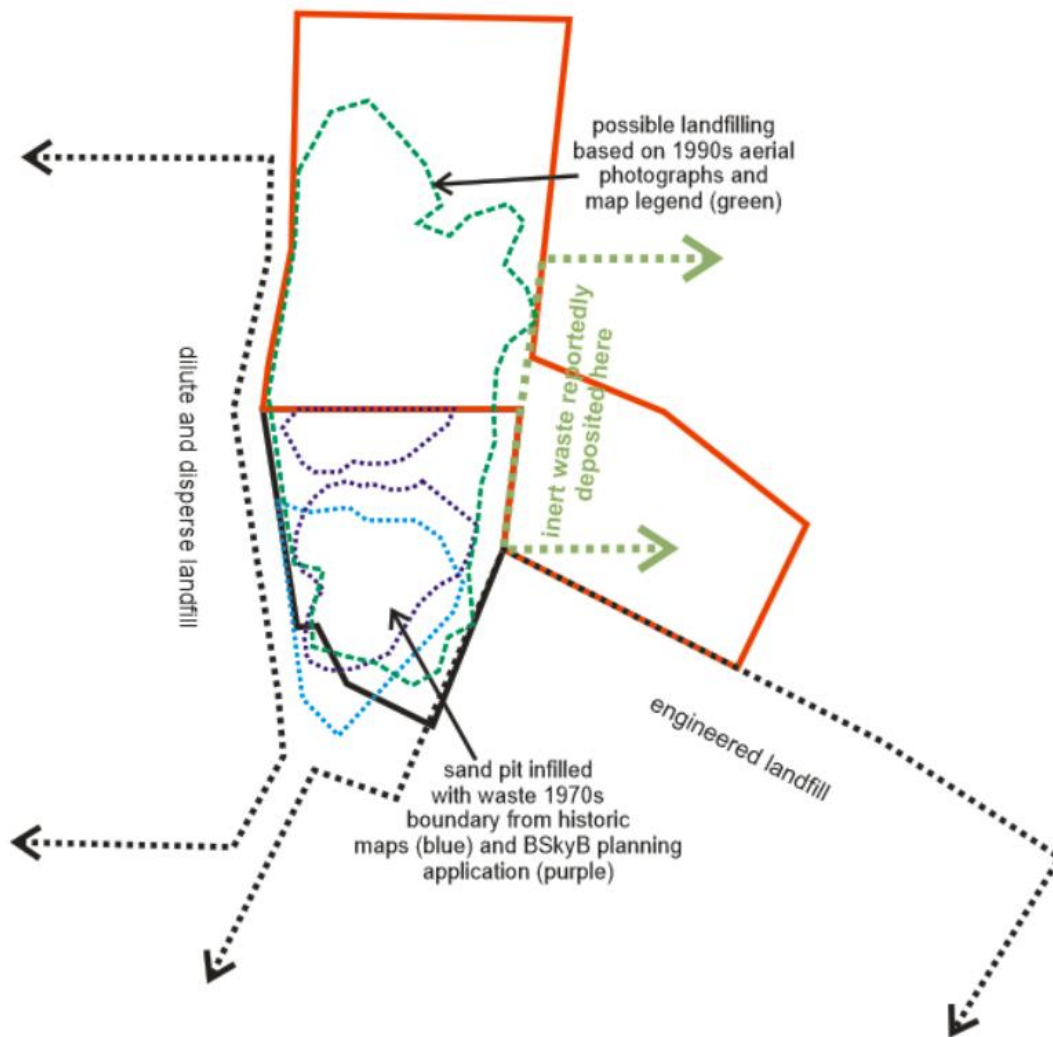


Figure 6: Approximate extent and location of landfilling as identified by historic records

Two separate areas of dilute and disperse landfilling outside the site boundary represent potential sources of historic gas/leachate in a position to impact the site via lateral migration. These are in the form of an aged dilute and disperse landfill to the west, and an infilled sand pit to the south/west, potentially extending beneath the site, and developed for commercial use c.2000. A more recent engineered landfill located at the southwest boundary of the site can be discounted as a potential source of gas/leachate due to its integrated gas extraction system and basal liner.

At the time of purchase by the Client in 2008, site investigation records identified that a large volume of waste was buried irregularly across the northern part of the site, some of which may have formed the northern extent of the infilled sand pit immediately to the south. The majority of the waste was removed as part of pre-development remedial works, with the exception of any residual material located beneath the access road. During these site clearance works; extensive sand deposits were identified beneath the site. Planning

permission was granted for the commercial extraction of the sand in the northern part of the site between 2012 and 2014.

In January 2014, an environmental permit was issued by the Environment Agency authorising the importation of inert waste for the restoration of the sand extraction pit. Between 2014 and 2016, inert predominantly clay material was imported and placed as backfill, together with natural site won overburden stockpiled on site throughout sand extraction works. During placement the infill materials were spread in thin layers and compacted using a 6-tonne sheep's foot roller. The surrender of the environmental permit was approved by the Environment Agency on the 19th February 2018. The southern area of the site has consistently been used as a site compound throughout this period, following removal of any made ground and the placement of inert carpark formation materials.

The extent of dilute and disperse landfilling in the direct vicinity of the site following completion of sand extraction and backfilling with inert imported material is depicted in Figure 7 below.

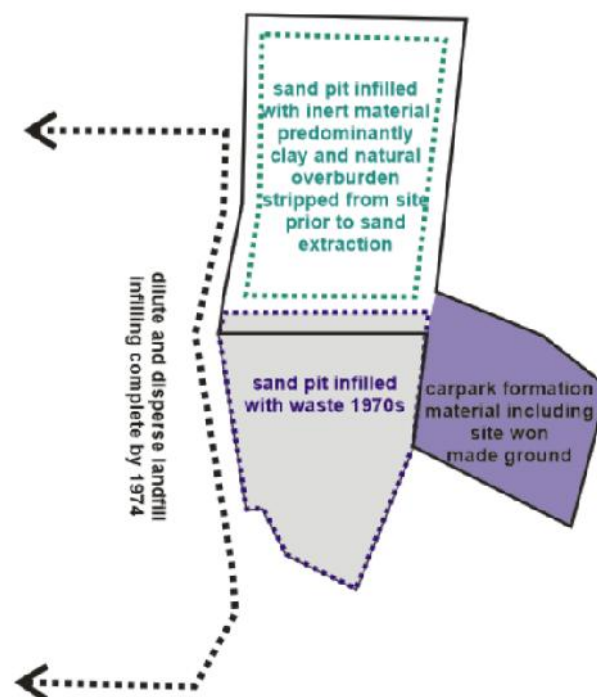


Figure 7: Current extent of dilute and disperse landfilling

In summary, it is evident that potential pollutant pathways may exist between the site and adjacent land parcels, and that the site cannot be considered in isolation from the areas of dilute and disperse landfilling within the Fair Oak landfill complex. Extensive areas of historic sand extraction and landfill are prevalent across the

area, and it must be concluded that they are in hydraulic and gaseous continuity despite being tipped at different times and with different waste composition. It is not considered that the inert backfill material imported to the northern part of the site represents a potential source of contamination, although there is the potential for some residual waste to be present beneath the current access road onto the site.

3. GROUND MODEL - NORTH

On completion of sand extraction across the northern part of the site, the excavation was backfilled using imported inert materials. This section summarises the available information detailing site conditions after backfilling, taken from the following source documents:

- *Factual report on a site investigation.* Albury S I Limited, November 2015;
- *Ground investigation report.* Geo-Environmental Services Limited, October 2017.

3.1 Summary of current ground conditions

A geotechnical investigation was undertaken in 2015 (during the later stages of infilling) by Albury S I, comprising six boreholes, and an additional investigation to identify current ground conditions was undertaken by GESL in 2017 on completion of infilling works. The approximate locations of the exploratory holes are indicated in Figure 8 below, and the ground conditions as described in the logs summarised within Table 2.

Ground conditions around the perimeter of the site have remained relatively unchanged during sand extraction and infilling works, and as such exploratory hole records from 2012 (GESL WS101 to WS108 inclusive) and 2010 (CGL G1 and G2) are included within this section to provide a fuller picture of ground conditions across the site. WS103, WS105, WS102 and WS108 remain as intact monitoring standpipes, although they have been renamed WS1, WS2, WS3 and WS4 respectively in gas monitoring results from 2017.

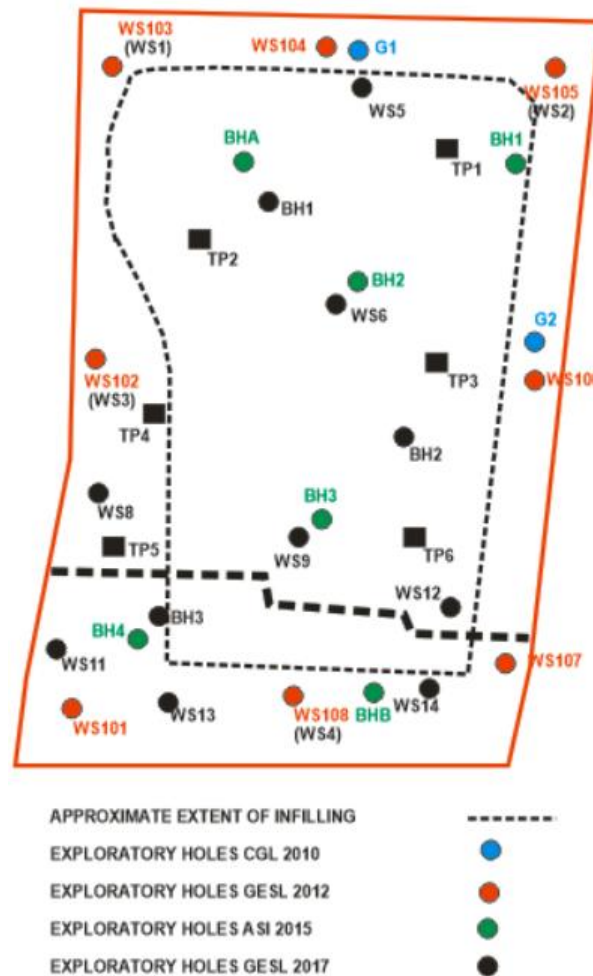


Figure 8: Approximate location of recent exploratory holes

Table 1: Summary of current ground conditions

Reference	Ground Conditions
G1-CGL 2010	GL-0.2: topsoil 0.2-0.7: brown sandy gravelly Clay (superficial) 0.7-4.4: Sand, varied clay content (WSM) 4.4-10.0 (end): sandy Clay (LCF) No groundwater encountered Standpipe installed, response zone 1.0m to 10.0m
G2-CGL 2010	GL-2.8: MG topsoil over grey brown clay with ash and brick 2.8-10.0 (end): sandy Clay (LCF) No groundwater encountered Standpipe installed, response zone 1.0m to 10.0m
WS101-GESL 2012	GL-0.65: MG brown fine sand 0.65-1.0: MG brown/grey very sandy clay 1.0-1.5: mottled brown sandy Silt/Clay 1.5-2.6: brown silty sandy Clay 2.6-5.0 (end): brown/grey silty sandy Clay, organic odour No groundwater encountered Standpipe installed, response zone 1.0m to 5.0m

Reference	Ground Conditions
WS102-GESL 2012	GL-0.6: MG brown gravelly fine sand 0.6-2.0: orange brown slightly gravelly fine Sand (WSM) 2.0-3.0 (end): brown and orange brown fine Sand (WSM) No groundwater encountered Standpipe installed, response zone 1.0m to 2.8m
WS103-GESL 2012	GL-0.2: MG brown sandy topsoil 0.2-0.7: MG brown gravelly clay 0.7-3.0 (end): orange brown fine Sand (WSM) No groundwater encountered Standpipe installed, response zone 1.0m to 2.8m
WS104-GESL 2012	GL-1.3: MG brown silty sandy clay 1.3-2.0: MG brown sandy topsoil with roots 2.0-2.7: MG brown fine sand with roots 2.7-5.0 (end): MG brown silty sandy clay with roots No groundwater encountered Standpipe installed, response zone 1.0m to 4.8m
WS105-GESL 2012	GL-0.2: MG brown fine sand 0.2-2.0: MG brown silty sandy slightly gravelly clay 2.0-4.0 (end): brown grey silty sandy Clay (LCF?) No groundwater encountered Standpipe installed, response zone 1.0m to 4.0m
WS106-GESL 2012	GL-1.5: MG brown silty sandy clay 1.5-5.0 (end): brown grey silty sandy Clay (LCF?) No groundwater encountered Standpipe installed, response zone 1.0m to 4.8m
WS107-GESL 2012	GL-1.3: MG black sand and gravel, including some brick 1.3-1.6: MG brown silty sandy clay 1.6-5.0 (end) brown grey silty sandy Clay (LCF?) No groundwater encountered Standpipe installed, response zone 1.0m to 4.8m
WS108-GESL 2012	GL-0.6: MG brown sand and gravel with brick and concrete 0.6-1.4: MG brown grey silty sandy slightly organic gravelly clay. Gravel includes brick and wood 1.4-5.0 (end): grey brown silty sandy Clay (LCF?) No groundwater encountered Standpipe installed, response zone 1.0m to 4.8m
BHA-ASI 2015	GL-2.1: MG brown grey sandy clay with gravel, brick and chalk particles 2.1-3.9: MG blue grey sandy clay with occasional gravel 3.9-6.8: MG brown grey sandy clay with gravel and brick particles 6.8-8.0: brown Sand with occasional clay pockets 8.0-9.0: brown very sandy Clay/very clayey Sand 9.0-10.0: blue-grey slightly clayey Sand with seams of clay 10.0-15.0 (end): blue grey very sandy Clay Groundwater seepage at 9.0m
BHB-ASI 2015	GL-0.4: MG brown sand 0.4-1.9: MG brown grey very sandy clay with gravel and brick 1.9-3.0: MG brown grey very sandy clay 3.0-4.1: MG brown sandy clay 4.1-7.0: MG blue grey very sandy clay (disturbed LCF?) 7.0-15.0 (end): blue grey very sandy Clay (LCF?) Groundwater seepage at 4.0m and 7.5m
BH1-ASI 2015	GL-1.6: MG brown very sandy clay with brick and chalk particles 1.6-5.0 (end): MG brown sandy clay No groundwater encountered
BH2-ASI 2015	GL-1.6: MG brown grey very sandy clay with gravel, brick and chalk particles 1.6-2.5: MG blue-grey organic sandy clay (LCF?) No groundwater encountered
BH3-ASI 2015	GL-1.6: MG brown grey sandy clay with gravel and brick particles 1.6-3.0 (end): MG brown sandy clay with chalk particles No groundwater encountered

Reference	Ground Conditions
BH4-ASI 2015	GL-1.6: MG brown grey very sandy clay with gravel and brick fragments 1.6-2.0 (end): MG brown sandy clay No groundwater encountered
TP1-GESL 2017	GL-1.8: MG orange brown sandy lay with some gravel of brick (including whole bricks), concrete, wood, clinker and flint, and rare tarmac and plastic 1.8-3.0 (end): MG orange brown sandy clay with some gravel of brick, concrete, flint, chalk and rare wood and plastic No groundwater encountered
TP2-GESL 2017	GL-2.0 (end): MG orange brown sandy clay with some gravel of brick and concrete and rare wood and plastic and rare flint and chalk No groundwater encountered
TP3-GESL 2017	GL-1.9: MG orange brown sandy clay with some gravel of brick concrete and flint and rare wood and chalk 1.9-3.0 (end): MG brown sandy clay and chalk fill with much gravel of chalk and rare gravel of brick, flint and concrete No groundwater encountered
TP4-GESL 2017	GL-1.1: MG orange brown sandy clay with some gravel of brick, concrete, flint and chalk, and rare wood 1.1-2.0 (end): MG orange brown sandy clay with some gravel of brick and rare flint, chalk and wood No groundwater encountered
TP5-GESL 2017	GL-2.3: MG orange brown sandy clay with some gravel of brick, concrete and clinker, and rare chalk and wood 2.3-3.0 (end): MG brown sandy clay and chalk fill with much gravel of chalk and rare gravel of brick, flint, concrete and wood No groundwater encountered
TP6-GESL 2017	GL-1.1: MG orange brown sandy clay with some gravel of brick and concrete and rare wood and chalk 1.1-2.0 (end): MG brown sandy clay and chalk fill with much gravel of chalk and rare brick flint and concrete and rare wood No groundwater encountered
BH1-GESL 2017	GL-1.5: MG clay and brick fill 1.5-2.4: MG brown clay fill 2.4-3.6: MG ash, brick and clay fill 3.6-7.5: MG brown clay fill 7.5-8.5: brown silty very sandy CLAY (WSM) 8.5-20.5: grey silty sandy CLAY (LCF) Groundwater strike at 8.5m rising to 8.0m after 20 minutes
BH2-GESL 2017	GL-1.8: MG clay and brick fill 1.8-2.9: MG brown sandy clay fill 2.9-4.8: MG grey clay and brick fill 4.8-7.1: orange brown and grey CLAY (WSM) 7.1-15.0 (end): grey silty sandy CLAY (LCF) Groundwater strike at 8.6m rising to 8.0m after 20 minutes
BH3-GESL 2017	GL-0.1: MG brick and stone fill 0.1-0.4: MG chalk fill 0.4-3.6: MG grey clay with brick fill 3.6-6.2: MG brown clay fill 6.2-7.1: brown silty SAND with bands of orange brown CLAY (WSM)) 7.1-20.5: grey silty CLAY with bands of grey sandy CLAY (LCF) Groundwater strike at 6.2m rising to 5.9m after 20 minutes
WS5-GESL 2017	GL-1.9: MG orange brown sandy clay with some gravel of brick and concrete and rare clinker, flint and wood and some fine rootlets 1.9-3.1: brown slightly clayey SAND with occasional rootlets (WSM) 3.1-5.0 (end): orange brown sandy CLAY with rare flint (LCF) No groundwater encountered Standpipe installed, response zone between 1.0m and 5.0m
WS6-GESL 2017	GL-1.8: MG orange brown sandy clay with some gravel of brick, concrete and flint and rare wood, chalk and clinker 1.8-3.9: MG orange brown sandy clay with some gravel of brick and rare flint and chalk 3.9-5.0 (end) MG dark grey clay with some gravel of chalk and flint No groundwater encountered Standpipe installed, response zone between 1.0m and 4.0m

Reference	Ground Conditions
WS8-GESL 2017	GL-0.3: MG brown sandy clay with some gravel of flint and brick and some rootlets 0.3-1.9: MG orange brown silty sand with some gravel of flint and rare brick 1.9-2.8: orange brown and yellow brown slightly clayey SAND (WSM) 2.8-4.5 (end): yellow brown and orange brown slightly silty SAND (WSM) No groundwater encountered Standpipe installed, response zone between 1.0m and 4.5m
WS9-GESL 2017	GL-1.2: MG dark grey sandy clay with some gravel of chalk, brick, concrete and flint 1.2-2.1: MG orange brown sandy clay with some gravel of chalk, brick and flint 2.1-5.0 (end): MG brown sandy clay with some gravel of chalk, flint and brick No groundwater encountered Standpipe installed, response zone between 1.0-5.0m
WS11-GESL 2017	GL-0.1: MG hardcore 0.1-0.3: MG chalk fill comprising orange brown sand and much chalk fragments with some gravel of brick, flint and clinker 0.3-1.0: MG yellow brown sandy clay with some gravel of brick, concrete and flint 1.0-3.75: MG yellow brown sandy clay with some gravel of brick, concrete, chalk, clinker and rare wood 3.75-5.0 (end): MG yellow brown clayey sand with rare gravel of brick No groundwater encountered Standpipe installed, response zone between 1.0m and 5.0m
WS12-GESL 2017	GL-1.1: MG orange brown sandy clay with some gravel of chalk, brick, flint and rare wood 1.1-3.4: MG dark grey sandy clay with some gravel of chalk, brick, concrete, clinker and flint 3.4-5.0 (end): orange brown and grey sandy CLAY (WSM) No groundwater encountered, response zone between 1.0m and 5.0m
WS13-GESL 2017	GL-0.1: MG hardcore 0.1-3.25: MG orange yellow brown sandy clay with some gravel of brick, concrete and flint and rare wood and plastic 3.25-5.0 (end): MG yellow brown clayey sand with rare gravel of brick No groundwater encountered Standpipe installed, response zone between 1.0m and 5.0m
WS14-GESL 2017	GL-0.1: MG hardcore 0.1-0.8: MG yellow brown sandy clay with some gravel of brick, concrete and flint and chalk and clinker and rare wood 0.8-1.5: MG yellow brown silty sand with some gravel of brick and clinker 1.5-2.6: MG brown sandy clay with some gravel of brick, tarmac and clinker and rare chalk 2.6-5.0 (end) orange brown clayey SAND (WSM) No groundwater encountered Standpipe installed, response zone between 1.0m and 5.0m
MG is Made Ground WSM is Whitecliff Sand Member LCF is London Clay Formation	

Ground conditions within the central area, where sand excavation and backfilling has occurred, show a significant thickness of made ground to a maximum proven depth of 7.5m recorded in GESL BH1. Made ground descriptions comprise a predominantly clayey matrix with limited anthropogenic material. This is consistent with it being inert fill or waste. There is some evidence that the infill material contains limited topsoil, with descriptions of organic clay, roots and rootlets (WS108-GESL, WS5-GESL and BH2-ASI). An organic odour was recorded in natural soils at some depth in WS101 adjacent to the site entrance. It should be noted that both WS108 and WS101 pre-date infilling, and as such the organic clay and organic odour are not related to imported infill materials. The Client advises that the full depth of the Whitecliff Sand Member was not excavated across the site, but that the excavation terminated around the depth where groundwater inflow occurred. This is supported by the recorded sand deposits underlaying the made ground in several exploratory holes.

3.2 Groundwater

Groundwater monitoring records from across the site are very variable, and the gradient cannot be accurately determined. It is considered likely that there is a high level of continuity throughout the perched/ groundwater bodies both on and off site.

3.3 Discussion

Following completion of sand extraction, the resultant excavation has been infilled using a combination of site-won overburden and imported inert material. The imported material has been robustly categorised throughout the importation period, and there are no indications that non-inert materials that represent a potential source of bulk gas or leachate generation or general contamination have been used as infill. A further consideration of exploratory hole records enables an approximate cross section to be developed across the centre of the site from north to south as illustrated in Figure 9.

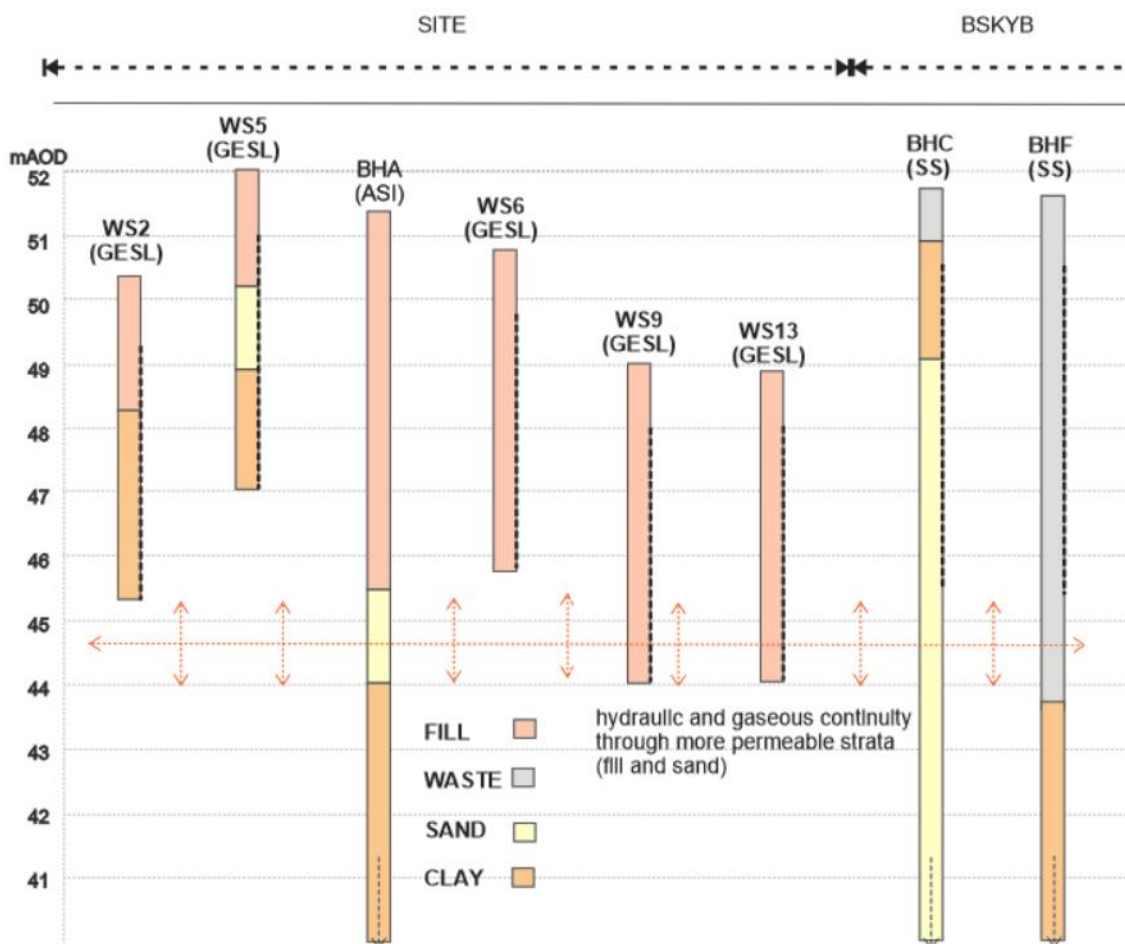


Figure 9: Approximate cross section north to south based on exploratory hole logs (NTS)

3.4 Ground gas

EPG's Detailed quantitative gas risk assessment (January 2018) was submitted to the Environment Agency as part of the permit surrender procedure. The report concludes that although gas is evident across the site it is considered, based on all the lines of evidence presented within the report, that the source is gases stored in dilute and disperse landfills adjacent to the site and is migrating in dissolved form via groundwater/leachate. The report recommends that the site is considered an Amber 1/CS2 classification, with a requirement for basic gas protection measures should any development proceed.

3.5 Soil contamination

Both the due diligence closure report (GESL, 2016) and the DQGRA (EPG, 2018) include details of the imported fill materials placed on site and conclude that no contaminated material has been introduced to the site. In addition, Geo-Environmental Services Limited produced a ground investigation report in October 2017 which included a generic quantitative risk assessment based on analytical results from twenty-seven soil samples. It is recommended that this report is referred to for a detailed description of the findings. The risk assessment included a consideration of various receptors in the form of human health, adjacent land users, and groundwater. The findings can be summarised as follows:

Human health: it is considered that remedial measures are unlikely to be required within areas of soft landscaping for the protection of end users from soil contamination.

Adjacent land users: it is concluded that the soils on this site pose no significant risk to surrounding residential land uses and no remediation measures are deemed necessary in respect of off-site migration of contaminants.

Groundwater: the report identifies that the site is underlain by a Secondary A Aquifer (in the form of the Whitecliff Sand Member) underlain by unproductive strata (in the form of the London Clay Formation) and is outside of any groundwater Source Protection Zone. It is concluded that no significant mobile contaminants were recorded during the investigation and as a result it is considered that the site presents a generally low risk to groundwater resources, and no remedial action in this regard is warranted.

It should be noted that there is the potential for residual waste material to be present beneath the site access road, which has not been explored or sampled.

3.6 Controlled waters

The Whitecliff Sand Member (WSM) is classified by the Environment Agency as a Secondary A Aquifer, underlain by the unproductive London Clay Formation. It has been identified above that the sand extraction activities did not extend to the full depth of the WSM across the site, and as such some of this more

permeable stratum will be present, although this is likely to be in the form of discontinuous elements. The Upper Chalk (designated as a Principal Aquifer) is present at a depth of >100m.

It is not considered that any of the surface water features identified in section 2.4 above could plausibly be impacted by any proposed piling works.

Groundwater monitoring results in standpipes installed across the site have identified that groundwater levels are extremely varied, which is indicative of highly variable permeability. Gas monitoring results suggest hydraulic continuity with dilute and disperse landfills beyond the site boundary.

3.7 Ground model

The information from sections 3.1 to 3.6 has been used to inform development of a ground model for the site. This is presented as Figure 10.

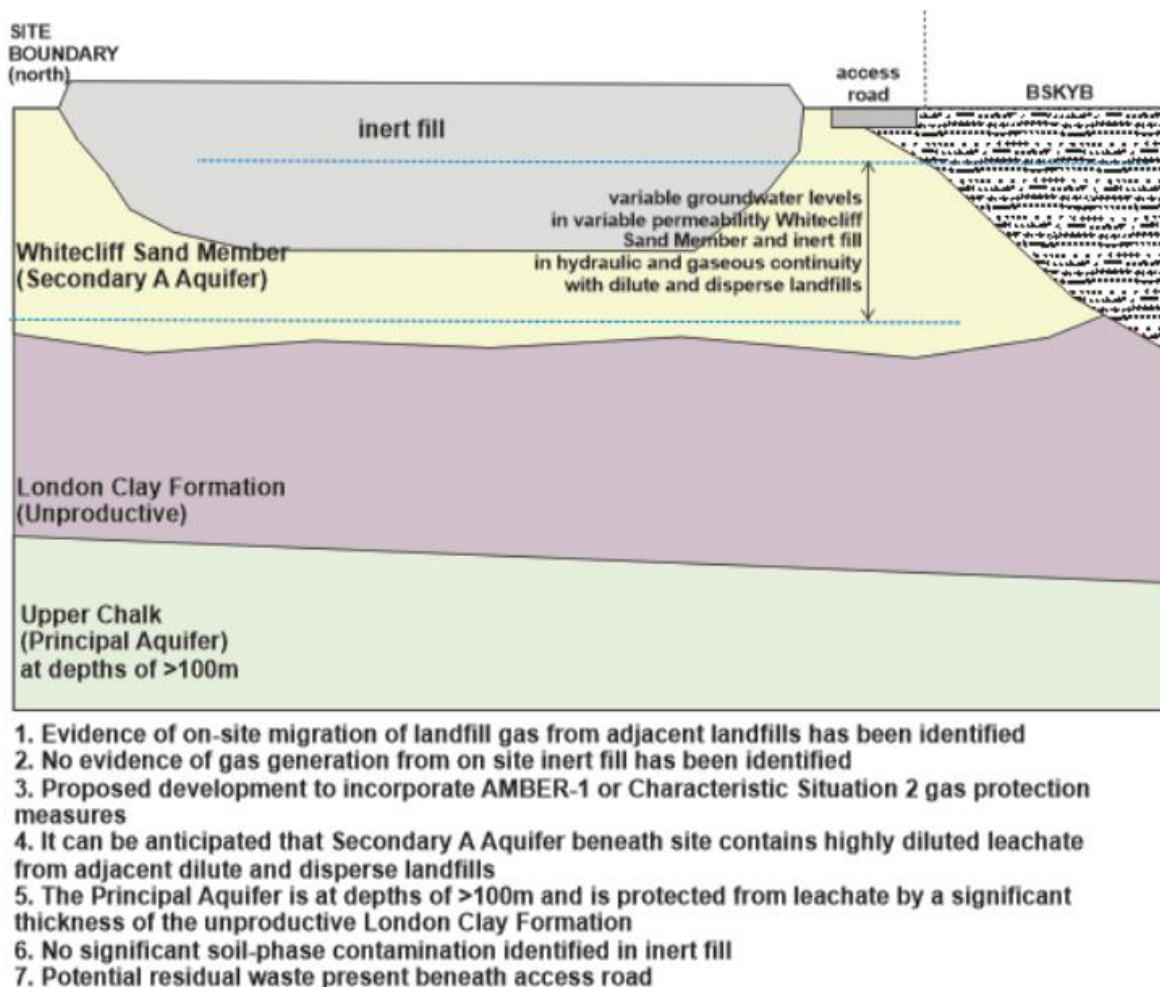


Figure 10: Ground model - North

4. GROUND MODEL - SOUTH

The southern part of the site has experienced significantly different past usages than the northern part, and as such current ground conditions are considered separately. This section summarises the available information detailing current site conditions, taken from the following source documents:

- *Factual report on a site investigation.* Albury S I Limited, November 2015; and
- *Ground investigation report.* Geo-Environmental Services Limited, October 2017.

4.1 Summary of current ground conditions

A geotechnical investigation was undertaken in 2015 by Albury S I, comprising two boreholes, and an additional investigation to identify current ground conditions was undertaken by GESL in 2017 comprising four boreholes. The approximate locations of the exploratory holes are indicated in Figure 10 below, and the ground conditions as described in the logs summarised within Table 3.

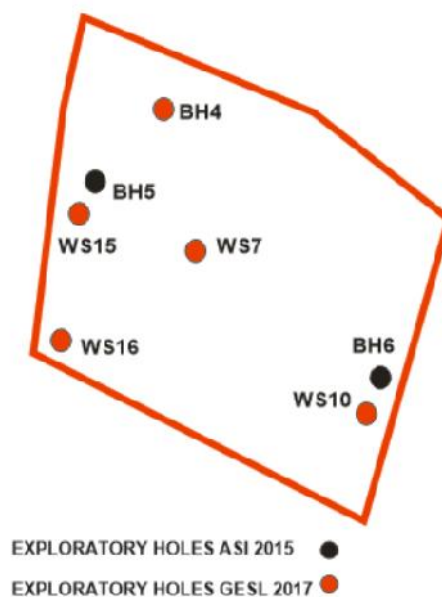


Figure 11: Approximate location of recent exploratory holes

Table 2: Summary of current ground conditions

Reference	Ground Conditions
BH5-ASI 2015	GL-1.6: MG brown grey very sandy clay with gravel and brick 1.6-4.5: MG brown sandy clay with black flecks of iron oxide and gravel 4.5-5.0: MG blue-grey organic sandy clay, oxidises to a brown colouration on exposure 5.0-5.5 (end): MG brown grey sand with pockets of clay No groundwater encountered
BH6-ASI 2015	GL-2.0 (end): MG brown grey very sandy clay with gravel and chalk particles No groundwater encountered
BH4-GESL 2017	GL-1.6: MG clay, stone, brick and concrete rubble fill 1.6-3.6: brown silty Clay (WSM) 3.6-4.8: brown silty sandy Clay (WSM) 4.8-15.0 (end): brown grey silty Clay (LCF) Groundwater strike at 1.4m, rising to 1.1m after 20 minutes
WS7-GESL 2017	GL-1.9: MG dark brown sandy clay with some gravel of brick, concrete, clinker, flint and rare chalk 1.9-4.2: orange brown grey mottled sandy Clay (WSM) 4.2-5.0 (end): orange brown and grey silty Sand (LCF) No groundwater encountered Standpipe installed, response zone between 1.0m and 5.0m
WS10-GESL 2017	GL-1.5: MG brown sandy clay with some gravel of chalk and flint and rare brick and concrete 1.5-4.0: orange brown grey mottled sandy Clay (WSM) 4.0-5.0 (end): dark grey sandy Clay (LCF) No groundwater encountered Standpipe installed, response zone between 1.0m and 5.0m
WS15-GESL 2017	GL-0.2: MG tarmac with hardcore sub base 0.2-0.4: MG brown sandy clay with some gravel of chalk, flint, brick and tarmac 0.4-0.6: MG brick rubble including whole bricks 0.6-1.1: MG brown sandy clay with some gravel of brick, concrete, clinker and flint 1.1-4.7: orange brown sandy Clay (WSM) 4.7-5.0 (end): grey brown sandy Clay (LCF) No groundwater encountered Standpipe installed, response zone between 1.0m and 5.0m
WS16-GESL 2017	GL-1.9: MG brown sandy clay and clayey sand with some gravel of brick, concrete, chalk, clinker and flint 1.9-3.9: orange brown clayey Sand (WSM) 3.9-5.0 (end): dark grey sandy Clay (LCF) No groundwater encountered Standpipe installed, response zone between 1.0m and 5.0m
MG is Made Ground WSM is Whitecliff Sand Member LCF is London Clay Formation	

Recorded ground conditions show made ground to be present across the site to a varied thickness, with a maximum thickness of 5.5m recorded in BH5-ASI. In the main, descriptions indicate that made ground comprises the compound formation layer of mixed hard core over sandy clay, although it should be noted that the description of material encountered in BH5-ASI below 1.6m is similar to the natural soils described across the site in other exploratory holes. None of the material identified represents a source of gross contamination.

The encountered natural soils comprise the Whitecliff Sand Member over the London Clay Formation.

Based on historic maps and aerial photographs, this area remained open agricultural land until purchased by the Client in 2008, although some indication of disturbed ground can be seen in the 1999 aerial photograph. Reportedly, arisings from the initial excavation of the large pond to the south of the compound were placed

across the area to create a semi-level platform. After purchase by the Client, the compound was reportedly stripped of any made ground to natural soils (to include reworked natural soils), and levelled, prior to placement of formation materials (including site-won inert made ground from both the northern part of the site and the compound area) and currently serves as a carpark and office compound. On the shared boundary with BSKyB, these works reduced final levels by approximately 2.25m, leaving a bank of exposed clay with inclusions of e.g. plastic, indicating that the infilled sandpit located within BSKyB extended across the boundary prior to these levelling works. The lack of such inclusions encountered within recent exploratory holes supports the Client's report of removal of all made ground prior to placement of formation materials.

4.2 Groundwater

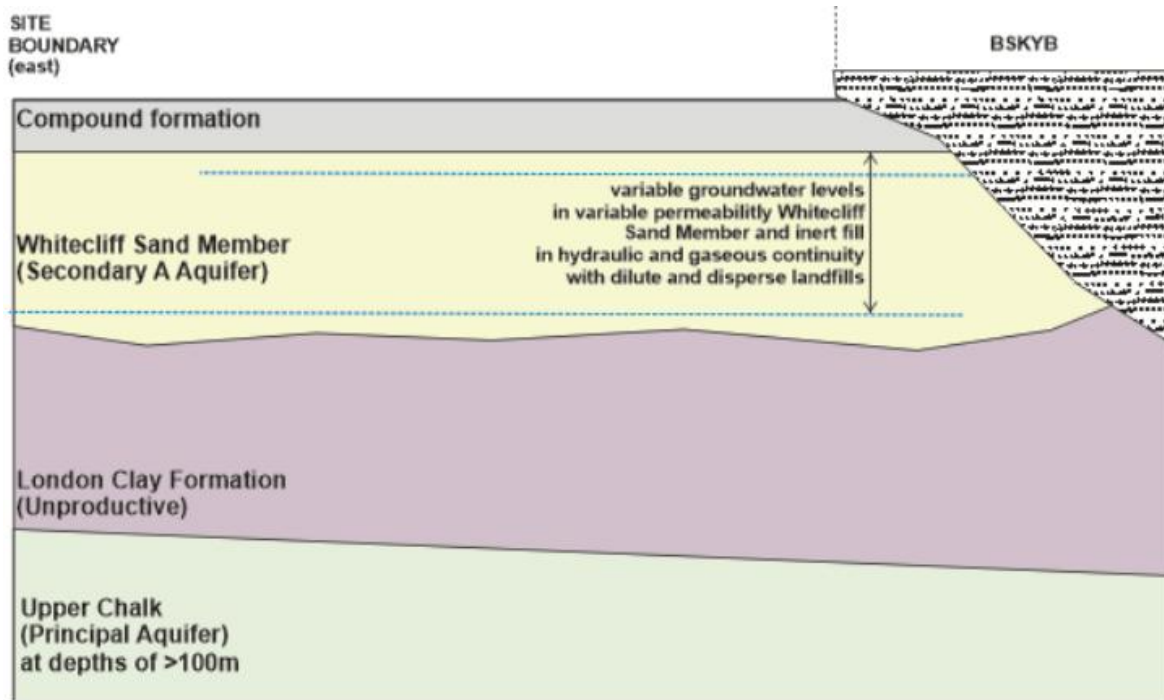
During site investigation, groundwater was only encountered in BH4-GESL, at a depth of 1.4m rising to 1.1m. Subsequent groundwater monitoring records within standpipes are variable, and a gradient cannot be accurately determined. It is considered likely that there is a high level of continuity throughout the perched/ groundwater bodies both on and off site.

4.3 Discussion

Details of ground gas, soil contamination and controlled waters is as above in Section 3.

4.4 Ground model

The information from sections 3.4 to 3.6 and 4.1 to 4.3 has been used to inform development of a ground model for the site. This is presented as Figure 11.



1. Evidence of on-site migration of landfill gas from adjacent landfills has been identified
2. Proposed development to incorporate AMBER-1 or Characteristic Situation 2 gas protection measures
3. It can be anticipated that Secondary A Aquifer beneath site contains highly diluted leachate from adjacent dilute and disperse landfills
4. The Principal Aquifer is at depths of >100m and is protected from leachate by a significant thickness of the unproductive London Clay Formation
5. No significant soil-phase contamination identified in inert fill

Figure 11: Ground model - South

5. RISK ASSESSMENT

The proposed development in the far north of the site will comprise up to 34 mixed low rise and high rise residential units with associated infrastructure. To the immediate north of the existing access road and across the southern site area it is proposed to construct office units with associated infrastructure. Due to the extremely variable ground conditions, a pile foundation strategy is required.

The Consulting Engineer (Cowan) has proposed utilisation of non-displacement piles, constructed via Continuous Flight Auger (CFA) techniques. The exact number and location of piles is not yet known, however it is anticipated that they will penetrate to a maximum of 25mBGL founding in the underlying London Clay Formation, and be typically 300mm diameter (maximum 400mm). It should be noted that no piling will be required in the location of the existing access road, where there is the potential for residual waste to be present.

EA Guidance (NC/99/73, 2001) details six generic pollution scenarios which may arise from the adoption of a piled foundation strategy. These scenarios have been considered in the context of the proposed development and the ground models presented above, and an estimated level of risk allocated as in Table 3 below.

Scenario	Source (S) Pathway (P) Receptor (R)		Risk allocation with mitigation measures applied as appropriate
Creation of preferential pathways through a low permeability layer to allow potential contamination of an aquifer	S	Contamination in higher layers	<u>Risk: Very low</u> 1. The Secondary A Aquifer (Whitecliff Sand Member) is already in direct hydraulic continuity with adjacent dilute and disperse landfills. As such, water quality will already be impacted. 2. No gross contamination has been identified in overlying soils. 3. The Principal Aquifer (Upper Chalk) is at >100mBGL in this area. 4. The proposed piling method (CFA) is a non-displacement method. As such, any disturbance to the ground is minimal and there should be no formation of preferential pathways as the concrete is cast in intimate contact with the surrounding soils.
	P	Pile/soil interface	
	R	Secondary A and Principal Aquifer	
Creation of preferential pathways through a low permeability surface layer to allow migration of landfill gas, soil gas or vapours to surface	S	Gas/Vapours	<u>Risk: Low (with mitigation)</u> 1. The inert fill has not been capped and as such there is no low permeability surface layer to be penetrated by piling 2. The proposed piling method (CFA) is a non-displacement method. As such, any disturbance to the ground is minimal and there should be no formation of preferential pathways as the concrete is cast in intimate contact with the surrounding soils. 3. Gas protection measures in accordance with NHBC AMBER-1 traffic light (low rise residential) or CIRIA Characteristic Situation 2 (high rise residential/commercial) will be incorporated into all buildings as specified within the detailed quantitative gas risk assessment (EPG, 2018) 4. No vapours have been identified within underlying soils
	P	Pile/soil interface	
	R	Buildings, construction workers, end users	

Scenario	Source (S) Pathway (P) Receptor (R)		Risk allocation with mitigation measures applied as appropriate
Direct contact of site workers and others with contaminated soil arisings that have been brought to the surface	S	Contaminated soils	Risk: Low 1. There is no evidence of contamination within the inert imported fill materials. 2. The potential for direct contact with arisings is noted. These risks are irrespective of the foundation type adopted as even traditional shallow foundations can result in direct contact pathways.
	P	Direct contact/ inhalation/ingestion of dust	
	R	Construction workers /third parties	
Direct contact of piles or engineered structures with contaminated soil or leachate causing degradation of pile materials	S	Contaminants in soils or groundwater	Risk: Low (with mitigation) 1. Below ground concrete will be designed to appropriate design sulphate (DS) and aggressive concrete environment classification (ACEC) based on site specific soil and groundwater analysis
	P	Direct contact	
	R	Below ground structures e.g. piles	
The driving of solid contaminants down into an aquifer during pile driving	S	Contaminated soils	Risk: Very low 1. The proposed piling method (CFA) is a non-displacement method which does not typically result in soil being driven downwards 2. There is no evidence of contamination within the inert imported fill materials
	P	Pile/source interface	
	R	Secondary A and Principal aquifers	
Contamination of groundwater, and subsequently, surface waters by wet concrete, cement paste or grout	S	Construction materials	Risk: Low (with mitigation) 1. The underlying Whitecliff Sand Member (Secondary A aquifer) which will be penetrated by the piles is located within an area of extensive dilute and disperse landfilling. As such it can be anticipated that the water quality is low 2. The Whitecliff Sand Member comprises sands with varied clay and/or silt content and groundwater flow is likely to be intergranular rather than by fracture flow. As such, migration of piling cement into the aquifer matrix is likely to be minimal providing that an appropriate mix has been used 3. The deeper Principal Aquifer will not be penetrated by the piles 4. An appropriate mix of concrete will be specified to prevent 'bleeding'
	P	Migration via permeable strata	
	R	Controlled waters	

The Secondary A aquifer underlying the site will not be adversely affected by piling, due in part to the fact it is already in hydraulic continuity with two dilute and disperse landfills and the absence of contamination in the fill materials through which the piles will be drilled. The deeper Principal A aquifer will not be adversely affected as it will be protected by a significant thickness of the unproductive London Clay Formation. No contamination has been identified within made ground across the site, and as such arisings should not represent a potential risk to human health. In conclusion, the risks of pollution occurring via the identified pollutant linkages can be considered low to very low.

6. CONCLUSIONS

In summary, the piling risk assessment has demonstrated that risks associated with the adoption of a non-displacement (bored, CFA) pile on the site are likely to be low. However, some important mitigation requirements have been highlighted by the assessment, which may be summarised as follows:

- Amber-2 gas protection measures are required for all proposed low rise residential dwellings;
- Characteristic situation 2 gas protection measures are required for all proposed high rise residential and commercial buildings;
- Appropriate working practices are to be implemented during the construction phase, e.g. adopt good levels of hygiene, minimise dust etc.;
- Appropriate Personnel Protective Equipment (PPE) is to be utilised;
- All arisings are to be managed in accordance with current UK waste management regulations;
- A concrete mix reflective of the prevailing ground and groundwater conditions is to be specified; and
- An appropriate mix of concrete is to be specified in order to prevent 'bleeding'.

In addition to the above, the following design/quality assurance/quality control requirements should be adhered to:

- During the drilling phase of each pile the depth of auger, speed of rotation and penetration rate are to be closely monitored and recorded. *Aim – To avoid undue disturbance of surrounding soils during construction process.*
- During the concreting phase of each pile the concrete pressure and rate of pumping is to be closely monitored and recorded. *Aim – To ensure that the intruded material is placed under pressure at a constant rate, consistent with that of the withdrawal of the auger, thus ensuring that the hole is supported at all times.*
- Piles are not permitted to interfere with each other, i.e. a minimum spacing of three pile diameters must be maintained between each pile constructed.
- No pile groups are permitted.

- A watching brief is to be maintained during the site piling activities. If any visual and/or olfactory evidence of contamination is observed this is to be reported immediately to the Consulting Engineer.
- Records are to be maintained which demonstrate that the design specification concrete mix was utilised, i.e. to prevent any degradation of the pile material and prevent 'bleeding' into the Secondary A aquifer of the Whitecliff Sand Member.

This report should be submitted to Eastleigh Borough Council together with the Detailed quantitative gas risk assessment (EPG, 2018) and the Ground investigation report (GESL, 2017), pursuant to discharge of condition 6.

