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# **STATION HILL, PHASE 2 FOUNDATION WORKS RISK ASSESSMENT**

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|               |                                         |
|---------------|-----------------------------------------|
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# 1. INTRODUCTION

## 1.1 Brief

Ramboll UK Limited (hereafter referred to as Ramboll) has been instructed by Lincoln MGT (the Client) to prepare a Foundation Works Risk Assessment (FWRA) for Phase 2 of the development at Station Hill, Reading, RG1 1NR.

This document outlines the potential risks to controlled waters (groundwater) in the Chalk aquifer from piled foundations, which may be needed at the site. The information outlined in this document is to be considered in the context of the structural, civil, and geotechnical schemes and designs.

This risk assessment should be considered by the piling contractor in determining the final proposed piling scheme method and designs. The contractor will be responsible for the final specification of the piling methods and protocols.

## 1.2 Planning Context

Reading Borough Council has granted full Planning Permission for the proposed development subject to the conditions outlined in Planning Application Number 192032.

This foundation works risk assessment (FWRA) report has been prepared in response to Planning Condition 12, which states:

*"(PCD) No development within the Phase 2 site (except demolition) shall be commenced until a method statement for the foundation design for all buildings within the Phase 2 site has been submitted to and approved in writing by the Local Planning Authority. The foundation works shall thereafter only be carried out in accordance with the agreed method statement, save to the extent that the Local Planning Authority approves any variation(s) to the approved statement.*

## 1.3 Proposed Development

The proposed development will comprise a new mixed-use residential and commercial town quarter realm that will include approximately 538 new homes and circa 25,000 sq. ft of commercial and leisure space.

The North Site comprises two phases of development: Phase 2 and Phase 3. The North Site area is approximately 1.43 ha; Phase 2 covers 0.66ha and Phase 3 covers 0.77ha.

Phase 2 comprises:

- Block G in the east (commercial).

Phase 3 comprises:

- Block A in the west (residential).
- Block B and D in the south west (residential), and,
- Block C in the north (commercial).

This report covers Phase 2 only, shown in red on Figure 1. The Phase 2 development comprises Block G, an eighteen-storey office building with flexible retail use at ground floor, vehicular access

and parking, surrounded by public realm and landscaping and a bridge link over Garrard Street to the south.

The Block G building within Phase 2 does not include a basement and is to align with existing ground level along the majority of peripheries of the site. However, along the northern periphery, at the interface with Station Hill Road, the proposed formation level is approximately 2.5m below existing ground level and therefore a retaining structure is required. The proposed substructure is anticipated to comprise piled foundations and a sheet piled retaining wall.

In 2021, the site boundary for the former temporary events area at the north of Phase 2 was extended to include an additional strip of land, utilised as public realm, to allow for obstructions to be removed prior to piling works commencing.



**Figure 1:** Proposed Development Phases (Source: MGT)

## 1.4 Previous Reports

Ramboll completed a Ground Investigation Report for the Station Hill, Reading, North Site development in August 2019 (ref: SHR-RAM-NB-XX-RP-G-000022). This report provides full details of the site description, previous reports, nature of historical land uses, geotechnical parameters and contamination identified at the site, as well as land contamination risk assessments.

## 1.5 Limitations

This document has been prepared for use by Lincoln MGT. This report summarises information provided from a number of external sources and cannot offer any guarantees or warranties for the completeness or accuracy of information relied upon.

The proposed risk management strategies and recommendations summarised in this report relate to details of the proposed development at the time of writing the report. Any substantial changes to the proposed design may require a reassessment of the environmental risks identified.

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## 2. SITE DESCRIPTION

### 2.1 Site Location

Phase 2 of the Station Hill Site is located in central Reading at RG1 1NR, immediately southwest of Reading train station. The Station Hill development is centred on National Grid Reference 471370, 173710.

### 2.2 Site Surrounds

The site is bounded by:

- Station Hill road to the north;
- Thames Tower to the east;
- Garrard Street and Station Hill Phase 1 to the south; and
- Greyfriars Road and Station Hill Phase 3 to the west.

### 2.3 Site Description

The Station Hill North Site formerly comprised four main buildings: an office building in the west, a bingo hall and adjacent bus station in the centre, Western Tower in the north east and an NCP multi-storey car park in the south east. The former bingo hall, bus station and Western Tower were situated within Phase 3 of the development and were demolished prior to Ramboll's 2019 ground investigation.

The NCP car park, located in the south of Phase 2, is being demolished at the time of writing, pursuant to Prior Approval ref. 182168, as amended in June 2021.

Electricity substations are present in the north west corner of the site, to the north of Xafinity House, and in the south adjacent to Garrard Street. A temporary radio mast is also present.

**Table 2.1 Site Setting**

|                   | Discussion                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Topography</b> | The topography of the site is relatively flat with a slight slope down to the south and varies between approximately 39 m above ordnance datum (AOD) at Garrard Street in the south and 40.80 m AOD at Station Hill in the north.                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Geology</b>    | <p>The Made Ground is underlain by the superficial deposits of Alluvium and Taplow Gravel formation. The Alluvium comprises slightly sandy clay with occasional gravel of flint. The Alluvium is discontinuous across the site and is predominantly in the northern extent of the site, to depths of up to 6.6 m bgl.</p> <p>The Taplow Gravel Formation is observed in the majority of exploratory locations across the site, to depth of up to 9.00 m bgl.</p> <p>The superficial deposits are underlain by the solid bedrock geology of the Upper Chalk Formation, comprising structureless chalk to depths up to 18.0 m bgl, underlain by structured chalk at depth (depth of which is unproven).</p> |
| <b>Hydrology</b>  | The nearest surface water feature is a drainage network approximately 315 m north east of the site, associated with the railway line.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

|                     | Discussion                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                     | <p>The easterly flowing River Thames, at its closest point, lies 370 m north east of the site.</p> <p>The River Kennett is located approximately 500 m south east of the site and also flows in an easterly direction where it connects to the River Thames approximately 1km east of the site.</p> <p>Overall, the site is considered to be of low environmental vulnerability in terms of surface water receptors.</p>                                   |
| <b>Hydrogeology</b> | <p>According to the Environment Agency (EA) the Made Ground is classed as unproductive strata. The underlying superficial deposits comprising Alluvium and the Taplow Gravel Formation are classified as Secondary A Aquifers; the underlying bedrock geology comprising the Upper Chalk is classified as a Principal Aquifer.</p> <p>Overall, the site is considered to be of moderate environmental vulnerability in terms of groundwater resources.</p> |

## 2.4 Underground Services

A high density of utility services exist in and around the site beneath Greyfriars Road and Garrard Street. Local service connections and other local services such as CCTV, fibre-optic also exist surrounding the site.

A 1,250 mm diameter Thames Water brick foul sewer runs west to east beneath Phase 2 at a depth of approximately 4 m bgl, with three 225 mm diameter sewers branching off, as seen in Figure 2 below. Protection zones associated with Thames Water tunnel asset may limit the location, proximity, and construction methods of foundations. Pre- and Post- construction condition surveys may be required, along with monitoring and inspections during the site development. Impact Assessments may also be required by Thames Water to demonstrate the effect of demolition and construction activities associated with the proposed development.

An unknown buried service was encountered in the centre of the site during the ground investigation (in TP208) running east to west, to the north of the Thames Water sewer, at an approximate depth of 2.20 m bgl. Further unknown buried services beneath the site which could present an obstruction to foundation excavations while also presenting a health and safety risk to site workers.

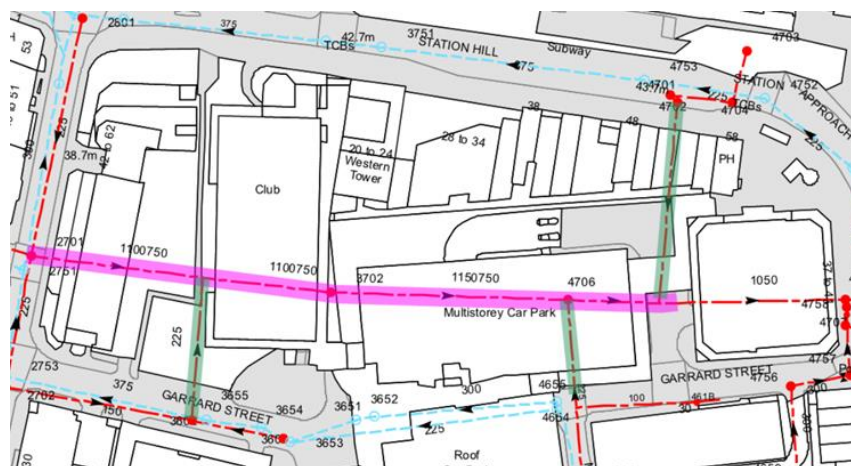


**Figure 2:** *Location of Thames Water Sewer beneath former buildings (Source: Hoare Lea Thames Water Note)*

## **2.5 Site Constraints**

The key site constraints for Phase 2 are:

- foundation obstructions relating to the former buildings;
- Thames Water foul sewer running east to west under the site;
- utilities running under the site;
- cut and fill balance;
- boundary/third party wall perimeter interfaces, particularly in the north and east, and
- busy, public roads on Station Hill and Garrard Street in the north and south.

## **2.6 Proposed Construction Activities**

The construction activities to be undertaken as part of the proposed Phase 2 development are as follows:

- reduction of Made Ground and levels along northern periphery in line with ground level in the south (reduced levels to formation level in former Temporary Events Area complete at time of writing);
- demolition of NCP car park and excavation of existing foundations (ongoing at time of writing);
- decommissioning of deep boreholes into the Chalk aquifer;
- new retaining walls;
- placement of piling mat;
- installation of building piles;
- excavation of soils/pile mat and cutting back of piles down to slab formation level;
- construction of pile caps and pile beams;
- construction of suspended reinforced concrete slab, and
- construction of proposed superstructure and infrastructure connections.

### 3. GROUND MODEL

#### 3.1 Ground Conditions

A summary of the geology encountered across the North Site during the ground investigation undertaken between 8<sup>th</sup> May and 18<sup>th</sup> June 2019 by Geotechnical Engineering Limited (GEL) on behalf of Ramboll, is provided in Table 3.1 below.

Further detail on the ground conditions can be found in the following reports:

- Ramboll, August 2019, *Ground Investigation Report, Station Hill, North Site, Reading*, Ref: 1620004761-SHR-RAM-NB-XX-RP-G-000022); and,
- Geotechnical Engineering Limited, July 2019, *Factual Report on Ground Investigation, Station Hill, North Site, Reading*, Ref: 35248.

**Table 3.1 Sequence of Strata Encountered**

| Strata                | Depth Range (m bgl) | Thickness Range (m) | Typical Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-----------------------|---------------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Made Ground</b>    | 0.0 – 6.0           | 0.0 – 6.0           | <p>Excavations to formation level are almost complete in the former Temporary Events Area in the north of Phase 2.</p> <p>Asphalt surfacing and concrete around the multistorey car park in the south of Phase 2.</p> <p>Concrete was encountered in several exploratory hole locations beneath the 6F2 in the west of the site, which may represent previous foundations relating to demolished building structures.</p>                                                                                                                                                                                                                          |
| <b>Alluvium</b>       | 1.9 – 6.6           | 0.6 – 1.7           | <p>The Alluvium is discontinuous across the site with the Alluvium only being encountered in four exploratory hole locations with an average thickness of 1.0 m, typically from around 2 to 3 m bgl.</p> <p>The Alluvium is generally described as greyish green mottled brown slightly sand silty CLAY gravel being subangular to rounded fine to coarse flint and chalk.</p> <p>A soft, grey strata at approximately 2.3 m bgl in the centre and north of the site recorded strong organic odours. It is considered that this layer of the top of the alluvium may relate to the former depression shown on the site on the historical maps.</p> |
| <b>Taplow Gravels</b> | 3.0 – 8.15          | 1.1 – 4.9           | <p>The Taplow Gravels were encountered in eight exploratory hole locations with an average thickness of 4.1 m from approximately 3.6 m to 7.7 m bgl.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

| Strata                             | Depth Range (m bgl) | Thickness Range (m) | Typical Description                                                                                                                                                                                                                                                                                                                                    |
|------------------------------------|---------------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                    |                     |                     | The Taplow Gravels encountered were typically medium dense orangish brown very gravelly SAND. Gravel is typically subrounded to angular with rare coarse flint, chalk and sandstone GRAVEL.                                                                                                                                                            |
| <b>Upper Chalk (Structureless)</b> | 4.3 – 15.5          | 0.35 – 11.20        | The structureless chalk was only encountered in the five boreholes and has a CIRIA probably grade Dm or Dc. It typically comprised structureless CHALK composed of white slightly silty GRAVEL or white slightly gravelly sandy SILT. Gravel subangular to subrounded fine and medium, with rare coarse, gravels of extremely weak low density, flint. |
| <b>Upper Chalk (Structured)</b>    | 7.35 - Unproven     | >20.65 (Unproven)   | The structured chalk was only encountered in the boreholes. With a top of stratum level ranging between 21.20m AOD and 30.95m AOD. The thickness was unproven. The CIRIA grade of the chalk included B5, B4, B3, C3, C4, and A5.<br><br>The typical description consists of weak medium density white CHALK with bands of marl.                        |

### 3.2 Groundwater

The Environment Agency (EA) classifies the Made Ground as an Unproductive Strata, the Alluvium and Taplow Gravel as a Secondary A Aquifer, and the Upper Chalk Formation as a Principal Aquifer.

Two groundwater strikes were recorded in WS202 at 4.24 m and WS203 at 4.21 m bgl during the ground investigation. Groundwater monitoring of all installed boreholes was undertaken on six occasions following the ground investigation. The mean groundwater level monitored was approximately 2.66 m bgl.

The groundwater elevations were in the region of +36.2 meters above Ordnance Datum (mAOD). The highest average groundwater level was measured at +39.84 mAOD in WS201, and the lowest average groundwater level was measured at +35.75 mAOD in BH203. Groundwater level data collected during groundwater monitoring visits indicates a groundwater level at approximately to 36.2 m AOD.

The groundwater levels measured during the ground investigation are similar to those encountered in the southern extent of the site and suggests groundwater continuity throughout the ground profile.

### 3.3 Ground Contamination Identified

Following the ground investigation, a number of potentially significant pollutant linkages were identified. The linkages relevant to piling and are summarised below in Table 3.2.

**Table 3.2 Contamination Identified as Requiring Remedial Action as Relevant to Piling**

| Contaminant                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Additional Actions Required                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>Asbestos</b> - Four samples, from three exploratory locations (WS202, WS203 and TP208) identified asbestos. The highest asbestos concentration was recorded at 0.024% in WS202 at a depth of 0.5-0.7m bgl and was detected as amosite loose fibres. There were no observations of possible asbestos containing material (ACM) observed in soil during the site investigation.</p>                                                                                                                                                                                                                                                   | <p>The risk assessment in Section 5 assesses the potential impact to human health from arisings containing asbestos. The maximum depth that asbestos was identified was 0.75 m bgl. It is therefore considered likely that the Made Ground material that contains asbestos will be removed as part of the earthworks.</p> <p>Waste assessment of earthworks and excavation arisings need to consider asbestos prior to removal from site.</p>                                                                                                                                                                                                                                |
| <p><b>PAH</b> - BaP (and contaminants that use the BaP GAC as a surrogate) were detected in nine locations above the GAC for residential end use without plant uptake. The highest concentration of BaP was recorded at WS203 at 1.1m bgl at a maximum concentration of 270 mg/kg. This exceeds the residential without plant uptake GAC of 5.3mg/kg.</p> <p>WS203 was undertaken in the location of a former tank adjacent to the former garage identified on historical maps. Elevated PAHs are therefore thought to be predominantly in the south east of the site, in the location of the former garage and current NCP car park.</p> | <p>The risk assessment in Section 5 assesses the potential impact to human health from arisings containing elevated PAHs. The soil materials containing exceedances were predominantly in shallow Made Ground and the majority of this material will be removed as part of the excavations prior to piling or cased off during piling.</p> <p>Waste assessment of pile arisings will be required to ensure appropriate disposal.</p>                                                                                                                                                                                                                                         |
| <p><b>TPHs</b> - Heavy end Aromatic TPH C21-C35 exceed the GAC for residential without plant uptake in WS203 at 1.1m bgl at a concentration of 2,600mg/kg and in TP208 at 1.5m bgl at a concentration of 2,900mg/kg. This exceeds the GAC for residential use without plant uptake used, 1,900mg/kg. No TPH results exceed the GAC for commercial use at 29,000mg/kg.</p> <p>WS203 and TP208 are both located in the centre of the site. WS203 in the location of a former tank, adjacent to the former garage. TP208 encountered a former underground service at 2.2m beneath the exceedance.</p>                                        | <p>The risk assessment in Section 5 assesses the potential impact to human health from arisings containing TPHs. The material containing the TPH exceedances identified is limited to the top 1.5 m bgl in Made Ground in the centre of the site. This material containing the two elevated TPH will be removed from site as part of the enabling works excavations.</p> <p>It is also worth noting that the area containing the elevated TPH readings is proposed for commercial use, will be covered by hardstanding and the TPH results do not exceed the commercial GAC.</p> <p>Waste assessment of earthworks and excavation arisings require appropriate disposal.</p> |

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|   |                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                        |
|---|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| 4 | <p><b>Groundwater</b> - Chemical analysis of seven groundwater samples collected from the Made Ground during the ground investigation revealed contaminant concentrations of PAHs and TPHs which exceeded the relevant GAC for assessment of controlled waters in BH204 in the south east of the site only. At this location, black staining was noted, and a hydrocarbon odour identified extending into the top of the Chalk formation.</p> | <p>Appropriate selection of piling methodologies shall be used to prevent migration of hydrocarbons into the deeper Chalk aquifer.</p> |
|---|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|

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## 4. FOUNDATION DESIGN

Although the EA recommends that piling on contaminated sites underlain by aquifers should be avoided where possible, it was considered by the design team that other foundation solutions were unfeasible for this particular development; the high base loads of the structure would have resulted in an excessive bearing pressure for a non-piled solution and beyond what the ground would be able to accommodate without excessively large spread foundations. A non-piled solution would have resulted in the need to excavate large quantities of material which could potentially mobilise contaminants and represent a greater potential for risk to sensitive receptors.

### 4.1 Proposed Foundation Design

The entire site is to be founded on piles, due to the variable extent and thickness of the superficial deposits that are considered unsuitable for shallow foundations. Piles are spaced at a minimum of three times the pile diameter to fully attain the base resistance of the structured Upper Chalk. The current proposal is to use Continuous Flight Auger (CFA) piles as these are more cost effective than bored piles, produce the least amount of vibration and noise and limit the potential spread of contamination from the shallow strata to the Chalk aquifer (as per the discussion in Table 4.1). Where soils are less cohesive and there is a potential for collapse the CFA method can use casing at shallow depth to provide additional support.

In addition to the building piles, new retaining walls are proposed to the north of the former NCP car park. Further details of the proposed piling technique are presented in Table 4.1 below.

**Table 4.1 Foundation / Piling Technique**

| Piling Technique | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Potential Hazards                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CFA              | This non-displacement piling method involves the drilling of an auger with a hollow stem (temporarily plugged) into the ground. Once the design depth is reached, concrete is pumped through the hollow stem of the auger while the auger is extracted at a controlled rate, keeping the end of the auger embedded into the concrete, maintaining a positive pressure throughout the process. Once the full length of the pile is concreted a reinforcement steel cage is pushed into the fluid concrete to provide additional strength. | <p>The introduction of non-displacement piles has the potential to bring contaminated soil arisings to the surface. Soil arisings will require disposal off-site or re-use as agreed in a Materials Management Plan. The soil contamination identified is limited to the shallow material and the material beneath is likely to be classified as non-hazardous or inert. Limited material may be classified as hazardous or potentially hazardous and therefore a protocol will need to be set in place for them to be managed as part of a Materials Management Plan.</p> <p>Segregation of this material from the vicinity of each pile location during piling will minimise the potential for cross contamination of arisings and the creation of additional waste that will need controlled disposal.</p> <p>The progression of CFA piles relies on the retention of soil on the auger flights to support the surrounding soil and prevent</p> |

|  |                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <p>collapse or migration outwards of soil. The potential for creation of a temporary pathway around the pile is limited with this method, and should one occur it would likely be short lived (in the region of minutes). The retention of soil in the auger as the pile commences will reduce the void space for migration of shallow contamination and subsequent concreting of the pile would close the pathway.</p> |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## 4.2 Pile Design

The pile capacity assessment has been conducted according to UK National Annex Euro Code 7 (NA+A1:2014 to BS EN 1997-1:2004+A1:2013) based on current loading assumptions and the current ground model.

Parameters for the Made Ground and Alluvium layers were not considered as the pile design has been based only on the strength of the Upper Chalk (Structureless), and Upper Chalk (Structured) layers as any contribution from the overlaying material is negligible.

Most columns require two-pile caps and need to be tied together with ground beams. A few three-pile and four-pile caps are required under heavily loaded columns. These typical pile caps are 1 m deep under the columns.

Pile caps underneath walls and lift and stair cores need to be deeper than typical pile caps and range between 1.6 m to 2.0 m depths.

The pile design takes into account the concrete Thames Water Sewer running from east to west across the centre of the North Site.

## 5. RISK ASSESSMENT

The assessment of piling risks utilises the EA documents:

- Piling into Contaminated Sites<sup>1</sup>.
- Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention NC/99/73<sup>2</sup>.
- Piling in Layered Ground: Risks to Groundwater and Archaeology<sup>3</sup>.

In particular this risk assessment makes reference to six pollution scenarios detailed within NC/99/73 which are summarised in Table 5.1 below.

**Table 5.1 Generic Pollution Scenarios**

| Scenario | Detail                                                                                                                                                        |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1        | Creation of preferential pathways through a low permeability layer (an aquitard) to allow potential contamination of an aquifer and/or surface water feature. |
| 2        | Creation of preferential pathways, through a low permeability surface layer, to allow migration of landfill gas, soil gas or vapours to surface.              |
| 3        | Direct contact between site workers and others, with contaminated soil arisings that have been brought to the surface.                                        |
| 4        | Direct contact between the piles or engineered structures, with contaminated soil or leachate causing degradation of pile materials.                          |
| 5        | The driving of solid contaminants down into an aquifer during pile driving.                                                                                   |
| 6        | Contamination of groundwater, and subsequently, surface waters by wet concrete, cement paste or grout.                                                        |

Consideration is given to whether the Scenarios 1-6 are significant in the context of the proposed piling regime at the site in Table 5.2. Each of the pollution scenarios for the site-specific piling methods are then assessed in terms of the likelihood of the risk being realised, and the severity of the consequence if the risk was realised, using the following criteria.

**Table 5.2 Severity and Likelihood Criteria for Piling Risk Assessment**

| Severity   | Criteria                                                                                                                                                                                       |
|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| High       | Significant pollutant linkage which would cause deterioration of water quality or significant risks to human health in the long term.                                                          |
| Medium     | Pollutant linkage which could result in deterioration of water quality or risks to human health in the long term or cause a short-term pollutant linkage restricted to the duration of piling. |
| Low        | Any pollutant linkage caused would not significantly affect water quality or risks to health.                                                                                                  |
| Likelihood | Criteria                                                                                                                                                                                       |

<sup>1</sup> Environment Agency (2002) Piling into Contaminated Sites

<sup>2</sup> Environment Agency (2001) Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination Guidance on Pollution Prevention NC/99/73

<sup>3</sup> Environment Agency (2014) Piling in Layered Ground: Risks to Groundwater and Archaeology SC020074

| Severity | Criteria                                                                                                                     |
|----------|------------------------------------------------------------------------------------------------------------------------------|
| High     | Would cause a pathway to be created.                                                                                         |
| Medium   | May cause a pathway to be created, but if it was realised, would not be likely to represent a significant risk.              |
| Low      | Would be unlikely to cause a pollutant linkage, but if it was realised, would not be likely to represent a significant risk. |

The severity and likelihood classifications are then used to provide an overall risk, as detailed in Table 5.3 below.

**Table 5.3 Piling Risk Assessment Method**

|            |        | Severity  |        |          |
|------------|--------|-----------|--------|----------|
|            |        | High      | Medium | Low      |
| Likelihood | High   | Very High | High   | Medium   |
|            | Medium | High      | Medium | Low      |
|            | Low    | Medium    | Low    | Very Low |

An assessment of the risks associated with foundation works at the site is provided in Table 5.4 below. The assessment is based on site-specific conditions and contamination as detailed in Table 3.1 and Table 3.2.

Table 5.4 Foundation Works Risk Assessment

| Site-Specific Pollution Scenario                                                                                                                                   | Activity                    | Source (S) Pathway (P) Receptor (R)                                                                                                  | Severity | Likelihood | Risk Assessment* | Mitigation Measures                                                                                                                                                                                                                                                                                                                                                                                   | Comments                                                                                                                                                                                                                                                                                                                                                         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------|----------|------------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1: Creation of preferential pathways through an aquitard to allow potential contamination of an aquifer.                                                           | CFA piles / retaining walls | <p><b>S</b> Contaminated soils / Shallow groundwater</p> <p><b>P</b> Pathway created by piles</p> <p><b>R</b> Underlying aquifer</p> | Medium   | Low        | Medium           | <p>The principal source of contamination, the Made Ground, will either be removed as part of the enabling works excavations prior to piling commencing or cased off and isolated during the piling process.</p> <p>The use of CFA piles minimises the risk of vertical pathway creation and is a method generally accepted by the EA for contaminated sites where important aquifers lie beneath.</p> | Hydrocarbon contamination was noted in the centre and south east of the site, in the location of the former garage and current car park. This contamination was noted at the top of the structureless chalk and in the groundwater.                                                                                                                              |
| 2: Creation of preferential pathways through a low permeability surface layer, allowing migration of landfill gas, soil gas or contaminant vapours to the surface. | CFA piles / retaining walls | <p><b>S</b> Underlying geology</p> <p><b>P</b> Pathway created by piles</p>                                                          | Medium   | Low        | Medium           | <p>The site has been classified as having a Gas Characteristic Situation of 2 (low risk).</p> <p>During construction, the enabling, piling and main works contractors are required to have appropriate safe working practices and health and safety measures in place during works including personal</p>                                                                                             | <p>The Alluvium was observed to contain organic content with a moderate ground gas generation potential. The natural bedrock geology (chalk) does not have a high gas generation potential.</p> <p>Slightly elevated VOCs were recorded across the site during the monitoring programme. VOCs will not impact deeper controlled waters in the Chalk aquifer.</p> |

|                                                                                                                                 |                             |          |                                                    |                |        |               |  |                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------------------------------------------------------------------------------------------------------------------------|-----------------------------|----------|----------------------------------------------------|----------------|--------|---------------|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                 |                             | <b>R</b> | Human health and buildings                         |                |        |               |  | protective equipment (PPE), (respiratory protective equipment) RPE and confined spaces entry systems etc.                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                 |
| 3: Direct contact of site workers and others with asbestos and contaminated soil arising that have been brought to the surface. | CFA piles / retaining walls | <b>S</b> | Contaminated soils / Shallow groundwater           |                |        |               |  | Site workers will require standard construction PPE and RPE; this will reduce the risk to low. Site activities are to be managed and controlled. Material is likely to be a combination of inert, non-hazardous and hazardous and require management, segregation and disposal accordingly. | Some Made Ground will be excavated (and disposed of off-site) to bring the site to formation level and deeper materials can be expected to be of low potential for contamination, such that exposure risks are considered to be low, with the exception of the area surrounding the former garage / current carpark until further delineation of this area has been undertaken. |
|                                                                                                                                 |                             | <b>P</b> | Soils brought to the surface                       | Low            | High   | Medium        |  |                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                 |
|                                                                                                                                 |                             | <b>R</b> | Site workers                                       |                |        |               |  |                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                 |
| 4: Direct contact of the piles or engineered structures with contaminated soil causing degradation of materials.                | CFA piles / retaining walls | <b>S</b> | Natural soil conditions such as elevated sulphates |                |        |               |  | The appropriate design of concrete specification will mitigate the risk.                                                                                                                                                                                                                    | An assessment of the ground and groundwater aggressivity suggests a Design Sulphate Class of DS-1 for all the strata present. The Aggressive Chemical Environment for Concrete (ACEC) Classification is AC-1 for all the strata present.                                                                                                                                        |
|                                                                                                                                 |                             | <b>P</b> | Contact                                            | Low            | Medium | Low           |  |                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                 |
|                                                                                                                                 |                             | <b>R</b> | Construction Materials                             |                |        |               |  |                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                 |
| 5: The driving of solid contaminants down into an aquifer during pile driving                                                   | CFA piles / retaining walls | <b>S</b> | Contaminated soils / shallow groundwater           | Medium to High | Low    | Low to Medium |  | Use of a convex/conical drilling shoe could limit driving material down. Furthermore, the shallow made ground (in which higher                                                                                                                                                              | The anticipated volume of material dragged down would be small owing to the nature of the method used.                                                                                                                                                                                                                                                                          |

|                                                                                                                   |                             |          |                          |        |     |     |  |     |                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|-------------------------------------------------------------------------------------------------------------------|-----------------------------|----------|--------------------------|--------|-----|-----|--|-----|------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                   |                             | <b>P</b> | Pathway created by piles |        |     |     |  |     | contaminant concentrations would be expected) is to be largely excavated during enabling works, prior to piling. | Groundwater is considered to be, for the most part, in continuity throughout the ground profile into the chalk. Contaminant concentrations in excess of GACs for controlled waters were only identified in one location in the south east of the site, adjacent to the former garage and current car park. As such the risk from mixing between shallower and deeper groundwater is considered to be low across the remainder of the site. |
|                                                                                                                   |                             | <b>R</b> | Underlying aquifer       |        |     |     |  |     |                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 6: Contamination of groundwater and, subsequently, surface waters by wet concrete, cement paste, grout or polymer | CFA piles / retaining walls | <b>S</b> | Construction Materials   | Medium | Low | Low |  | N/A |                                                                                                                  | Whilst the risk of contamination of groundwater cannot be discounted the impact is assessed as low as both concrete and grout have low mobility potential.                                                                                                                                                                                                                                                                                 |
|                                                                                                                   |                             | <b>P</b> | Pathway created by piles |        |     |     |  |     |                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                                                                                                                   |                             | <b>R</b> | Underlying aquifer       |        |     |     |  |     |                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                            |

## 6. CONCLUSIONS

This document discusses the potential risks to the Chalk aquifer water environment that may arise from the proposed piling activities at the site, as required by Condition 12 of Planning Application Number 192032.

Prior to piling commencing, a reduction of levels and removal of shallow Made Ground up to formation level is proposed. Excavations in the north of Phase 2, in the area of the former Temporary Events Area, are almost complete and no significant contamination has been identified during the environmental watching brief visits in this area. The excavation to formation level across the remainder of Phase 2 in the south will remove the majority of hydrocarbon exceedances identified within the soils.

However, in the south east corner of Phase 2, hydrocarbon odours and a black staining between 2.8m and 4.8m extended into the top of the chalk formation. In this area casing should be placed to a minimum of 6.0 m bgl to isolate the shallow contamination when piling.

With the method proposed and the ground conditions encountered through site investigation to date, the potential for the creation of pollutant linkages is considered to be limited and CFA piles are considered suitably appropriate and protective of the controlled waters environment in the Chalk aquifer.

The adoption of CFA piling techniques will result in arisings being brought to the surface. The majority of these arisings are likely to be a combination of inert and non-hazardous in terms of waste classification. The site investigation was limited due to the buildings still requiring demolition and therefore previously unidentified contamination cannot be discounted and if contaminated material is encountered then this may be classified as hazardous. Arisings should therefore be characterised, managed and re-used or disposed of in accordance with a Materials Management Plan.

### 6.1 Roles and Responsibilities

This document discusses the potential risks to the water environment that may arise from proposed piling activities at the site. These risks will be considered and mitigation measures adopted by the Piling Contractor in developing their piling methodology and final designs.

During the course of works the piling Contractor shall ensure that appropriate Quality Assurance/Quality Control (QA/QC) methods are incorporated to demonstrate that high levels of workmanship have been used.

On completion of the piling works, the Piling Contractor shall validate that the works were carried out in accordance with the agreed piling method.